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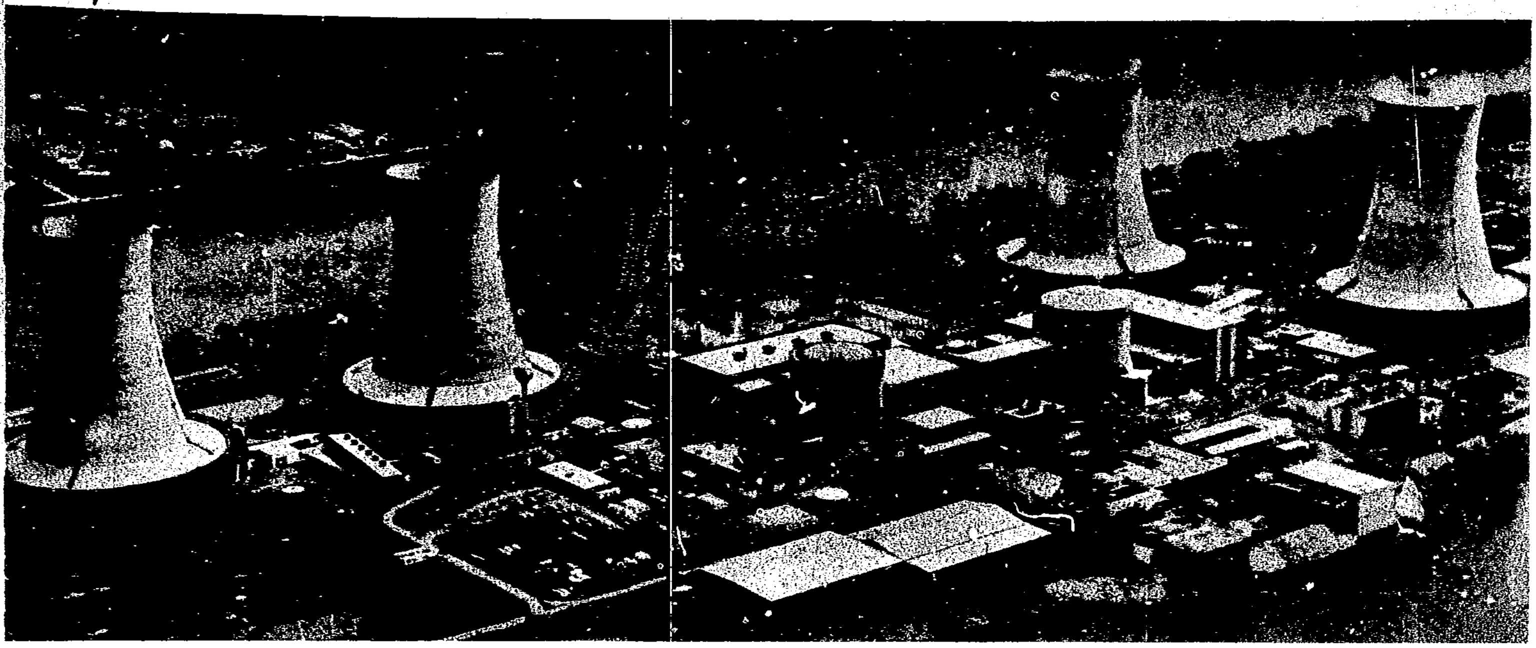

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Quick Look Inspection: Report on the Insertion of a Camera into the TMI-2 Reactor Vessel through a Leadscrew Opening Volume I

Bechtel Northern Corporation

March 1983

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Three Mile Island Operations Office
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QUICK LOOK INSPECTION: REPORT ON THE INSERTION OF A CAMERA INTO THE TMI-2 REACTOR VESSEL THROUGH A LEADSCREW OPENING. VOLUME I

Published March 1983

Bechtel Northern Corporation
Gaithersburg, Maryland 20877

Prepared for EG&G Idaho, Inc.
Under Subcontract No. K-9067
and the U.S. Department of Energy
Three Mile Island Operations Office
Under Contract No. DE-AC07-76ID01570

ABSTRACT

The purpose of the insertion of a camera into the reactor vessel through a leadscrew opening, known as the Quick Look, was to visually inspect a portion of the plenum and fuel inside the TMI-2 reactor vessel in order to make an assessment of their condition. This was accomplished by uncoupling the center control rod drive mechanism (CRDM) leadscrew from the control rod assembly and removing the leadscrew from the CRDM, resulting in an access path to a plenum guide tube and to the core region. This report describes the preparations and plant modifications required to accomplish this Quick Look. Additionally, the report summarizes the containment entries, data collected, and the observations from the camera inspections. As a result of the Quick Look, two general conclusions can be made: (a) although a significant amount of debris was observed, plenum distortion was not apparent, and (b) the top center of the core was observed in the form of a loose rubble bed approximately 5 feet below the design location.

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Continued)

FIGURES (Cont.)

CONTENTS (Continued)

FIGURES (cont.)

CONTENTS (Continued)

FIGURES (cont.)

1. INTRODUCTION

1.1 Objective of the Quick Look Inspection

The objective of the Quick Look Inspection was to inspect control rod guide tubes, a portion of the upper grid, the tops of fuel assemblies, and, if upper end fittings were missing, the reactor core. This inspection provided the first visual information on the condition of the core and upper internals and was of significant interest to both researchers and recovery planners. A significant benchmark was established from which the projected range of core condition and accident sequence estimates can be narrowed (see Figure 1-1).

The method for obtaining this information was to insert a radiation-tolerant, underwater closed-ciruit television (CCTV) camera through an opening created by the removal of a leadscrew from a control rod drive mechanism (CRDM) (see Figure 1-2). The camera was manipulated using the camera power cable and a separate articulating cable to obtain access to the desired inspection areas.

The basic approach was to lower the TV camera from the top of a control rod drive mechanism, down through the leadscrew hole to the region of the tenth spacer plate of a guide tube in the upper plenum assembly (see Figure 1-3). The main inspection was to start in the general region of the tenth spacer plate (see Figure 1-4) and then, depending on the conditions found, attempt the following inspections:

1. General area inspection of the tenth spacer plate and upper end fitting of the fuel assembly (see Figure 1-5) directly below the opened leadscrew hole.

2. Inspection of the upper end fittings of the four adjacent fuel assemblies by manipulating the TV camera out the flow holes in the side of the guide tube.

3. Following the inspection of each adjacent fuel assembly end fitting, inspect the next outer fuel assembly which has a control rod assembly (see Figure 1-6), in an attempt to determine the status of its end fittings.

4. A detailed inspection of the end fitting directly below the opened leadscrew hole, followed by a detailed inspection of the tenth spacer plate and its guide tubes. If the inspection of this region indicated that it has seen higher temperatures, the eighth and ninth spacer castings were also to be inspected.

If, during the above examination, end fittings were found to be missing, the general intent was to continue the inspection along the pattern described above without lowering the camera into the fuel region. If an end fitting was found to be missing from its normal position and the above inspections had been basically completed, the TV camera was to be lowered through the opening to determine where the top of the core was generally located, and a general inspection made to determine conditions in that region.

As a follow-up to the core inspections, leadscrew uncoupling was attempted on all the leadscrews not uncoupled for the camera inspections. Information gained from this activity will be used to determine what contingency tooling will be required to support reactor vessel head removal.

1.2 Established Schedule

The Leadscrew Quick Look Schedule No. S-1, Figure 1-7, reflects the originally scheduled activities with a second line showing actual or forecast dates for progress and performance determination. Key milestones for the task included:

1. Safety evaluation approval
2. Lowering of the primary system water level

3. Removal and cutting of the leadscrew
4. Video inspection

The Quick Look I camera inspection was originally scheduled for the week ending July 23, 1982, and was in fact performed on July 21, 1982. After the Quick Look I camera inspection, Quick Look II, Quick Look III, and leadscrew uncoupling activities were scheduled as follows:

- Quick Look II - August 5, 1982
- Quick Look III - August 12, 1982
- Leadscrew Uncoupling - August 23 and 25, 1982

1.3 Sequence of Quick Look Camera Inspections

1.3.1 Quick Look I - July 21, 1982

The camera was lowered into the CRDM guide tube at position 8H (see Figure 1-3). After the inside of the guide tube was examined to the level of the top of the core, the camera was snaked through a flow hole in the guide tube into an adjacent location. Due to symmetry and lack of reference points, the new location of the camera was indeterminate. In this position, as in position 8H, the control spider was not visible.

The camera was then retracted into the 8H guide tube and lowered into the core region. Nothing was observed until the camera encountered a rubble bed, approximately 5 feet below the top of the core region. After scanning the debris, the camera was rotated upward into a vertical position and raised to a point from which the underside of the upper plenum assembly was viewed.

Once the upper plenum was scanned, the draw cable was lowered until the camera was horizontal. In this position, the camera was rotated through 360 degrees at a point 15 inches above the rubble bed without obstruction. The sweep of the camera was 21 inches in diameter, which indicated that the void at the center of the core encompassed at least the nine fuel elements surrounding position 8H.

1.3.2 Quick Look II - August 6, 1982

The leadscrews at the 8B and 9E positions were removed in preparation for this camera inspection. An auxiliary light was lowered into the void through the 8H guide tube. The first insertion of the camera took place on the core periphery through 8B. During the inspection of the control spider, which was in its normal position, the light on the camera failed. When the camera was replaced, the inspection of the spider continued.

The camera was raised and maneuvered into an adjacent location where a burnable poison rod assembly (BPRA) was located. From this position, the BPRA retainer with the spider hub inside was visible. Since this spider and the one at 8B were still in their normal locations, the camera could not be lowered further.

After the camera was withdrawn from 8B, it was lowered into the core region through the 9E guide tube. Nothing was encountered until the camera reached the rubble bed, approximately 5 feet below the top of the core region. The examination of the debris in the rubble bed was extensive, since much of the debris was identifiable.

Attempts were made to rotate the camera around a vertical axis, as was done in the first Quick Look; however, the camera and cable were repeatedly obstructed. The camera was then pointed upward and raised until it came into contact with the underside of the plenum. The junction of four upper end fittings without fuel bundles attached, but still suspended from the underside of the plenum, was observed.

1.3.3 Quick Look III - August 12, 1982

In this final camera inspection, the camera was inserted through the 9E guide tube with the auxiliary light inserted through 8H. The inside of the guide tube was reexamined, as were the underside of the plenum and the rubble. A stainless steel rod was used to probe the rubble at positions 8H and 9E. In both places, the rod appeared to penetrate 14 inches into the rubble bed (see Section 3.4).

The first camera was removed and a second camera, fitted with a right-angle viewing lens, was inserted at 9E to perform a detailed examination of the CRDM guide tube. When the examination had been performed, a panoramic scan was made 2 feet 6 inches below the top of the core region.

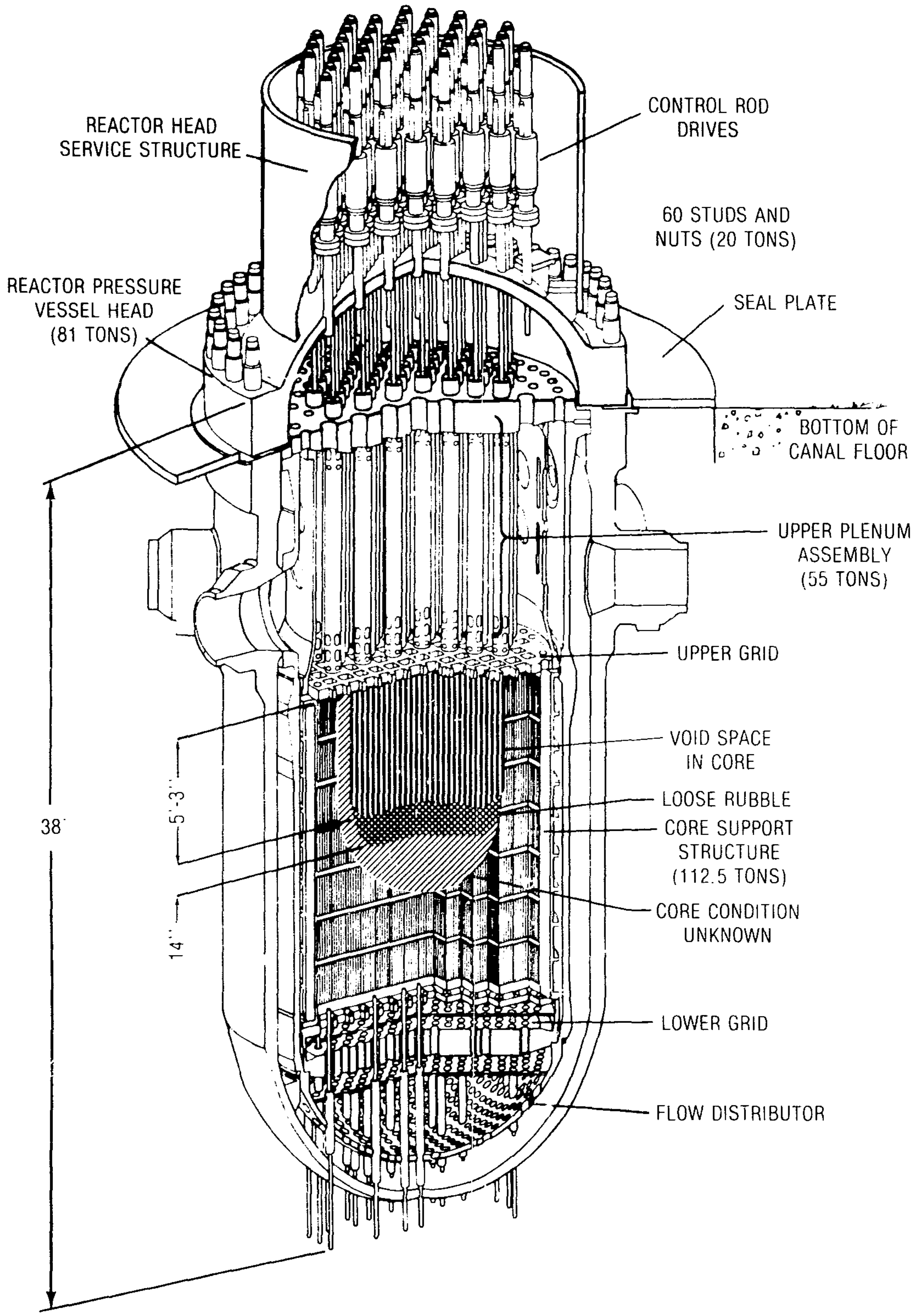


Figure 1-1. Cutaway view of the reactor vessel.

Postulated core damage is shown, which is based on camera inspections and core probes in locations 8H and 9E.

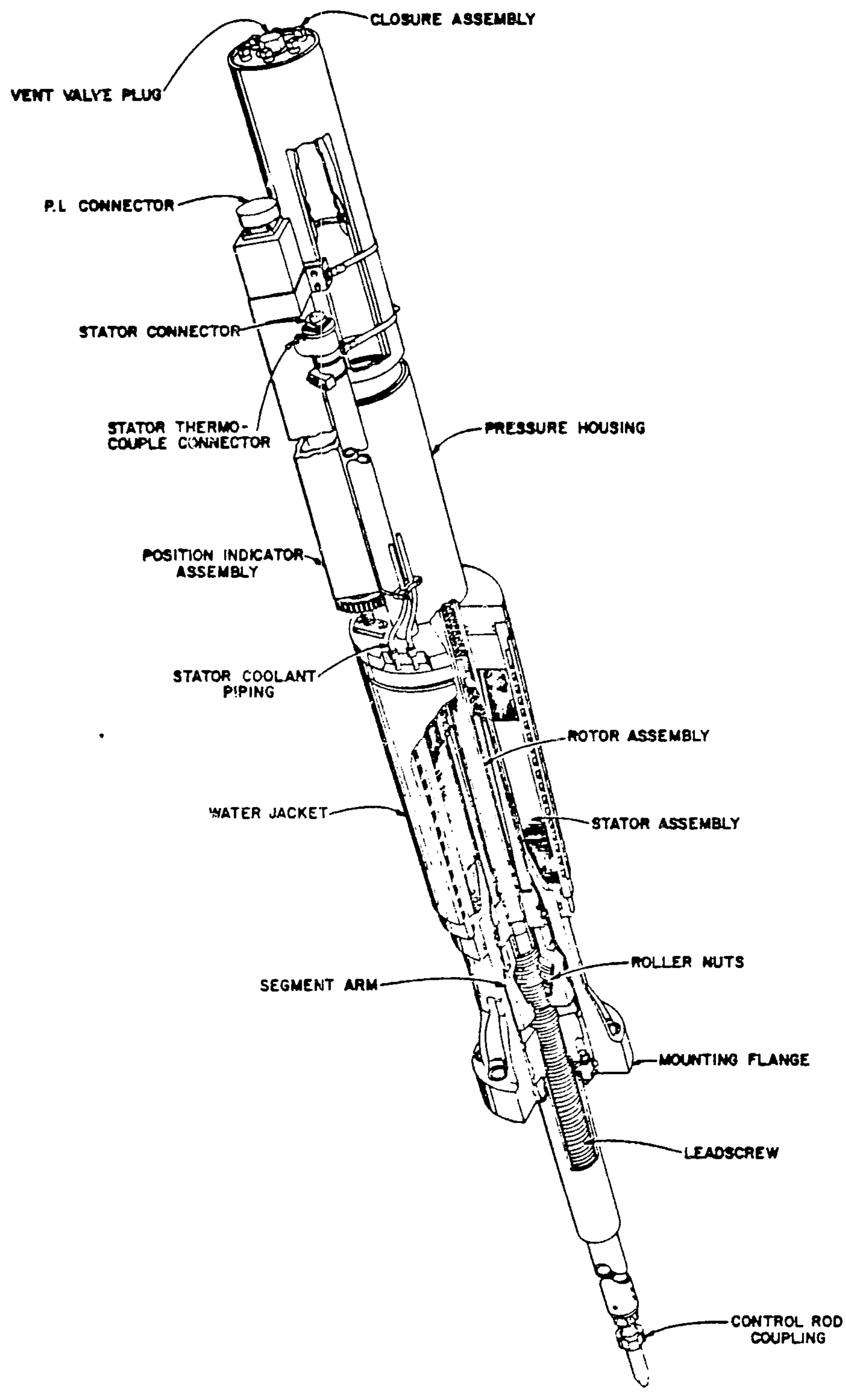


Figure 1-2. Control rod drive mechanism.

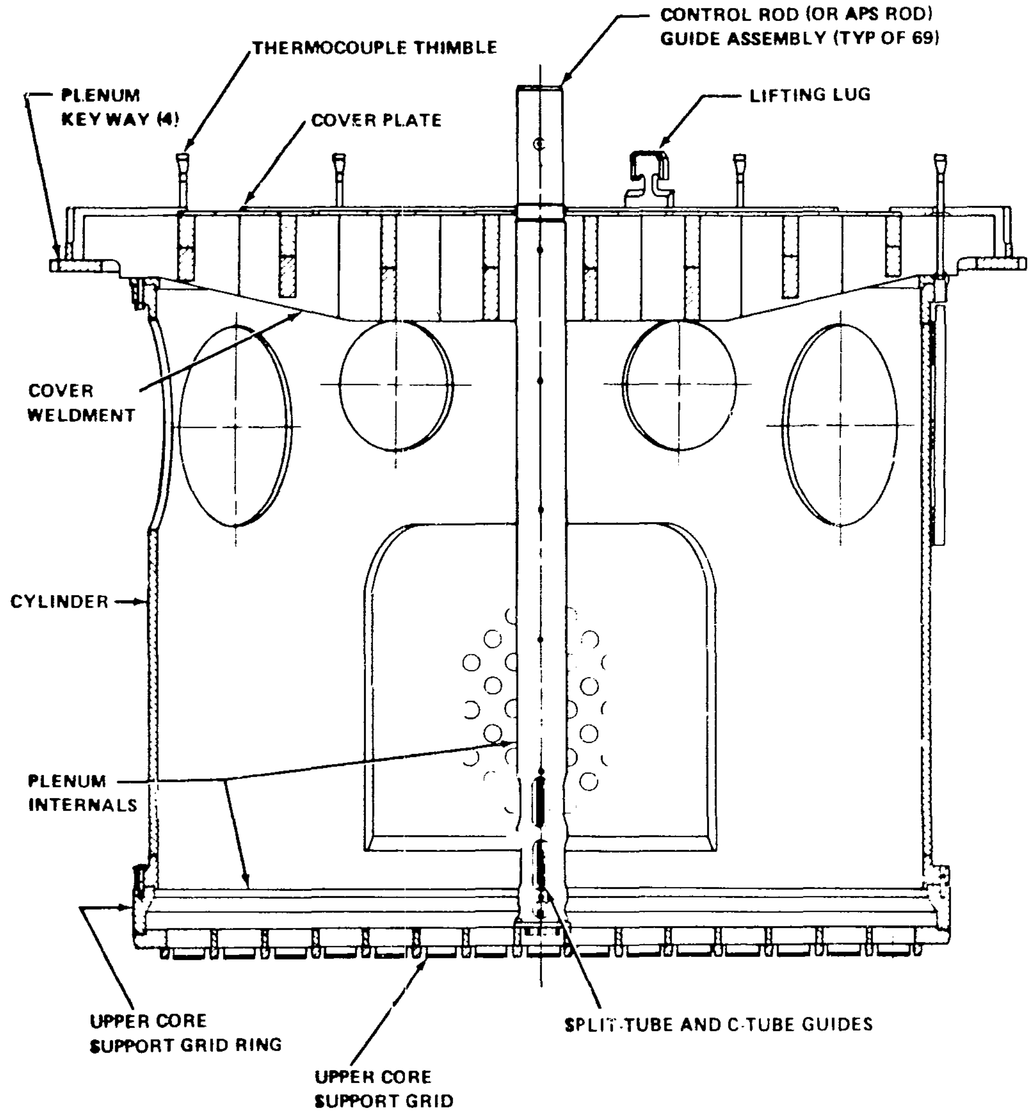


Figure 1-3. Plenum assembly.

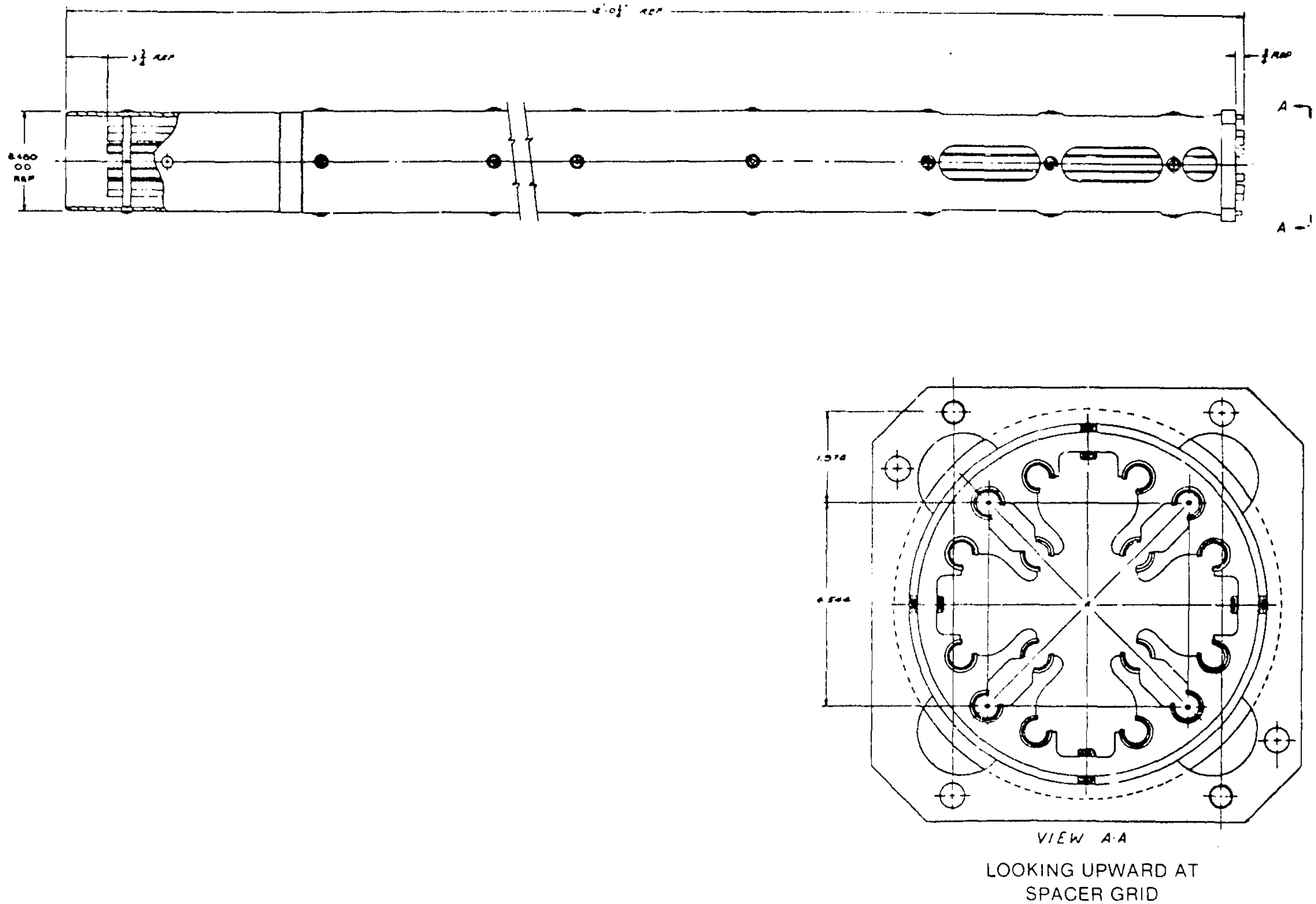


Figure 1-4. Control rod guide assembly.

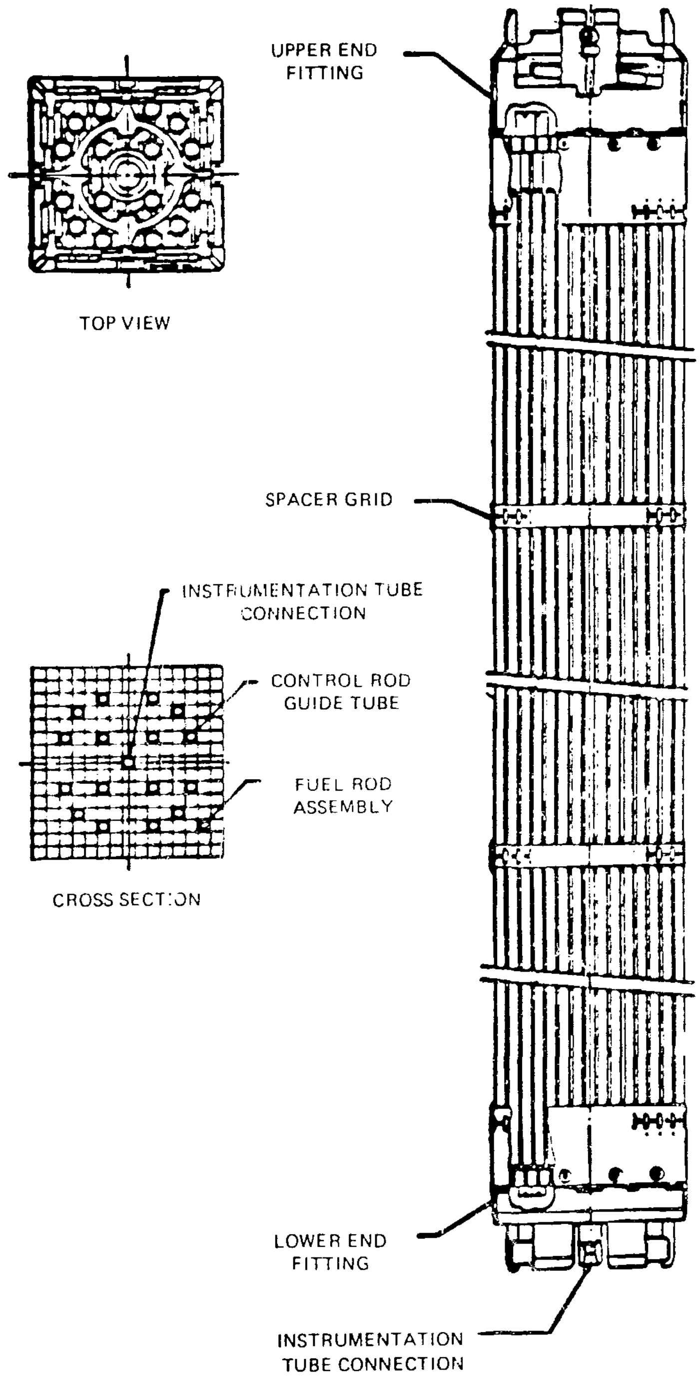
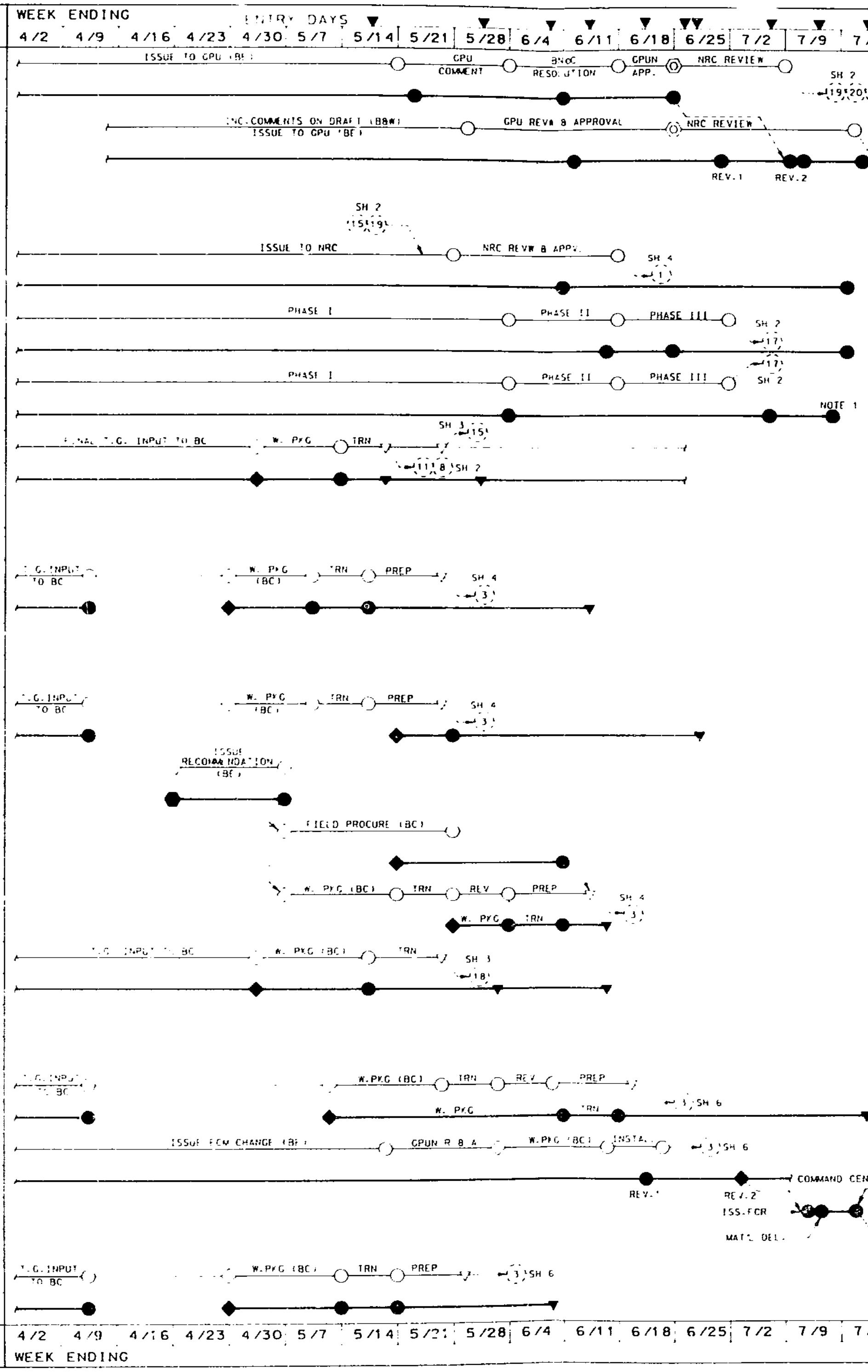


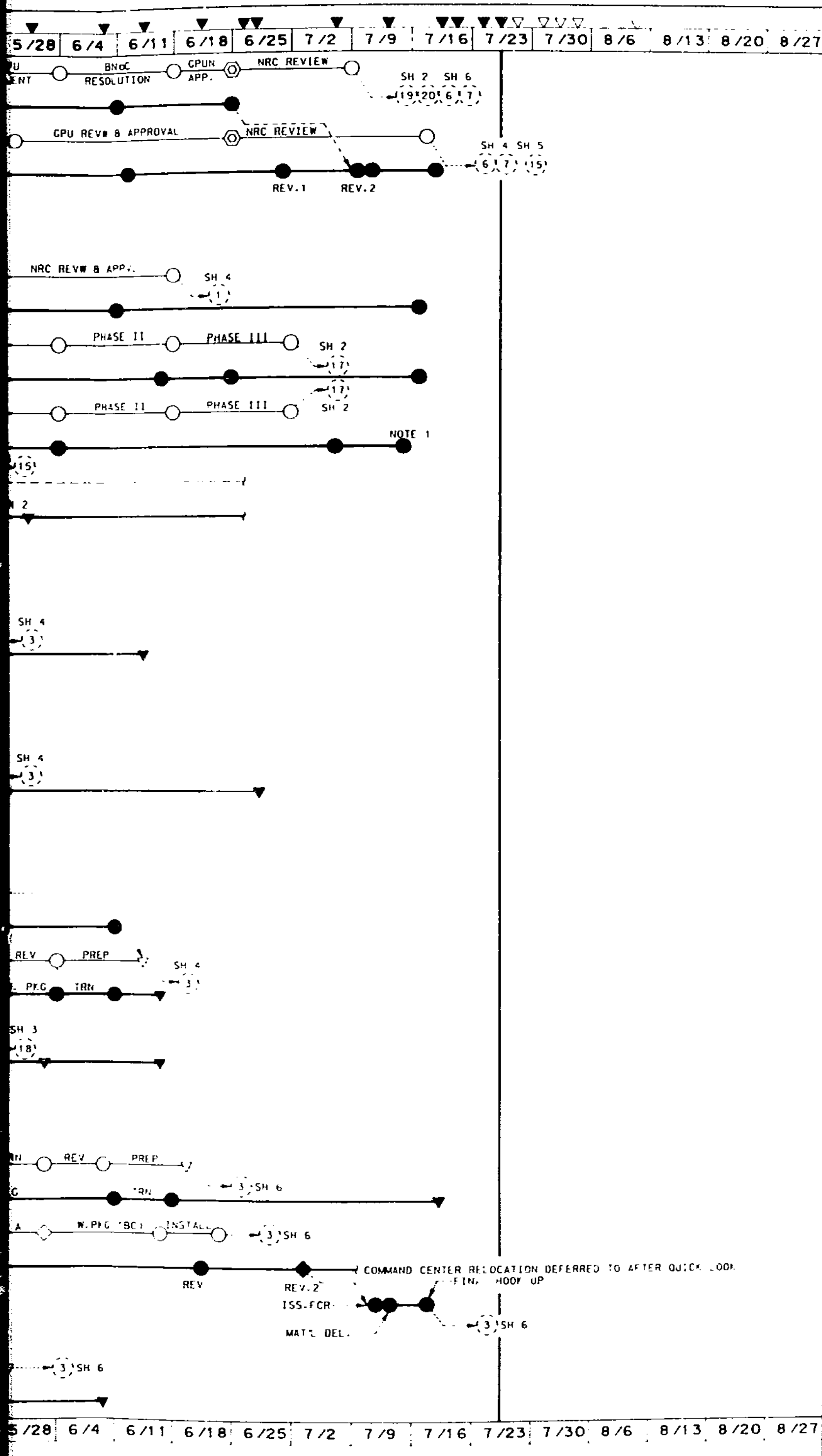
Figure 1-5. Fuel assembly.

SCHEDULE DESCRIPTION	LINE NO.	RESP.
SAFETY ASSESSMENT/ EVALUATION REV. 0	1	BE
SAFETY ASSESSMENT (CRITICALITY ANALYSIS) REV 1	2	BE
TECH. SPEC. CHANGES:	3	
ISOLATION OF SPC SYSTEM & ST LEVEL	4	GPUN
PROCEDURES: 2104-10.0 SEQUENCING & ADMIN DOCUMENT	5	GPUN
EMERGENCY PROCEDURES	6	GPUN
☆ HP SURVEY/PHOTOS	7	BC
POWER:	8	
☆ CHECKOUT 110V, 480V SYSTEMS	9	BC
LIGHTING:	10	
☆ RELOCATE EXISTING LIGHTING	11	BC
EMERGENCY LIGHTING	12	BE
PROCURE EMERGENCY LIGHTING	13	BC
☆ INSTALL EMERGENCY LIGHTING	14	BC
☆ CHECKOUT N_2 SYSTEM	15	BC
COMMUNICATIONS:	16	BC
☆ RELOCATE RADIO ANTENNAE	17	BC
CONNECT EARMARK TO COMMAND CENTER (ECM 995)	18	BC
UPGRADE EXISTING COMMAND CENTER	19	BC
☆ RELOCATE CCTV'S	20	BC

GENERAL PREREQUISITES



WEEK ENDING



LEGEND:

- START OR FINISH OF WORK ACTIVITY
- ACTIVITY COMPLETED
- ENGINEERING START
- TECHNICAL EVALUATION REPORT
- PLACE PO CONTRACT BID
- CONSTRUCTION START
- MILESTONE
- RESTRAINT INDICATES THE DEPENDENCY OF ONE WORK ACTIVITY ON ANOTHER
- RESTRAINT FROM ANOTHER ACTIVITY TO LINE 16
- RESTRAINT FROM LINE 16 TO ANOTHER ACTIVITY
- INDICATES REDUCED WORK EFFORT
- STATUS DATE LINE

ABBREVIATIONS

BC	-BECHTEL NORTHERN CONSTRUCTION
BE	-BECHTEL NORTHERN ENGINEERING
BL	-BECHTEL NORTHERN LIAISON ENGINEERING
B&W	-BABCOCK & WILCOX
GPUN	-GENERAL PUBLIC UTILITIES NUCLEAR
T.G.	-LEADSCREW QUICK LOOK TASK GROUP
W.PKG.	-WORK PACKAGE
ISS.	-ISSUE
REQ.	-REQUIREMENTS
TRN.	-TRAIN
REV.	-REVISE
PREP.	-PREPARATIONS
R	-REVIEW
A	-APPROVE
☆	-IN-CONTAINMENT ACTIVITY

PHASE I	SUBMIT TO PORC.
PHASE II	PORC. REVW. & APPR., SUBMIT TO NRC
PHASE III	NRC R & A, GPU ISSUE OF.

NOTES:

1. OPERATOR TRAINING SHALL PROCEED WITH PORC VERSION OF EMERGENCY PROCEDURES IF NRC APPROVED PROCEDURE IS NOT AVAILABLE FOR TIMELY TRAINING.

REV. NO	DATE	REMARKS	BY	L.S. ENGR	PROJ ENGR
5	7/26/82	REVISION & PROGRESS			

BECHTEL NORTHERN CORPORATION
GAITHERSBURG, MD

GENERAL PUBLIC UTILITIES NUCLEAR
METROPOLITAN EDISON
THREE MILE ISLAND-UNIT 2

Figure 1-7. Leadscrew Quick Look.

JOB NO	SCHEDULE NO	SHEET	REV
13587	S-1	1 OF 7	5

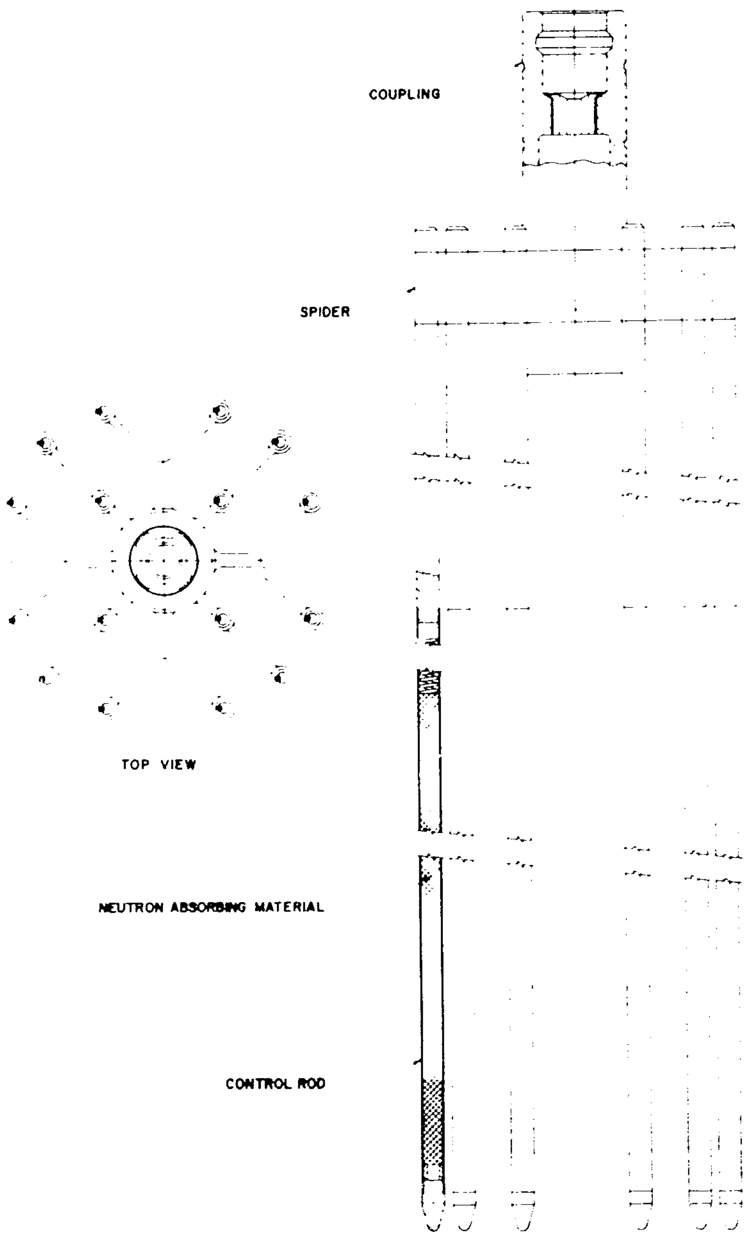
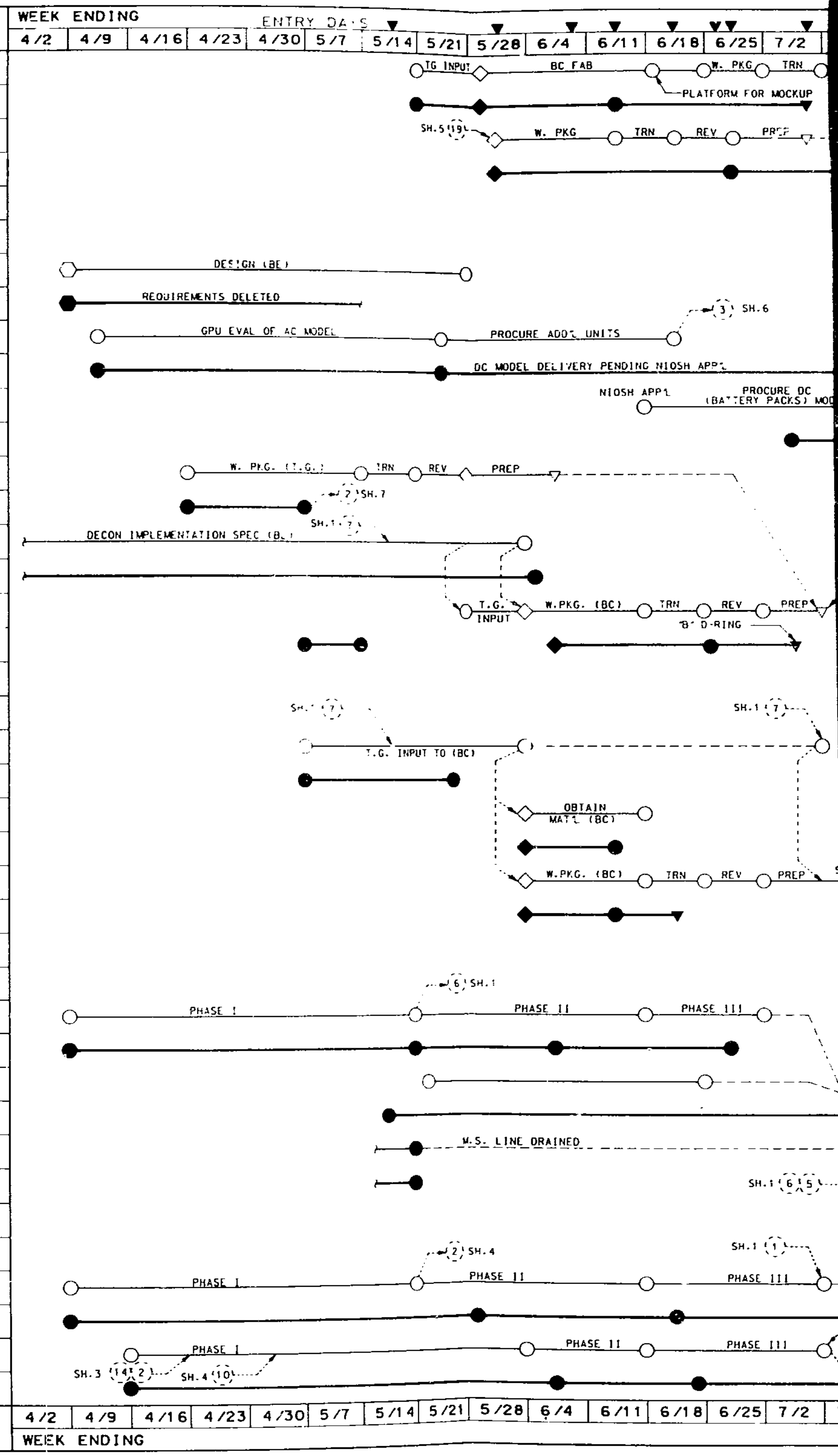
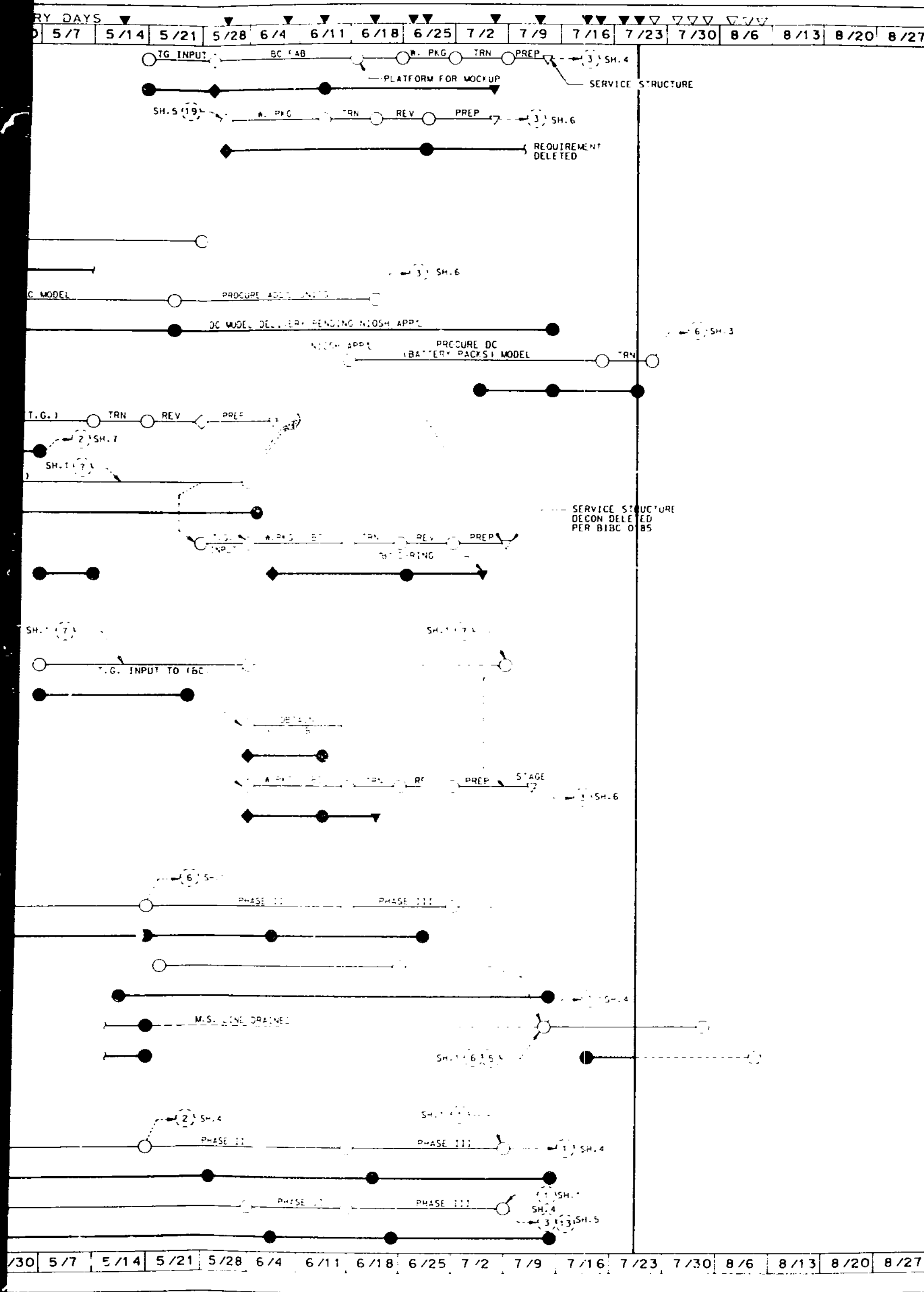


Figure 1-6. Control rod assembly.

	SCHEDULE DESCRIPTION	LINE NO.	RESP.
GENERAL PREREQUISITES	☆ ACCESS PLATFORMS	1	BC
	☆ COLOR CCTV	2	BC
	BREATHING AIR:	3	
	ENGINEER SYSTEM	4	BE
	PROVIDE BREEZERS	5	GPUN
		6	
	☆ DISCONNECT CRDM P.I. CABLES	7	TG
	HANDS-ON DECONTAMINATION OF SERVICE STRUCTURE	8	BL
	☆ PERFORM DECON	9	BC
	PROVIDE SERVICE STRUCTURE SHIELDING	10	
	ESTABLISH REQUIREMENTS	11	TG
	OBTAIN SHIELD MATERIAL	12	BC
	☆ STAGE	13	BC
LOWER SECONDARY LEVEL	PROCEDURES:	14	
	2104-10.1, SECONDARY PLANT PROCEDURE	15	GPUN
	SECONDARY PLANT PREREQUISITE TASKS	16	GPUN
	MAINTAIN LEVEL AT APPROX. 326' EL.	17	GPUN
LOWER PRIMARY LEVEL	PROCEDURES:	18	
	2104-10.2, PRIMARY PLANT PROCEDURE	19	GPUN
	2104-10.7, CRDM & SAMPLE HANDLING PROCEDURE	20	BL





LEGEND:

- START OR FINISH OF WORK ACTIVITY
- ACTIVITY COMPLETED
- ENGINEERING START
- TECHNICAL EVALUATION REPORT
- PLACE PO/CONTRACT/BID
- CONSTRUCTION START
- MILESTONE
- RESTRAINT INDICATES THE DEPENDENCY OF ONE WORK ACTIVITY ON ANOTHER
- RESTRAINT FROM ANOTHER ACTIVITY TO LINE 16
- RESTRAINT FROM LINE 16 TO ANOTHER ACTIVITY
- INDICATES REDUCED WORK EFFORT
- STATUS DATE LINE

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REQ.	-REQUIREMENTS
TRN.	-TRAIN
REV.	-REVISE
PREP.	-PREPARATIONS
R	-REVIEW
A	-APPROVE
☆	-IN-CONTAINMENT ACTIVITY
PHASE-I	SUBMIT TO PORC.
PHASE-II	PORC. REV'W. & APPR'L. SUBMIT TO NRC
PHASE-III	NRC R & A, GPU SIGN OFF

REV NO	DATE	REMARKS	BY	LSL ENGR	PROJ ENGR
5	7/26/82	REVISION & PROGRESS			

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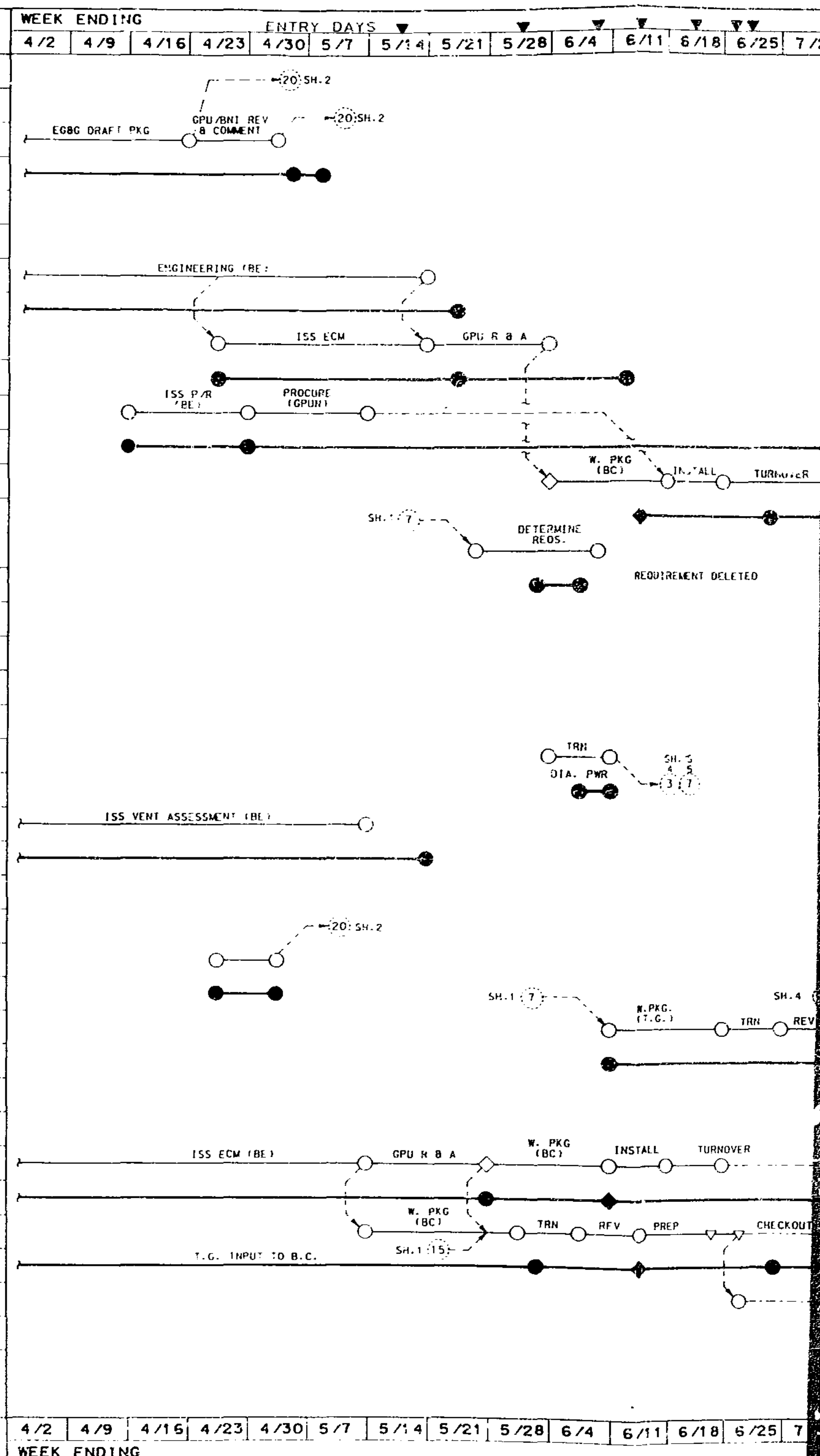
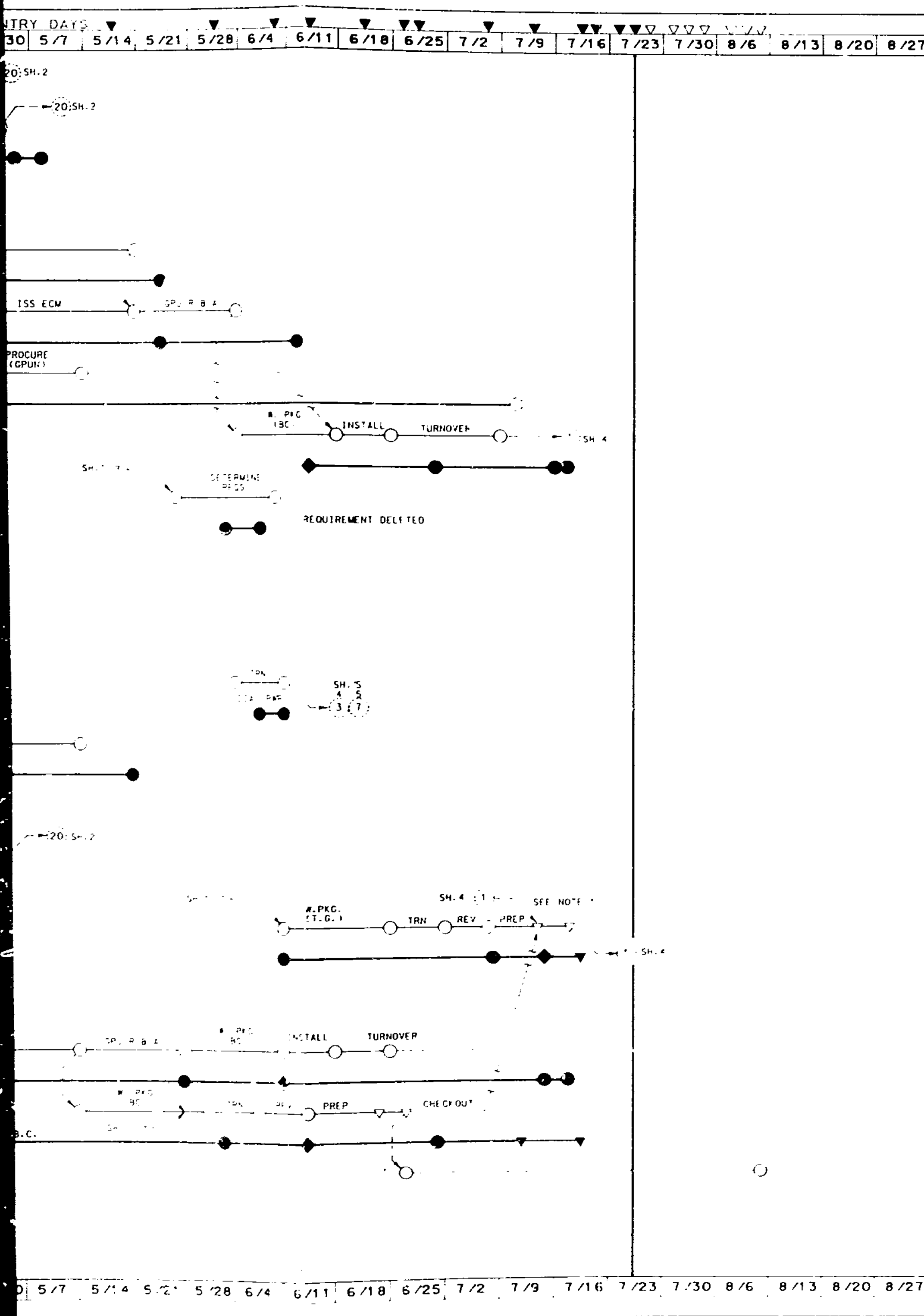
Figure 1-7. Leadscrew Quick Look. (Continued)

JOB NO	SCHEDULE NO	SHEET	REV
13587	S-1	2 OF 7	5

LOWER PRIMARY SYSTEM LEVEL

SCHEDULE DESCRIPTION	LINE NO.	RESP.
SAMPLE PACKAGES:	1	
CRDM VENT GAS SAMPLE (4.1)	2	EG&G
WATER LEVEL MONITORING:	3	
ENGINEERING-DIGITAL READOUT SYSTEM	4	BE
ECM 1040-DEVELOPMENT / APPROVAL	5	BE
PROCURE DIGITAL SYSTEM PARTS	6	GPUN
HOOKUP OF DIGITAL SYSTEM	7	BC
DETERMINE REQUIREMENTS FOR TYGON OPTION	8	GPUN
	9	
	10	
MOCKUP FOR CRDM VENT / SAMPL: COLLECTION	11	T.G.
ENGINEERING ASSESSMENT OF VENTING IN CONTAINMENT	12	BE
ALTERNATE RCS SAMPLING METHOD:	13	
DETERMINE REQUIREMENTS	14	GPUN
☆ VENT HIGH POINTS	15	T.G.
NITROGEN SYSTEM:	16	
INSTALL REGULATOR ECM 1041	17	BC
☆ INSTALL HEADERS & HOSES	18	BC
BLANKET AS REQUIRED	19	GPUN
	20	





LEGEND:

- START OR FINISH OF WORK ACTIVITY
- ACTIVITY COMPLETED
- ENGINEERING START
- TECHNICAL EVALUATION REPORT
- PLACE PO/CONTRACT/BID
- CONSTRUCTION START
- MILESTONE
- RESTRAINT INDICATES THE DEPENDENCY OF ONE WORK ACTIVITY ON ANOTHER
- (16) RESTRAINT FROM ANOTHER ACTIVITY TO LINE 16
- 16 RESTRAINT FROM LINE 16 TO ANOTHER ACTIVITY
- INDICATES REDUCED WORK EFFORT
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☆ -IN-CONTAINMENT ACTIVITY
PHASE I SUBMIT TO PORC.
PHASE II PORC. REV'W. & APPRVL. SUBMIT TO NRC
PHASE III NRC R & A, GPU SIGN OFF

NOTES:

1. PARTIAL DEPRESSURIZATION OF THE RCS WILL PRECEDE VENTING OF HIGH POINTS.

REV NO	DATE	REMARKS	BY	LSL ENGR	PROJ ENGR
5	5/26/82	REVISION & PROGRESS			

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METROPOLITAN EDISON
THREE MILE ISLAND-UNIT 2

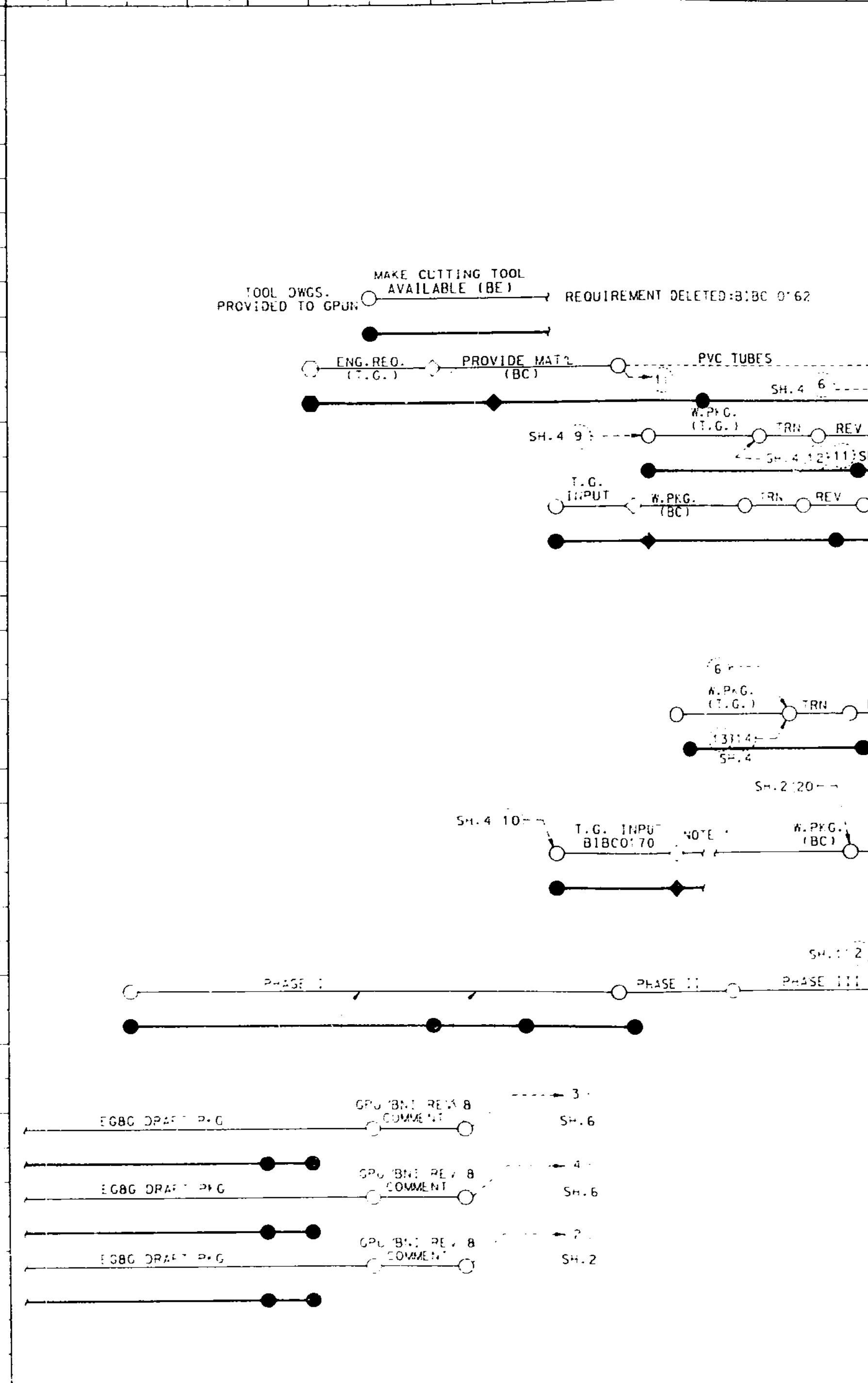
Figure 1-7. Leadscrew Quick Look. (Continued)

JOB NO	SCHEDULE NO	SHEET	REV
13587	S-1	3 OF 7	5

SCHEDULE DESCRIPTION		LINE NO.	RESP.
UNCOUPLE/REMOVE LEADSCREW		1	
		2	
		3	
		4	
	PROVIDE GLOVE BAG FOR LEADSCREW CUTTING	5	GPUN
	PROVIDE ENCLOSURES FOR CUT LEADSCREW	6	BC
	☆ VENT & UNCOUPLE CRDM	7	T.G.
	☆ STAGE TOOLS FOR CRDM UNCOUPLING/LS. REMOVAL, CUTTING	8	BC
		9	
		10	
	☆ REMOVE & CUT LEADSCREW	11	T.G.
		12	
	☆ LEADSCREW RIGGING	13	BC
IN-VESSEL INSPECTION	PROCEDURES:	14	
	2104-10.5, UNIT II CORE CAMERA INSPECTION PROC.	15	BL
	SAMPLE PACKAGES:	16	
	VIDEO INSP PLAN (4.3)	17	EG&G
	RCS LIQUID SAMPLES (4.4)	18	EG&G
	OPER VIDEOTAPE (4.5)	19	EG&G
		20	

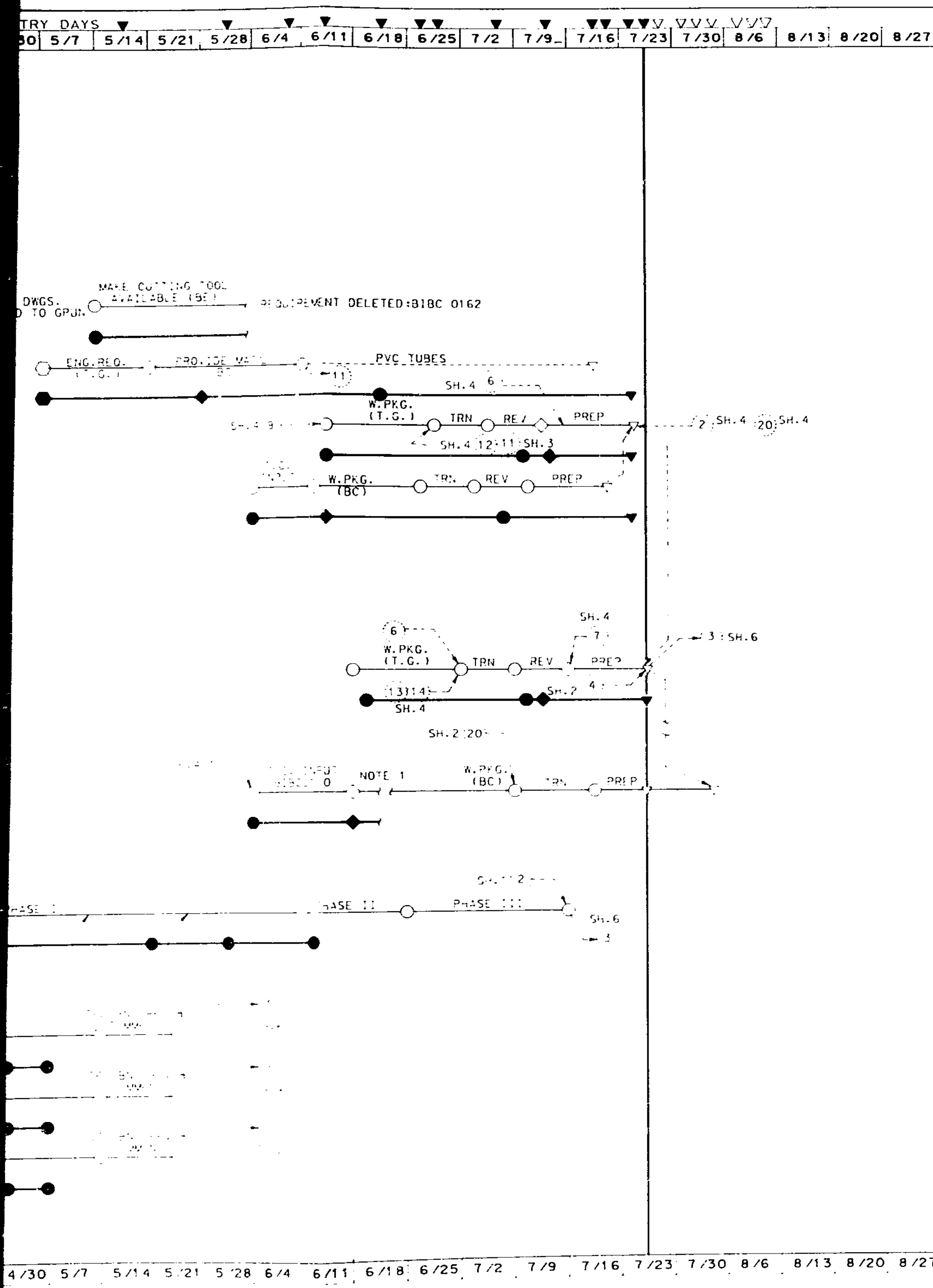
WEEK ENDING — ENTRY DAYS

4/2	4/9	4/16	4/23	4/30	5/7	5/14	5/21	5/28	6/4	6/11	6/18	6/25	7/2



4/2	4/9	4/16	4/23	4/30	5/7	5/14	5/21	5/28	6/4	6/11	6/18	6/25	7/2

WEEK ENDING



LEGEND:

- START OR FINISH OF WORK ACTIVITY
- ACTIVITY COMPLETED
- ENGINEERING START
- SAFETY ASSESSMENT/EVALUATION
- CONSTRUCTION START
- ENTRY
- RESTRAINT INDICATES THE DEPENDENCY OF ONE WORK ACTIVITY ON ANOTHER
- 16 RESTRAINT FROM ANOTHER ACTIVITY TO LINE 16
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PHASE II	-PORC. REV'W. & APPRVL. SUBMIT TO NRC
PHASE III	-NRC R & A, GPU SIGN OFF

NOTE 1: RIGGING REQUIREMENTS TO B DETERMINED FOLLOWING RAD SURVEY OF LEADSCREW PIECES.

REV. NO.	DATE	REMARKS	BY	LSL ENGR	PROJ ENGR
5	7/26/82	REVISION & PROGRESS	MDS	LLG	RLC

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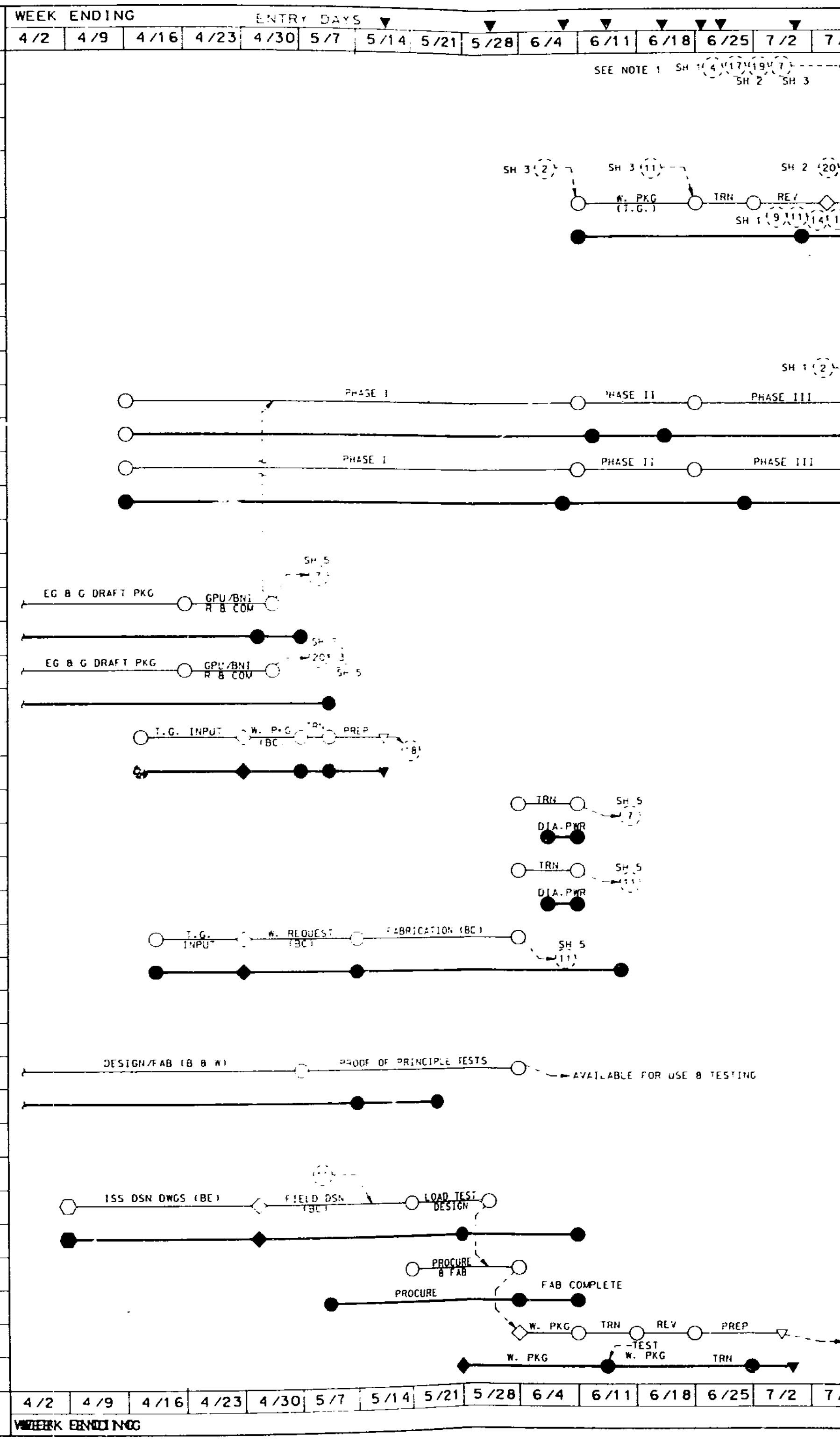
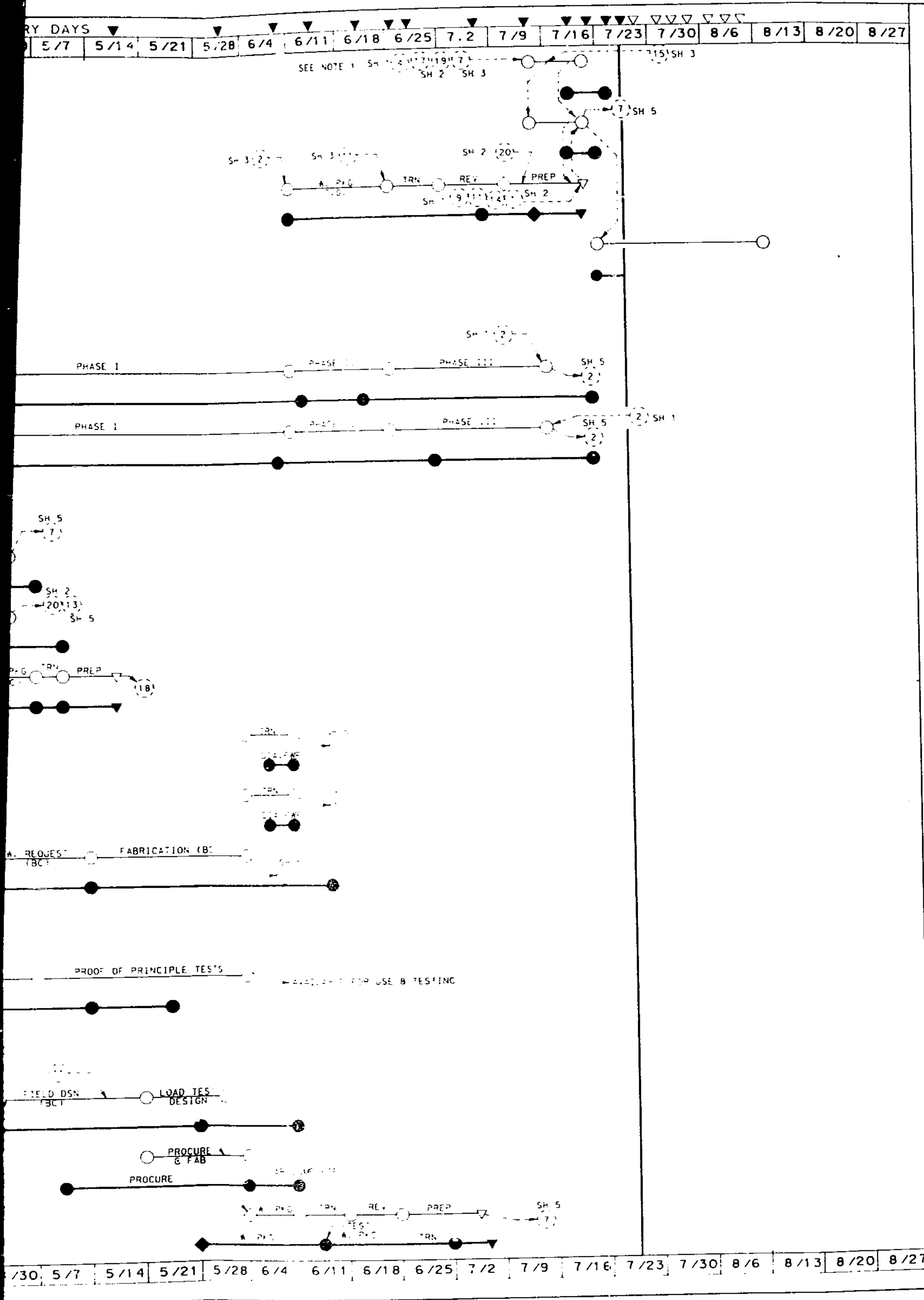
Figure 1-7. Leadscrew Quick Look. (Continued)

JOB NO	SCHEDULE NO	SHEET	REV
13587	S-1	5 OF 7	5

	SCHEDULE DESCRIPTION	LINE NO.	RESP.
LOWER PRIMARY SYSTEM	DEPRESSURIZE RCS	1	GPUN
	LOWER PRIMARY SYSTEM TO EL.335'	2	GPUN
☆	VENT SINGLE CRDM, OBTAIN GAS & LIQUID SAMPLE	3	T.G.
	MAINTAIN RCS LEVEL	4	GPUN
UNCOUPLE/REMOVE LEADSCREW	PROCEDURES:	5	
	2104-10.3, CRDM UNCOUPLING PROCEDURE	6	BL
	2104-10.4, LEADSCREW REMOVAL PROCEDURE	7	BL
	SAMPLE PACKAGES:	8	
	CRDM UNCOUPLING DATA (4,2)	9	EG&G
	LEADSCREW SAMPLES (4,7)	10	EG&G
☆	MEASURE MISSILE SHLD GAP	11	BC
	MOCKUP TRAINING FOR L.S. UNCOUPLING/HOISTING	12	T.G.
	MOCKUP TRAINING FOR L.S. CUTTING	13	T.G.
	MOCKUP FOR L.S. RIGGING (SERVICE STRUCTURE)	14	T.G.
	TOOLS:	15	
	DESIGN & FABRICATION	16	B&W
	HOIST PROVISION:	17	
	ENGINEERING	18	BC
	PROCUREMENT / PRE FAB	19	GPU/BC
☆	INSTALLATION	20	BC





LEGEND:

- START OR FINISH OF WORK ACTIVITY
- ACTIVITY COMPLETED
- ENGINEERING START
- SAFETY ASSESSMENT/EVALUATION
- CONSTRUCTION START
- ENTRY
- RESTRAINT INDICATES THE DEPENDENCY OF ONE WORK ACTIVITY ON ANOTHER
- RESTRAINT FROM ANOTHER ACTIVITY TO LINE 16
- RESTRAINT FROM LINE 16 TO ANOTHER ACTIVITY
- INDICATES REDUCED WORK EFFORT
- STATUS DATE LINE

ABBREVIATIONS

BC	-BECHTEL NORTHERN CONSTRUCTION
BE	-BECHTEL NORTHERN ENGINEERING
BL	-BECHTEL NORTHERN LIAISON ENGINEERING
B&W	BABCOCK & WILCOX
GPUN	-GENERAL PUBLIC UTILITIES NUCLEAR
T.G.	-LEADSCREW QUICK LOOK TASK GROUP
W.PKG.	-WORK PACKAGE
ISS.	-ISSUE
REQ.	-REQUIREMENTS
TRN.	-TRAIN
REV.	-REVISE
PREP.	-PREPARATIONS
R	-REVIEW
A	-APPROVE
☆	-IN-CONTAINMENT ACTIVITY
PHASE I	-SUBMIT TO PORC.
PHASE II	-PORC. REV'W. & APPRVL. SUBMIT TO NRC
PHASE III	-NRC R & A. GPU SIGN OFF

NOTES:

1. PARTIAL DEPRESSURIZATION OF THE RCS WILL PRECEDE VENTING OF HIGH POINTS.

REV NO	DATE	REMARKS	BY	LSL ENGR	PROJ ENGR
5	7/26/82	REVISION & PROGRESS			

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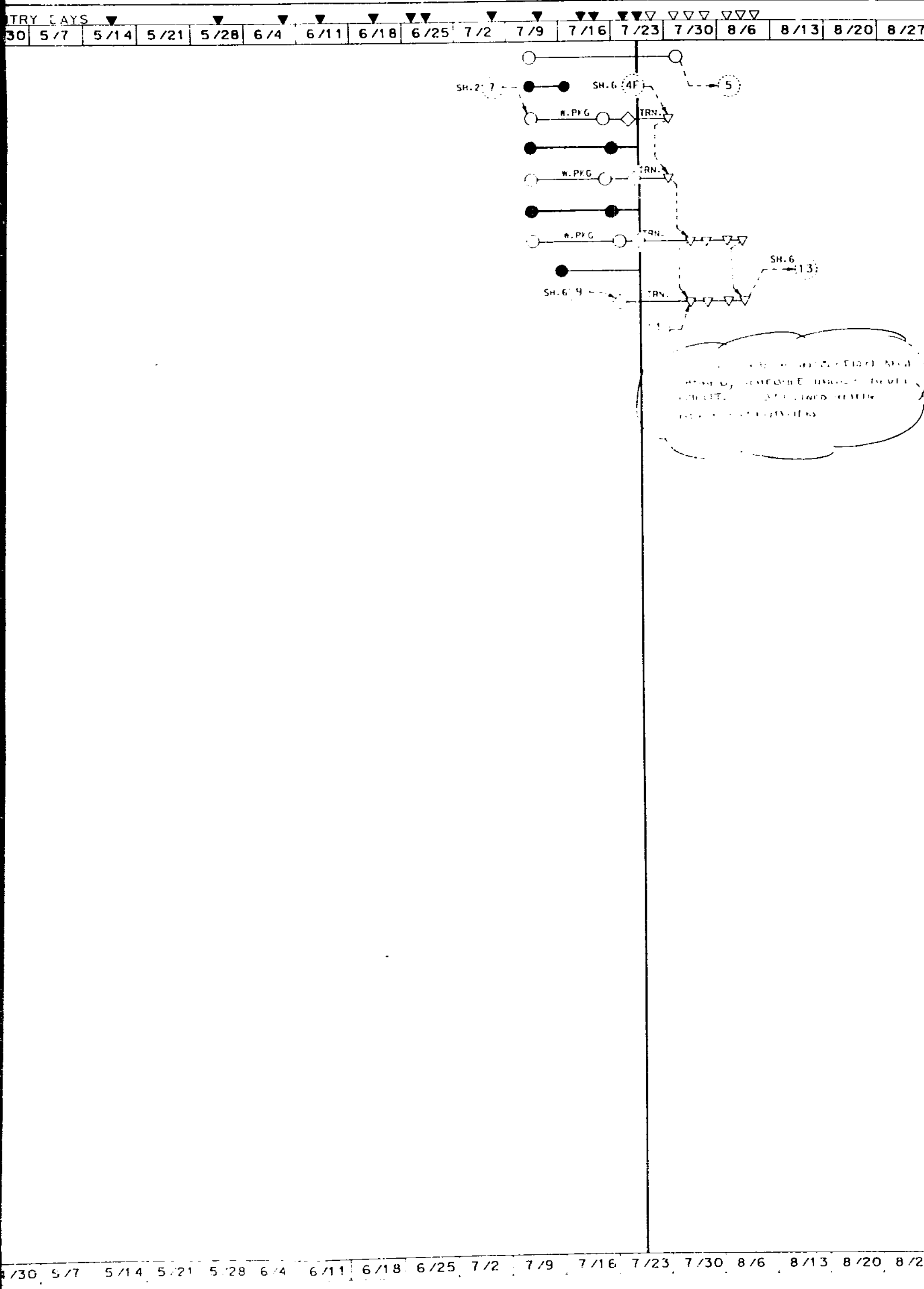
THREE MILE ISLAND-UNIT 2

Figure 1-7. Leadscrew Quick Look. (Continued)

JOB NO	SCHEDULE NO	SHEET	REV
13587	S-1	4 OF 7	5

SCHEDULE DESCRIPTION	LINE NO.	RESP.	WEEK ENDING / ENTRY DAYS
			4/2 · 4/9 · 4/16 · 4/23 · 4/30 · 5/7 · 5/14 · 5/21 · 5/28 · 6/4 · 6/11 · 6/18 · 6/25 · 7/2 · 7/
PROVIDE CLOSURE MATERIALS	1	T.G.	SH. 2 7
REMOVE CRDM P.I. CABLES	2	T.G.	
REMOVE CRDM LOCKWIRE. PREP CLOSURE FOR REMOVAL	3	T.G.	
REMOVE CLOSURE. UNCOUPLE	4	T.G.	
REINSTALL CLOSURE	5	T.G.	
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
	16		
	17		
	18		
	19		
	20		
			4/2 · 4/9 · 4/16 · 4/23 · 4/30 · 5/7 · 5/14 · 5/21 · 5/28 · 6/4 · 6/11 · 6/18 · 6/25 · 7/2 · 7/
			WEEK ENDING



LEGEND:

- START OR FINISH OF WORK ACTIVITY
- ACTIVITY COMPLETED
- ENGINEERING START
- TECHNICAL EVALUATION REPORT
- PLACE PO/CONTRACT/BID
- CONSTRUCTION START
- MILESTONE
- RESTRAINT INDICATES THE DEPENDENCY OF ONE WORK ACTIVITY ON ANOTHER
- (16) RESTRAINT FROM ANOTHER ACTIVITY TO LINE 16
- (16) RESTRAINT FROM LINE 16 TO ANOTHER ACTIVITY
- INDICATES REDUCED WORK EFFORT
- STATUS DATE LINE

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REV.	-REVISE
PREP.	-PREPARATIONS
R	-REVIEW
A	-APPROVE
☆	-IN-CONTAINMENT ACTIVITY
PHASE-I	SUBMIT TO PORC.
PHASE-II	PORC. REV'W. & APPRVL. SUBMIT TO NRC
PHASE-III	NRC R & A. GPU SIGN OFF

REV NO	DATE	REMARKS	BY	LSL ENGR	PROJ ENGR
5	7/26/82	REVISION & PROGRESS	NDS	CCK	RLR

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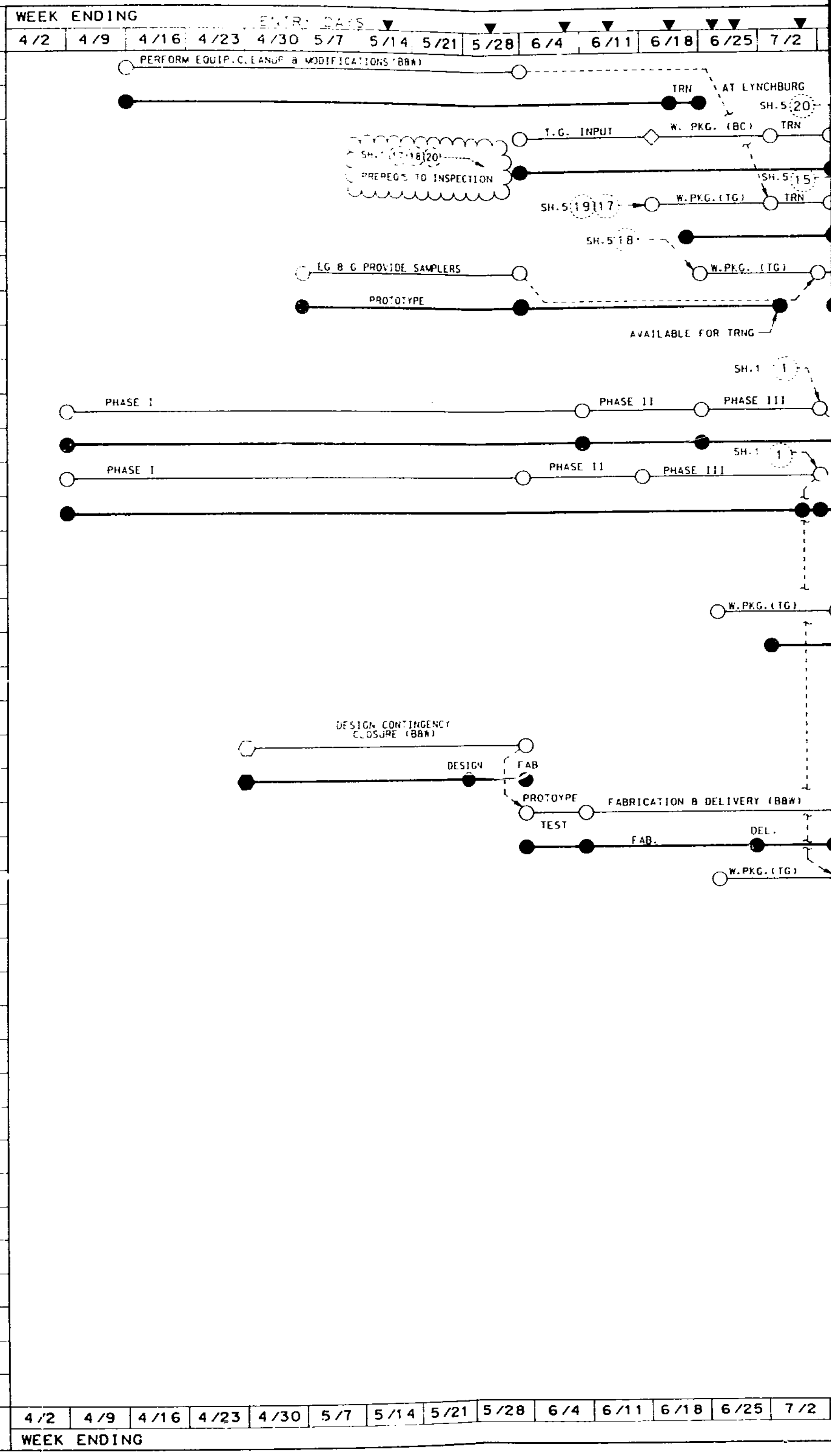
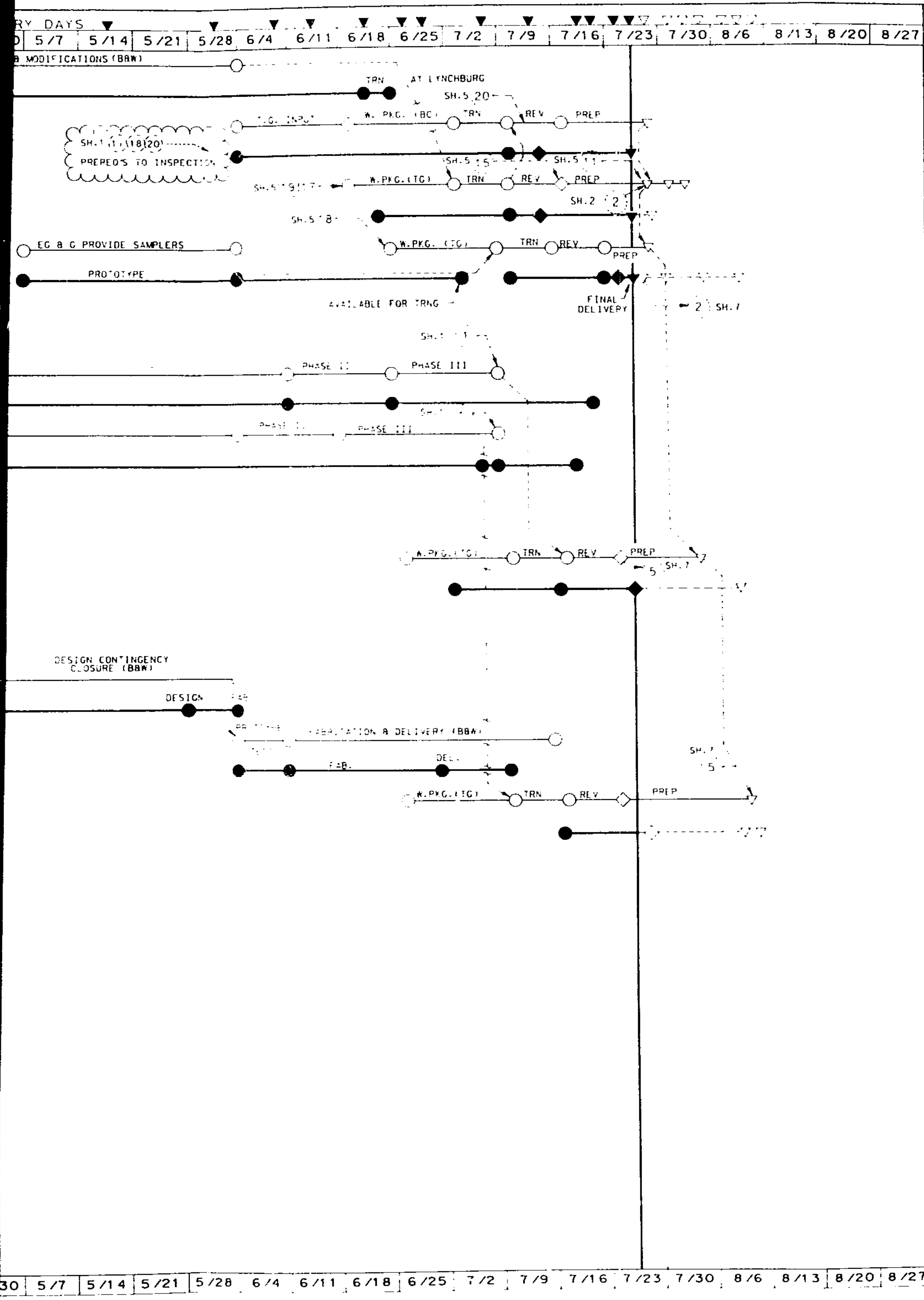
METROPOLITAN EDISON
THREE MILE ISLAND-UNIT 2

Figure 1-7. Leadscrew Quick Look. (Continued)

JOB NO	SCHEDULE NO	SHEET	REV
13587	S-1	7 OF 7	5

	SCHEDULE DESCRIPTION	LINE NO.	RESP.
IN - VESSEL INSPECTION	PROVIDE INSPECTION EQUIPMENT	1	B&W
	☆ STAGE INSPECTION EQUIPMENT. HOOKUP	2	TG5
	☆ PERFORM VIDEO INSPECTION	3	TG
	☆ OBTAIN RCS LIQUID SAMPLE	4	TG
POST-INSPECTION ACTIVITIES	PROCEDURES:	5	
	2104-10.6.CRDM CLOSURE PROCEDURE	6	BL
	2104-10.8.PRIMARY PLANT FINAL OPERATING PROCEDURE	7	GPUN
	CRDM CLOSURE:	8	
	☆ INSTALL NORMAL CLOSURE DEVICE	9	TG
	CLOSURE FOR STUCK L.S.	10	
	ENGINEERING	11	B&W
	FABRICATION	12	B&W
	☆ REFILL RCS.VENT HIGH POINTS	13	TG
		14	
		15	
		16	
		17	
		18	
		19	
		20	





LEGEND:

- START OR FINISH OF WORK ACTIVITY
- ACTIVITY COMPLETED
- ENGINEERING START
- SAFETY ASSESSMENT/EVALUATION
- CONSTRUCTION START
- ENTRY
- RESTRAINT INDICATES THE DEPENDENCY OF ONE WORK ACTIVITY ON ANOTHER
- 16 RESTRAINT FROM ANOTHER ACTIVITY TO LINE 16
- 16 RESTRAINT FROM LINE 16 TO ANOTHER ACTIVITY
- INDICATES REDUCED WORK EFFORT
- STATUS DATE LINE

ABBREVIATIONS

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A	-APPROVE
☆	-IN-CONTAINMENT ACTIVITY
PHASE I	-SUBMIT TO PORC.
PHASE II	-PORC. REV'W. & APPRVL. SUBMIT TO NRC
PHASE III	-NRC R & A, GPU SIGN OFF

REV NO	DATE	REMARKS	BY	LSL ENGR	PROJ ENGR
5	7/26/82	REVISION & PROGRESS	NDS	RLR	RLR

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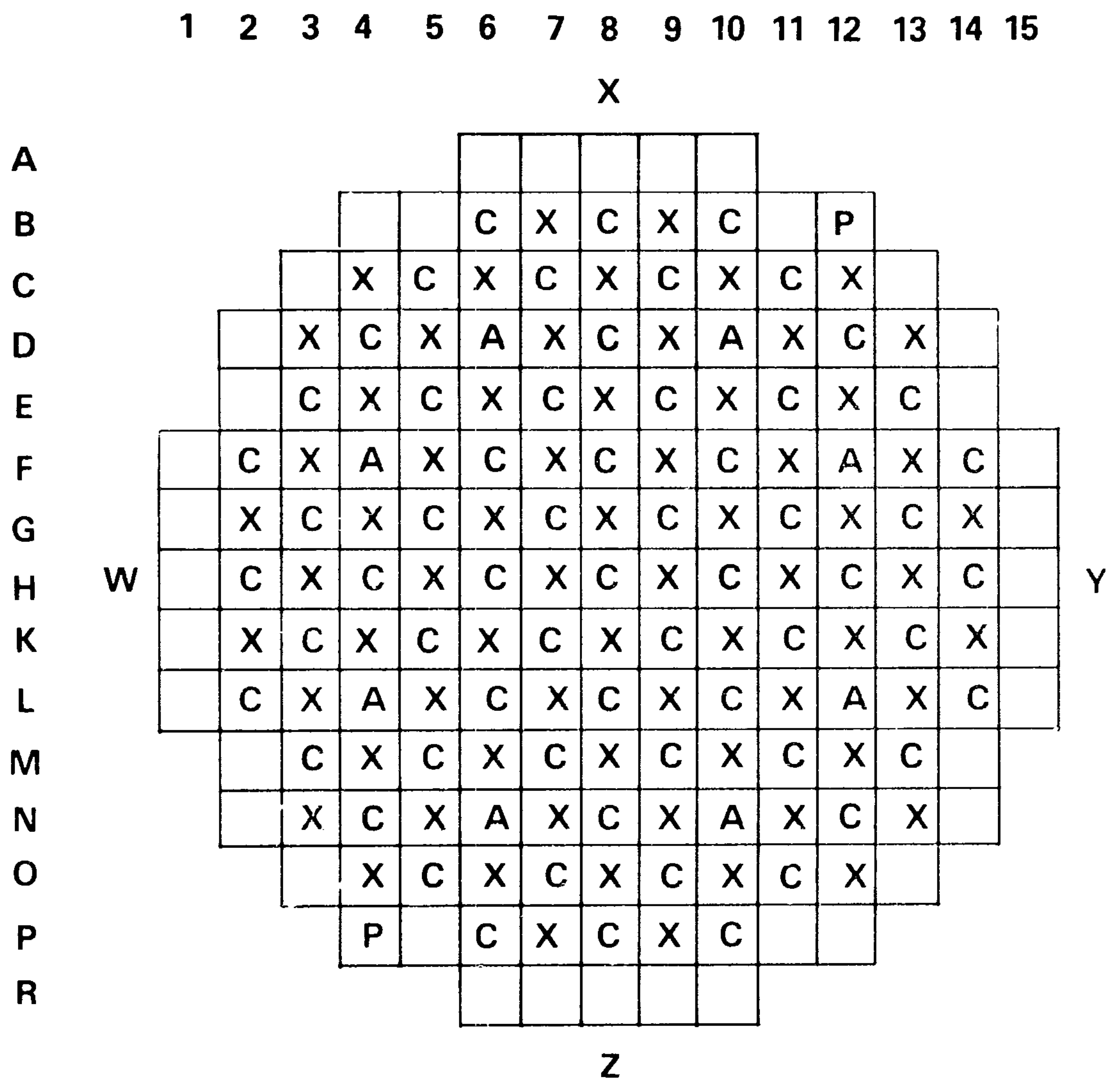
METROPOLITAN EDISON
THREE MILE ISLAND-UNIT 2

Figure 1-7. Leadscrew Quick Look. (Continued)

JOB NO	SCHEDULE NO	SHEET	REV
13587	S-1	6 OF 7	5



CONTAINS NO CONTROL COMPONENT

C CONTROL ROD ASSEMBLIES

A AXIAL POWER SHAPING ROD ASSEMBLIES

X BURNABLE POISON ROD ASSEMBLIES

P PRIMARY NEUTRON SOURCES

Figure 1-8. Locations of core control elements.

2. METHODS AND APPROACH

2.1 Supporting Studies and Licensing Documents

2.1.1 Criticality Analysis

The Babcock and Wilcox (B&W) report, "Methods and Procedures of Analysis for TMI-2 Criticality Calculations to Support Recovery Activities Through Head Removal,"[1] was prepared to document criticality safety results obtained from the analyses of various geometrical configurations of moderator, reflector, and fuel. These configurations represented both credible and hypothetical fuel arrangements which could exist or could occur in the reactor coolant system (RCS) as a result of activities relating to through-head inspections and reactor vessel closure head removal.

Examples of some of the proposed activities that could produce fuel rearrangements or otherwise affect the subcriticality of the fuel system were:

- Insertion of the axial power shaping rods (APSRs)
- CRDM uncoupling attempts
- Insertion of inspection and sampling equipment into the reactor vessel through penetrations in the head
- Removal of the reactor vessel head

The purpose of the analytical assessment was to demonstrate that during all of these proposed activities, the TMI-2 reactor would be maintained in a safe shutdown condition considering any credible fuel configuration and considering the effects of postulated fuel disturbances and changes in physical conditions. The specific objectives were:

- To evaluate the reactivity of postulated TMI-2 core configurations.

- To evaluate the reactivity of potential fuel accumulations outside the core region.

- To evaluate the potential reactivity effects of various perturbations resulting from the proposed activities.

- To verify that a boron concentration of 3500 ppm would maintain an adequate margin of subcriticality under all postulated credible conditions.

2.1.2 Decay Heat Removal Analysis

The B&W report, "TMI-2 Decay Heat Removal Analysis,"[2] assessed the thermal status of the core and predicted the thermal response of the system to partial draindown of the RCS.

The criterion used in this study was based on TMI-2 operating procedures for natural cooling, which restrict the average incore coolant temperature to less than 170 F. This criterion was adopted as a conservative value for the recovery program to maintain a positive margin to boiling.

The analyses were directed at evaluating two concerns: (a) system effects of lowering the RCS level, and (b) coolant temperatures with lowered water level. In order to perform this evaluation it was first necessary to assess the current method of heat removal, thereby establishing a basis for the predicted response to a lowered water level. This analysis was based on an RCS water level 1 foot above the plenum cover (elevation of the plenum cover is 322'-6").

The results of the analysis showed that:

1. There appeared to be some migration of water through the loops, with the result that the heat rejection mode prior to lowering the RCS water level included system components beyond the reactor vessel and head.

2. Lowering the reactor water level and isolating the system components might cause an increase in reactor water equilibrium temperature.

3. The reactor temperature increase to achieve equilibrium conditions was dependent upon the heat sink temperature (i.e., containment temperature).

4. The anticipated heatup rate, after draindown to elevation 323'-6", was expected to be less than 5 F per day in mid-1982 at 100 F containment temperature. Thus, ample time was available to monitor the actual heatup rate and determine if enhanced heat removal would be required.

5. The enhanced heat removal, if required, would have been accommodated by existing systems such as:

   - Feed and bleed through letdown and the standby pressure control system

   - Refill of the RCS

   - Mini-decay heat removal system

2.1.3 Gaseous Release Analysis

Prior to venting the RCS, analyses were performed to determine the quantities of hydrogen and krypton-85 (Kr-85) in the RCS which were available for release to the containment and the environment.

The consequences of releasing the Kr-85 first to the containment and then to the environment might have resulted in an increase in radiological environmental releases due to the release of Kr-85 from the RCS. This potential release was evaluated using the following assumptions: (a) the entire RCS inventory of dissolved and free Kr-85 was released in 1 hour into the containment purge exhaust, (b) the Kr-85 was diluted by a plant vent stack flow rate of 100,000 cfm, and (c) no credit was taken for Kr-85 dilution in the containment.

The total quantity of Kr-85 in the RCS available for release was calculated to be approximately 30 Ci. Using this result and the guidance provided in Regulatory Guide 1.109, the increased dose at the nearest residence was calculated to be 2.1×10^{-5} mrem (total body dose). The release rate of Kr-85 from the containment resulting from the Quick Look was calculated to be well within the limits of the TMI-2 Technical Specifications.

In evaluating the consequences of releasing the hydrogen to the containment, the gas vented from the RCS was assumed to be 100 percent hydrogen. It was discharged into a dilution flow stream with a minimum dilution factor of 25. This prevented the discharge of a flammable hydrogen mixture to the containment atmosphere. The discharge was directed away from personnel areas.

During leadscrew withdrawal and cutting operations the RCS was at atmospheric pressure. The RCS surface area exposed to the atmosphere via the open CRDM motor tube was less than 4 square inches. Hydrogen offgassing via this small surface area had been calculated to be approximately 0.03 scfm. Such a low release rate did not present a hydrogen flammability hazard when vented directly to the containment.

2.1.4 Safety Evaluation

The report entitled "Safety Evaluation for Insertion of a Camera into the Reactor Vessel Through a Leadscrew Opening"[3] (Quick Look Safety Evaluation) was prepared in accordance with GPUN Procedure EP-016, Revision 1. It evaluated the following concerns:

- o The potential releases of radioactivity to the containment
- o The potential releases of radioactivity to the environment
- o The effects on reactivity as a result of potential disturbances of the fuel
- o The effects of RCS draindown on decay heat removal capabilities
- o The potential for inadvertent boron dilution
- o The release of gases from the RCS to the containment atmosphere
- o Occupational exposure
- o The effects on RCS chemistry as a result of breaching the reactor coolant pressure boundary (RCPB)

Based on the analyses described in Sections 2.1.1, 2.1.2, and 2.1.3, and in the Quick Look Safety Evaluation, it was shown that the activities associated with the Quick Look would not have constituted an unreviewed safety question and that these activities could have been performed within existing TMI-2 Technical Specifications and presented no undue risk to the public health and safety.

2.2 Leadscrew Uncoupling Plan and Tool Development

To gain access to the reactor vessel for the Quick Look camera, a leadscrew uncoupling and removal plan was established, and the tooling required for this plan was developed.

2.2.1 Leadscrew Uncoupling and Removal Plan

The basic approach for uncoupling and removing a leadscrew was to first uncouple a central leadscrew using either of two normal uncoupling techniques. The first technique to be used was the leadscrew nut method of uncoupling; if this was unsuccessful, the torque tube method of uncoupling would be attempted. After successful uncoupling, the leadscrew was to be lifted to the "parked" position. Leadscrew cutting tools were to be staged next. The 24-foot long leadscrew had to be cut to remove it, since the clearance under the missile shields is only about 20 feet. The leadscrew was then to be lifted out of the CRDM and cut.

The detailed leadscrew uncoupling plan developed is illustrated in Figure 2-1.

2.2.2 Tool Development

To perform leadscrew uncoupling and removal and the subsequent camera inspection with the missile shields installed, existing tools had to be modified and new tools developed.

The following criteria were established for the Quick Look tool development effort:

- Tools were to be capable of being manually transported through the personnel air lock and to the service structure platform.

Since both air lock doors were permitted to be open simultaneously, the personnel air lock would not have been a constraint on tool design.

- Leadscrew uncoupling and parking for the Quick Look were to access CRDM shim safety drive locations in rows 7, 8, and 9.

- Leadscrew up/down movement and/or spider disengagement from plenum brazement C-tubes was acceptable prior to uncoupling.

- Core disturbances were to be minimized.

- Leadscrews were rotated 40 to 55 degrees and there was to be indication of load reduction prior to attempting leadscrew parking.

- An unsuccessful uncoupling would end with refurbishment and installation of the existing motor tube closure.

- The potential existed that, without special radiation protection provisions, it might not have been feasible to leave a highly contaminated leadscrew in the parked position while other necessary operations were performed on the service structure. In that event, the leadscrew would be lowered until preparations for removal and cutting were completed.

- A successful uncoupling would end with the leadscrew parked in the top of the drive using a leadscrew parking tool (C-washer).

- Specific design functional criteria were established for all new or modified tools (see Appendix A for design functional criteria).

The following new and modified tools were developed to perform leadscrew uncoupling, removal, and camera inspection operations (see Appendix A for new and modified tool drawings):

- Modified lightweight leadscrew lifting tool - This tool is similar to the existing Diamond Power Specialty Company (DPSC) lightweight leadscrew lifting tool. The tool was modified to reduce the overall length, enabling manual operation under the TMI-2 missile shields. The tool also accommodated the use of a leadscrew nut runner.

- Nut runner - This tool is similar to the nut runner sleeve on the existing DPSC leadscrew installation/removal tool, and operates with the modified lightweight leadscrew lifting tool.

- Band saw - This is a portable band saw, de igned to operate with the worker a distance of 3 feet from the leadscrew.

- Band saw mounting fixture - This is a device to facilitate mechanical support of the band saw during leadscrew removal and cutting operations.

- Leadscrew lifting and cutting clamps - These clamps were designed to lift the lower portion of a leadscrew after it had been cut and to stabilize the upper portion of the leadscrew during cutting operations.

- Chip deflector - This is a device which provided a positive means of preventing cutting chips from falling into the motor tube.

- Modified jumping jack - This tool is similar to the standard DRSC air-operated jumping jack. The tool was modified for hydraulic operation and to provide load indication. This tool was used with the alternate uncoupling tool.

- Leadscrew closure clamp and support ring - This clamp and support ring were designed to support a cut leadscrew under a closure. The support ring was to be used only as a contingency leadscrew parking tool.

- Motor tube contingency closure - This closure was to be used to secure the RCS if a leadscrew became stuck in the parked position, or if a leadscrew became stuck in a position partially out of a motor tube.

- Video camera - This is the EG&G/TIO Task Order No. 8, Westinghouse Model ETV 1250 camera, modified by removing the camera screen and installing an articulating cable. Included with the camera were a control unit, tape recorder, and TV monitor.

To ensure safe and proper operation, proof-of-principle testing was performed on all new or modified tooling. The criteria for the proof-of-principle testing were:

1. All tools had to be tested against their respective tool instructions. Proper tool operation, performed according to the instructions, had to be verified.

2. The tests performed had to verify all design functional criteria requirements.

3. Equipment and tooling operations had to be tested on mock-ups simulating, to the maximum extent practical, the space constraints at the service structure.

4. The tests performed had to follow and verify the program plan for uncoupling and parking.

5. The tests performed had to demonstrate that tooling and system design had included consideration for "as low as reasonably achievable" (ALARA) criteria (i.e., minimum time to perform operations, maximum personnel distance from radiation sources).

6. The tests had to establish estimated operating times and the in-containment man-hour requirements for each operation to be performed with each piece of equipment.

The following existing tools were also to be used to perform leadscrew uncoupling associated operations: alternate uncoupling tool, leadscrew lifting tool, venting tool, and leadscrew parking tool.

2.3 Plant Modification and Additions

2.3.1 Venting and Draining

To permit opening a CRDM to atmosphere for leadscrew removal, it was necessary to depressurize and lower the RCS water level. To achieve this Quick Look prerequisite, it was necessary to vent the RCS, partially drain it, and provide a nitrogen cover gas to prevent corrosion of the RCS. The various operations/changes required are described below. The venting, draining, and nitrogen cover provisions are shown in Figure 2-2.

The RCS was to be vented to the reactor building environment. An evaluation of the RCS venting operation with respect to hydrogen and Kr-85 concerns was performed. This evaluation is discussed in Section 2.1.3. Based on the evaluation, certain precautions were taken. These were necessary to prevent a source of ignition from being near the discharge point and to minimize occupational exposure from Kr-85 during the venting operating. The precautions taken during initial venting were to connect each RCS vent point to a hose which was routed to a duct on the discharge side of a 1750 cfm blower to provide immediate dilution of the vented gas. The duct was run down inside of the D-rings, thus directing the diluted vent gas away from personnel.

To lower the RCS water level to the Quick Look elevation of 333'-2", about 21,000 gallons of reactor coolant had to be drained. The primary side was drained via the letdown line to reactor coolant bleed holdup tank WDL-T-9C. An average flow rate of 5 gpm was obtained during draining operations. It was not necessary to pressurize the primary side in order to drain it.

A pressure-regulating station was installed in the auxiliary building on the nitrogen supply piping to the reactor building. The station was added since the regulator in the reactor building was presumed faulty. The majority of the nitrogen piping in the reactor building was not used. The piping was isolated at valves NM-V207 and NM-V218. The nitrogen supply line in the reactor building consisted of a hose routed from an existing test connection at elevation 339'-6", upstream of valves NM-V207 and NM-V218, to a piping manifold at elevation [illegible]'-8" on top of the D-ring. The supply line contained a Bullard™ filter upstream of the manifold. From the manifold, separate nitrogen supply hoses were routed to venting/nitrogen blanketing lines at the following RCS locations:

- o Steam generator "A" hot leg
- o Steam generator "B" hot leg
- o Pressurizer

The RCS boundary from the steam generator "B" hot leg venting/nitrogen blanketing line was extended beyond the hose to a double valved piping assembly, from which hose was routed to the aforementioned piping manifold. This extension was made due to high radiation levels at the "B" hot leg, and permitted workers to vent and nitrogen blanket the steam generator "B" hot leg from outside the D-rings.

The general sequence used to venc and drain the RCS follows:

1. The RCS was depressurized to about 30 psig at the top of the hot legs by reducing standby pressure control (SPC) system pressure.

2. Each hot leg and the pressurizer were vented.

3. The SPC system was isolated.

4. RCS pressure was reduced to about 0 psig (or slightly negative) at the top of the hot legs by letting down reactor coolant.

5. A 1-psig nitrogen blanket was added to the hot legs, with an initial nitrogen pressure of 10 psig to clear piping/hose loop seal arrangements of any standing liquid.

6. RCS pressure was reduced to about 0 psig (or slightly negative) in the pressurizer by letting down reactor coolant.

7. A 1-psig nitrogen blanket was added to the pressurizer with an initial nitrogen pressure of 10 psig to clear the piping/hose loop seal arrangement of any standing water.

8. CRDM 8H was vented and sampled.

9. RCS level was reduced to elevation 333'-2" by letting down reactor coolant.

10. Nitrogen pressure was decreased to 0 psig by isolating the RCS from the nitrogen supply system and venting the nitrogen supply lines.

Throughout the Quick Look the water level in the secondary side of the steam generators was maintained at an elevation below that of the RCS water level, as required by Appendix C of Reference 3. This prevented a secondary-to-primary leak, which could have caused a boron dilution event. It also ensured that any accumulation of fuel in the steam generators would remain subcritical while the RCS was drained to the level required for the Quick Look.

The secondary side was drained in two phases. First, the main steam lines were drained. Then a nitrogen blanket was placed on the secondary side via connections on the main steam lines. Final draining of the secondary side to the level required for the Quick Look (the bottom of the main steam nozzles) was through the main feedwater lines.

2.3.2 Water Level Monitoring

To determine when the RCS levels were at the elevations required for venting, CRDM uncoupling, RCS sampling, and video inspection, a highly accurate water level monitoring system was provided. This system consisted of two diverse primary sensing devices: level transmitter RC-LT-100 and level indicator RC-LI-101 located on instrument mount F9 at elevation 284'-6" of the fuel handling building. Both devices, which were connected to the normal decay heat line, were provided with an elevated zero to sense the head of water in the RCS between the centerline of the reactor vessel hot leg nozzle (elevation 315'-6") and the top of the hot leg (elevation 363'-8"). A range of 0 to 600 inches of water was selected to cover this elevation difference.

The transmitter was wired to analog indicator RC-LI-100 on panel SPC-PNL-1 in the fuel handling building, and to digital indicator RC-LI-100A and strip chart recorder RC-LR-100 on panel SPC-PNL-3 in the main control room. The accuracy of this loop was ±5 inches of water and the accuracy of the local indicator was ±6 inches of water.

To ensure that this system was not affected by RCS nitrogen overpressure, a compensating line was installed to the low pressure connections on the transmitter and local indicator from the nitrogen system. This line also served to compensate the level indication for any differential pressure between the fuel handling building and reactor building when the nitrogen was vented in the containment prior to opening the RCS.

2.3.3 Leadscrew Rigging and Handling

The rigging and handling devices described below were used to remove the leadscrew from CRDM 8H, position the leadscrew for cutting, and place the cut leadscrew sections into containers.

A hoist/trolley assembly was installed on reactor pressure vessel (RPV) missile shields R2 and R3, and was used to remove and position the leadscrew. The assembly consisted of a trolley which traversed across the top of the missile shields, a connecting load support penetrating the gap between the missile shields, and a hoist attached to the lower end of the load support below the missile shields. This design limited the hoist to leadscrews in CRDMs in rows seven, eight, and nine. Both the hoist and the trolley were manually operated. The trolley was operated from the east side of the service structure using a rope/pulley control arrangement. The hoist was a hand-operated chain type. The hoist/trolley assembly was rated for a load of 1 ton.

A 500-pound spring scale was used to provide indication of any binding that developed during leadscrew removal from the drive mechanism. The spring scale also provided flexibility in the rigging while manipulating the leadscrew. The spring scale was installed between the chain hoist hook and the leadscrew lifting tool.

The leadscrew was cut into two sections and each section was placed into separate leadscrew storage containers using the hoist/trolley. The containers basically consisted of 4-inch, schedule 40 polyvinyl chloride (PVC) pipe sections with end caps and rope attached to each end of each container for rigging and transfer purposes. Once loaded, both containers were secured to the service structure handrail, and were suspended vertically into the refueling canal for temporary storage.

2.3.4 Communications Systems

Audio communications consisted of two separate systems. The first provided communications for the inspection team and the second established communications between the inspection team and the command center (See Figure 2-3).

The inspection team system was a hard-wired system which permitted the three members of the inspection team (TV control unit operator, technical director, and TV camera manipulator) to converse. Each individual was provided with a headset which was wired to an audio mixer. The audio mixer, in addition to providing talk-around capability, produced a composite audio signal which was wired to the underwater inspection camera videotape recorder (VTR) #1. Thus, a tape was produced which combined the video signal and the real-time conversations of the inspection team.

The system which provided communications between the containment and the command center was a two-way duplex radio system which included the following design features:

- Two antennas (one each for receive and transmit) were located in the containment to provide coverage for the inspection team on the service structure. The receive and transmit antennas were located at elevations 347'-6" and 305'-0", respectively. An additional receive antenna was located at elevation 305'-0". These antennas were wired to the base station in the command center via RG58 coaxial cables through penetration R507. Two additional antennas (receive and transmit) were located in the anteroom to permit checkout of the system prior to entering the containment.

- The signal from the containment was generated by transmitter T24. This transmitter was wired to VTR #1 to transmit the composite audio signal produced by the inspection team system. The signal was received at the base station by receiver R24 via the containment receive antenna.

- From the base station in the command center, the audio signal was fed to VTR #2, speakers in the command center, and speakers in the new command center. The speakers in the new command center supplemented the "VIP" video monitors.

- To allow the command center to talk to the inspection team, transmitter T28 was provided in the base station to transmit, via the transmit antenna, the output from a microphone located in the command center to the R28 receiver in the containment. (The microphone output is also fed to the speakers and VTR described in the previous paragraph.) An R28 receiver was wired to the headset of the inspection team technical director to permit direct communications with the command center.

Video communications inside the containment consisted of the Task No. 8 underwater inspection camera and camera control unit, VTR #1, and a video monitor. The camera control unit, videotape recorder, and video monitor were located on the service structure. The output from the underwater camera was wired to VTR #1 via the camera control unit. The video output of VTR #1 provided the input to the video monitor for the inspection team. The video output from the video monitor was wired to the command center CCTV console via the existing CCTV system (CCTV camera #5 circuit). (Note: VTR #1 is the same VTR that is recording the inspection team's dialogue.)

At the command center, the signal was displayed on the CCTV console and was recorded on VTR #2, which was provided with a dedicated monitor. The signal was also fed to "VIP" video monitors located in the new command center.

2.4 Operator Training

Operator training on the use of the CRDM tools was completed at the Diamond Power Specialty Company facility in Lancaster, Ohio. The training covered the following topics:

- CRDM construction
- CRDM venting
- Leadscrew uncoupling and parking procedure
- Leadscrew removal and cutting procedure
- CRDM contingency closure

The camera inspection team consisted of personnel experienced in this area. Team training included a demonstration of the camera at TMI Unit 1 and training at B&W in Lynchburg, Virginia.

A site mock-up of the service structure was constructed and was available for training on July 2, 1982. The mock-up was full scale and included a CRDM, the hoisting mechanism, and the space constraints presented by the missile shields. The mock-up was used for walkthroughs of all planned in-containment activities. Work packages were modified as activities were fine-tuned as a result of the walk-throughs.

A dress rehearsal was conducted, reviewed, and approved by GPUN Radiological Engineering and the NRC. The dress rehearsal included the work packages for leadscrew uncoupling and parking, and leadscrew removal and cutting.

2.5 Procedure Preparation

A total of 11 procedures were written and six procedures revised to prepare and maintain the primary system in the condition required for the Quick Look.

An additional five procedures were written to cover the Quick Look itself. These procedures and a brief description of the subject covered follow:

- o 2104-10.3 The CRDM Uncoupling Procedure provided instructions for the normal and alternate methods to uncouple and park the designated leadscrew.

- o 2104-10.4 The Leadscrew Removal Procedure provided instructions for the method used to remove and cut a parked leadscrew.

- o 2104-10.5 The Unit II Core Camera Inspection Procedure defined the equipment to be used and the portions of the reactor internals to be inspected during the camera inspection.

- o 2104-10.6 The CRDM Closure Procedure provided instructions to remove or install the CRDM normal closure and to install or remove a contingency closure.

- o 2104-10.7 The CRDM and Sample Handling Procedure provided instructions for obtaining a CRDM vent gas sample and a core water sample.

A listing of the procedures used to support the Quick Look is included in Table 2-1.

TABLE 2-1. PROCEDURE WORK SUPPORTING QUICK LOOK

I. NEW PROCEDURES GENERATED

Operating Procedures

2104-10.0	Sequencing and Administration Document
2104-10.1	Secondary Plant Procedure
2104-10.2	Primary Plant Procedure
2104-10.3	CRDM Uncoupling Procedure
2104-10.4	Leadscrew Removal Procedure
2104-10.5	Unit II Core Camera Inspection Procedure
2104-10.6	CRDM Closure Procedure
2104-10.7	CRDM and Sample Handling Procedure
2104-10.8	Primary Plant Final Operating Procedure

Emergency Procedures

2202-10.1	Changing RCS Water Level Beyond Normal Span for CRDM Camera Inspection
2202-10.2	Changing OTSG Water Level Beyond Normal Span for CRDM Camera Inspection
2202-5.5	Loss of RCS Level Indication

Miscellaneous Procedures

4000-ADM-3240.1	Access to Work in the Containment Building
SOP	Processing Thru Epicor II from CDI
SOP	Draining, and Venting Core Flood Tanks
SOP	Post Accident Check of Portions of the N_2 System Inside Reactor Building

II. EXISTING PROCEDURES REVIEWED AND REVISED AS NECESSARY

Operating Procedures

2104-1.10	Nitrogen for Nuclear and Radwaste System
2106-2.4	Feedwater

TABLE 2-1. (Continued)

Emergency Procedures	
2202-4.18	RCS Leak and Small Break LOCA
2202-5.2	Loss of RCS Pressure Indication
2202-1.2	Unanticipated Criticality
2202-2.6	OTSG Tube Rupture

In support of Quick Look tasks subsequent to the initial inspection, several Temporary Change Notices (TCNs) to the procedures were required. These changes included:

1. Revised technique for obtaining RCS liquid samples
2. Additional in-vessel video inspections
3. Core probing
4. Installation of in-vessel acoustical monitor
5. CRDM uncoupling

In addition, two Special Operating Procedures (SOPs) were written to measure the gas buildup in the reactor vessel and to sample the gas from the RCS system high points:

1. SOP-R-2-82-53 Gas Sampling Core Location H8
2. SOP-R-2-82-56 RCS High Point Vents Gas Sampling

2.6 Radiological Considerations

2.6.1 Radiological Predictions

2.6.1.1 Man-Rem Prediction. Approximately 50 to 150 man-rem of exposure were estimated for the performance of the Quick Look. These numbers were based on the Quick Look requiring an estimated 300 man-hours in radiation fields of 0.15 to 30 rem/hour.

2.6.1.2 Dose Rate from Leadscrew. To estimate the dose rate from the removed leadscrew, two approachs were taken. The first approach was to relate the change in gamma dose rate outside the CRDM to the gamma dose rate from the leadscrew once it was removed. The second approach attempted to establish an upper bound for the gamma dose rate from the removed leadscrew by assuming worst-case plateout conditions and physical restrictions. Specific assumptions and results for each approach are given below.

2.6.1.2.1 Prediction of Leadscrew Activity by Dose Rate Measurements--The background radiation was established at a specified position outside the CRDM motor tube prior to parking the leadscrew. The detector position chosen was sufficiently distant from the inserted leadscrew that the leadscrew surface activity had minimal effect on the measured background level. The leadscrew was then moved from the fully inserted position to the parked position. The change in background radiation level at the point of measurement was then directly attributable to the parked leadscrew.

An analysis was performed to determine the shielding effectiveness of the CRDM motor tube and torque tube. It was assumed that Cs-137 was the source with a gamma energy of 0.661 MeV. The result of the analysis was:

Gamma dose rate for leadscrew removed from the CRDM (detector at same distance from leadscrew as when located outside CRDM motor tube)	= 1.25 x	(increase in gamma dose rate due to parking the leadscrew)

The effect of different isotopes with different gamma energies on the above relationship is:

- o For higher energies the relationship is conservative (i.e., over-predicts dose rate)

- o For lower energies the relationship is non-conservative (i.e., under-predicts dose rate)

2.6.1.2.2 Prediction of Leadscrew Activity by Estimation of Plateout-- To provide a "feel" for what could be expected, it was necessary to perform a calculation which scoped a broad range of possible source activities. The physical quantity of material required to attain the given level of activity and its corresponding dose rate was of particular interest. This physical quantity was used to determine a realistic upper bound for the dose rate from the leadscrew.

To perform the analysis, several simplifying assumptions were made. The major assumptions were:

1. Source could be modeled as a line source 10 feet long.

2. No credit was taken for the leadscrew acting as a shielding material for the activity on the backside of the leadscrew.

3. The radiation source was Cs-137. The source strength (Ci/cm^3) was based on the initial core shutdown inventory decayed to July 1982, divided by the total volume of the fuel. The density of the material on the leadscrew was assumed to be the same as that of fuel prior to the accident (i.e., $\cong$10.15 gm/cm^3).

4. Thickness of source on leadscrew was assumed to be $\cong$1/16 of an inch.

The overall effect of the given assumptions produced conservative results. Nevertheless, the results provided a "feel" for the magnitude of the dose rate from a removed leadscrew.

The results of the analysis predicted a conservative upper bound of ≅ 46 rem/hour at 1 foot from the leadscrew. In addition to the upper bound gamma dose rate, a more realistic gamma dose rate range of 0.5 to 10 rem/hr at 1 foot was estimated. This was done using the same model but a more realistic plate-out source on the leadscrew.

2.6.2 ALARA Provisions

ALARA provisions were implemented in procedures and tool design for the Quick Look. Provisions for ALARA are summarized below.

2.6.2.1 Procedures.

1. Attempt to unthread leadscrew nut first.

   By first attempting to rotate the leadscrew nut, the operator obtained an early indication of whether the leadscrew could be removed. If the leadscrew nut was damaged and could not be unthreaded, the leadscrew could not be removed from the drive even though it might be uncoupled and parke:. Because leadscrew removal was a key prerequisite to the Quick Look, early determination of nut functionality would reduce the man-rem expended on damaged drive locations.

2. Leave the torque taker in a lowered position unless raising is recessary.

If the leadscrew could be lowered 3/8 inch after unthreading the leadscrew nut, the leadscrew could be uncoupled, parked, and removed without raising the torque taker. In normal operating plants, the torque taker is a significant radiation source because its magnet tends to collect radioactive crud.

3. Monitor the uncoupling operations closely for indications of interference.

   Critical steps (e.g., leadscrew lifting and removal) were closely monitored in an attempt to avoid jamming a leadscrew inside the drive. If increased load indications were noted during leadscrew withdrawal, operations would be terminated at that drive location and uncoupling and removal operations would proceed to the next sequential drive location. This action would avoid, to the extent practical, the need for invoking contingency closure installation operations.

4. Provide for a leadscrew lowering contingency.

   While the leadscrew was being lifted and parked, the radiation level was monitored. If the levels rose above a predetermined limit, the leadscrew could be lowered back into the drive until removal and cutting equipment was set up.

5. Disconnect position indicator (PI) cables.

The PI cables were disconnected from the PIs and removed from the service structure to reduce radiation exposures from the cables and to improve worker access, as a prerequisite to CRDM leadscrew uncoupling and removal operations.

6. Install platforms.

Platforms to facilitate personnel access and equipment laydown were installed.

7. Provide borated water.

Borated flush water was provided to flush contaminated equipment if necessary.

8. Provide an electrically driven hydraulic pump.

The electrically driven hydraulic pump was used with the modified jumping jack for leadscrew uncoupling activities. A manual hydraulic pump was used for removing the leadscrews for the camera inspections. The electrically driven pump reduced the time required for leadscrew uncoupling.

2.6.2.2 Tool Design.

1. Long-handled clamp

   Because the leadscrew could be a source of high radiation levels, the leadscrew clamp was designed to be tightened by an operator located 3 feet away from the leadscrew.

2. Saw stand

   The band saw cutting fixture was designed for quick installation (i.e., gravity mount onto adjacent motor tubes), quick saw changeout (i.e., saw fixed to mounting plate; assembly could have been changed out in a matter of seconds), and quick blade changeout (i.e., if a blade broke, the second saw and mounting plate assembly could have been installed and the damaged blade replaced in a reduced radiation exposure area). In addition, the band saw had a 5-foot T-handle which allowed the operator to stand as far as 6 feet away from the leadscrew during cutting operations.

3. Equipment maneuverability

   All tools were designed to minimize the amount of in-containment assembly and material transport problems. The heaviest piece of equipment was the band saw support base (weight-30 lbs.), which was easily carried by one man. There were two long-handled tools (approximately 14 feet long); however, the two tools together were less than 30 pounds.

4. Mock-up testing

   Mock-up testing of tool designs included the restraints and restrictions imposed by contamination control equipment, e.g., amount of anti-contamination gear worn, types of gloves, and types and sizes of contamination control enclosures.

5. Chip collector

   Plastic sleeving and a chip collector were provided for contamination control during leadscrew cutting operations.

6. Beta shields

   Beta shields were provided to shield against beta radiation from the leadscrew during leadscrew cutting operations and while transporting the leadscrew to the disposal container.

2.6.3 Operational Radiological Controls

Early in the development of the procedures for the Quick Look, it was decided that detailed radiological control measures would be more appropriately included in the work packages than the procedures. Generally, specific instructions were written into the work packages at points where the potential existed for significant changes in the radiological conditions. At these points the radiological controls technician monitored radiation levels and reported to the command center. Appropriate stay times or instructions were written into the work packages based on anticipated radiological conditions. This was done to allow flexibility in allowing work to continue if significant changes in radiation levels were encountered.

Initial surveys were taken on the head service structure prior to initiating a work package; stay times for the job were based on this survey. If the general area gamma exposure rates exceeded 1 R/hour during the execution of the work package, the team was to secure the job, since the performance of the work as planned would have resulted in personnel exceeding their authorized exposure.

During leadscrew removal and cutting the radiological controls technician monitored the beta and gamma dose rates. If these dose rates measured at 1 foot exceeded 10 R/hour gamma or 300 rad/hour beta, the team was to secure the work and await instructions from the command center.

Radiation detectors were located on the service structure to continuously monitor radiation levels. The operation of these monitors was written into the work packages as a prerequisite step. These monitors consisted of the following detectors connected to Eberline RM-16^{TM} meters, which were located on a card table placed on the position indicator cable support platform:

1. A neutron detector placed on the card table behind the meter; it was set to alarm at 10 mrem/hour

2. A gamma detector placed on the card table on top of the meter; it was set to alarm at 2 R/hour

3. A gamma detector placed alongside the CRDM motor tube from which the leadscrew was being removed; the detector was suspended 12 feet below the top of the motor tube with the meter set to alarm at 80 R/hour.

Contamination control was provided by raising the leadscrew into a 10-inch diameter plastic sleeve. This prevented loose contamination on the leadscrew from spreading or becoming airborne. The area where the leadscrew was to be cut was tightly wrapped with cloth tape about 6 inches above and below the cut line. Containment of the chips from the leadscrew cutting operation was not

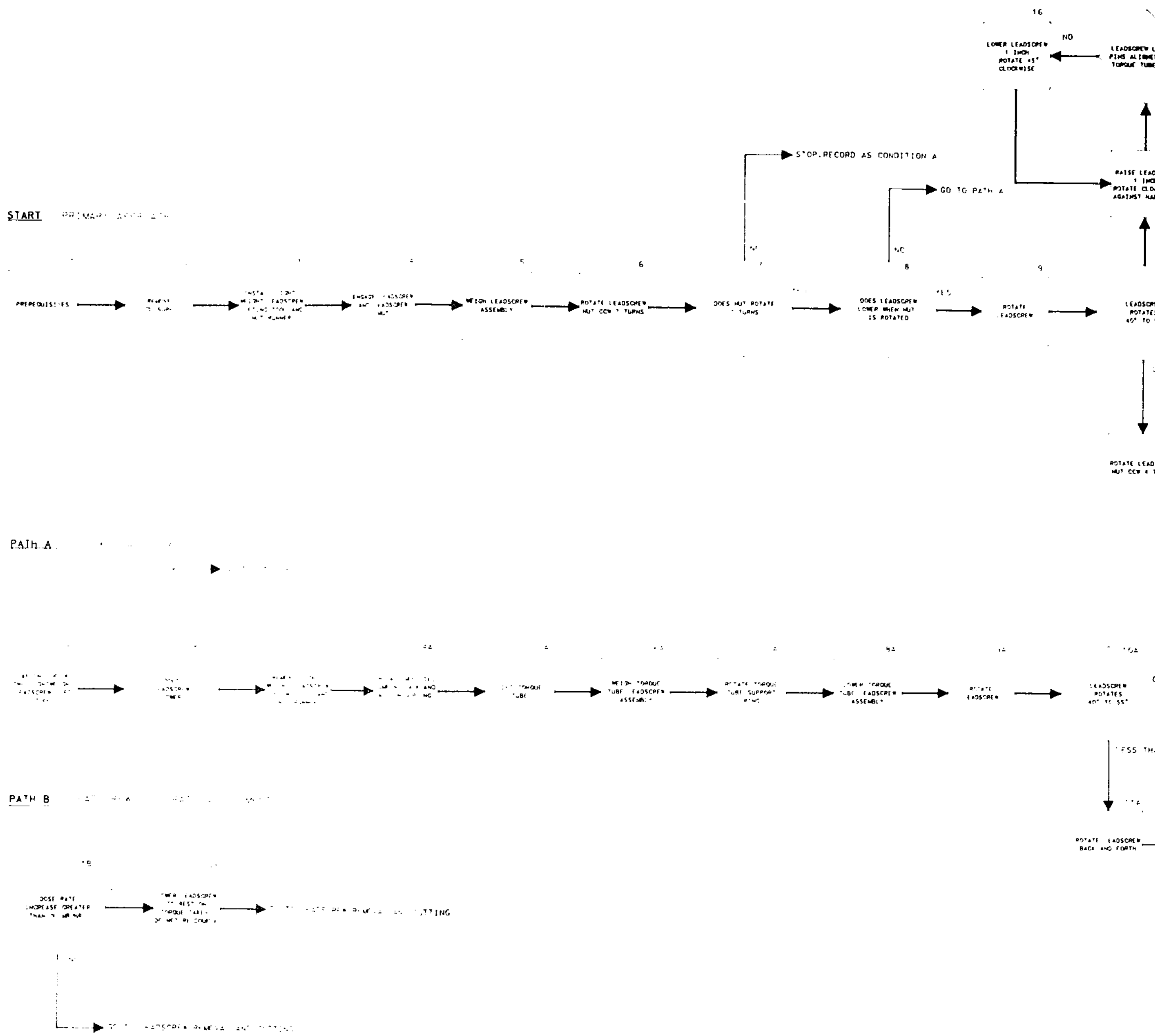
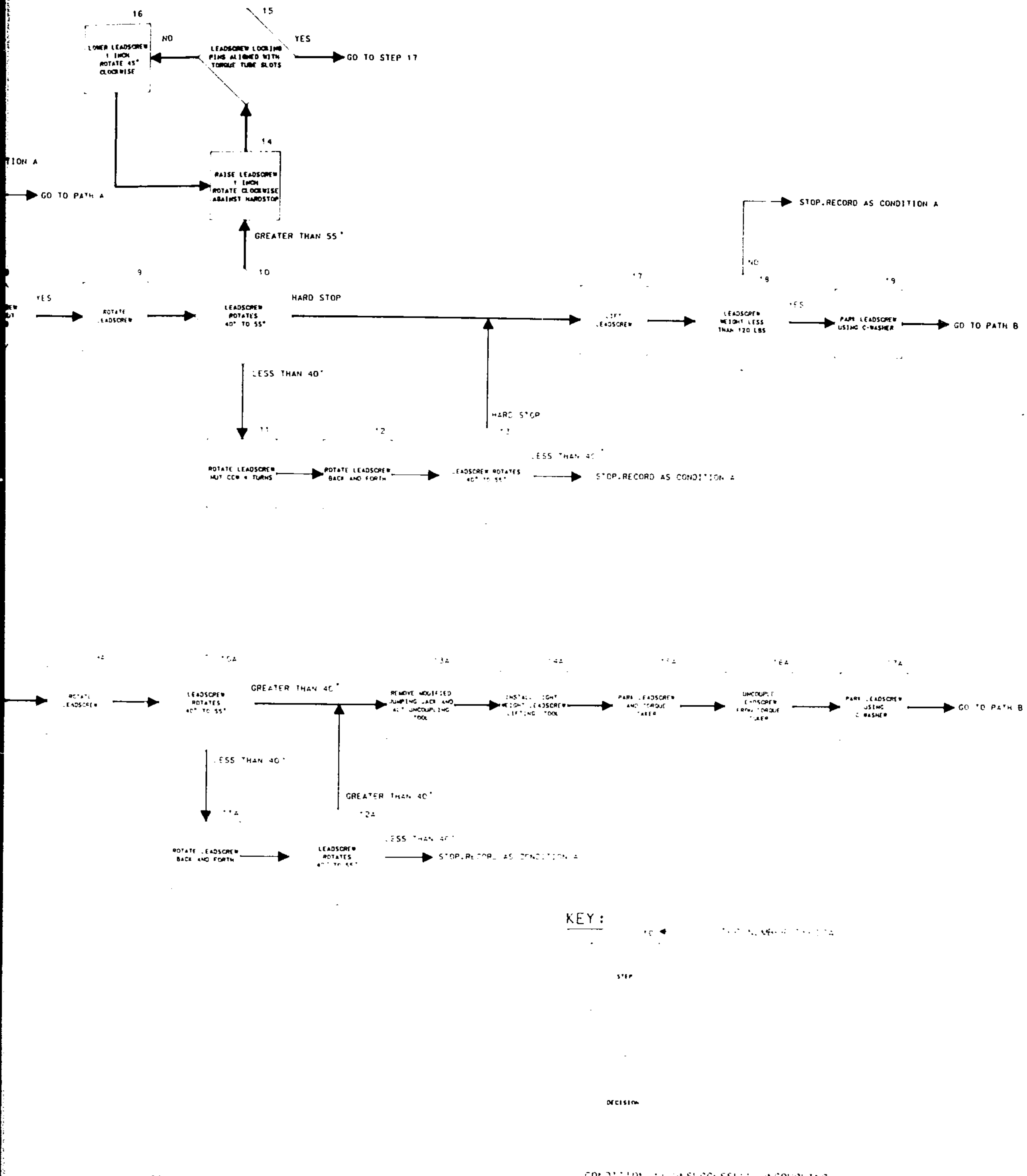


Figure 2-1. CRDM leadscrew uncoupling and cr



crew uncoupling and parking plan.

considered to be essential due to the fact that the loose surface contamination levels on the head service structure exceeded 10^4 dpm/100 cm^2. The leadscrew chips were not expected to increase these levels significantly.

Protection from beta radiation was provided by the use of shielding and clothing requirements as necessary. A shield was constructed of 1/4-inch Plexiglass^{TM} and was designed to shield workers on the working platform as the leadscrew was being raised. An additional shield was constructed of a 10-foot length of PVC pipe approximately 3/8-inch thick, split lengthwise into two halves and hinged by a length of cloth tape. The shield was placed and taped around the upper and lower sections of the leadscrew after each had been raised out of the motor tube. This effectively encased the leadscrew and eliminated the beta radiation.

Protection from beta radiation was provided by eye protection and protective clothing, especially the ice vests used for body cooling. During evolutions where the skin of the extremities was expected to be exposed to beta dose rates high enough to approach the quarterly administrative limit (6 rem) or when pulling items out of the motor tube, the operators were instructed to wear lineman's gloves.

All tools and equipment that came into contact with reactor coolant were wiped down to remove contamination. If deemed necessary by monitoring, borated water was available to flush an item as it was being raised out of the motor tube in an effort to remove contamination.

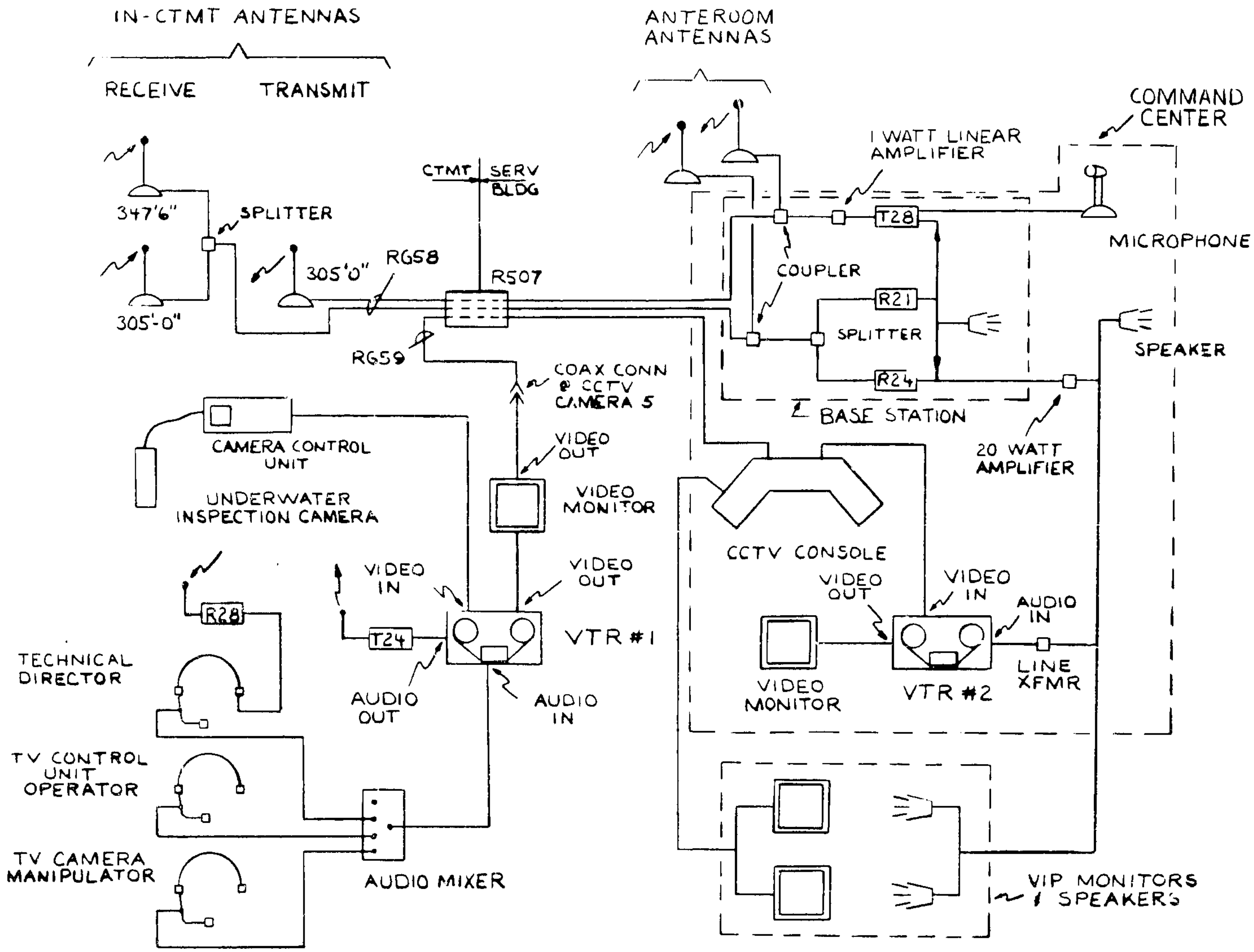


Figure 2-3. Quick Look communications systems.

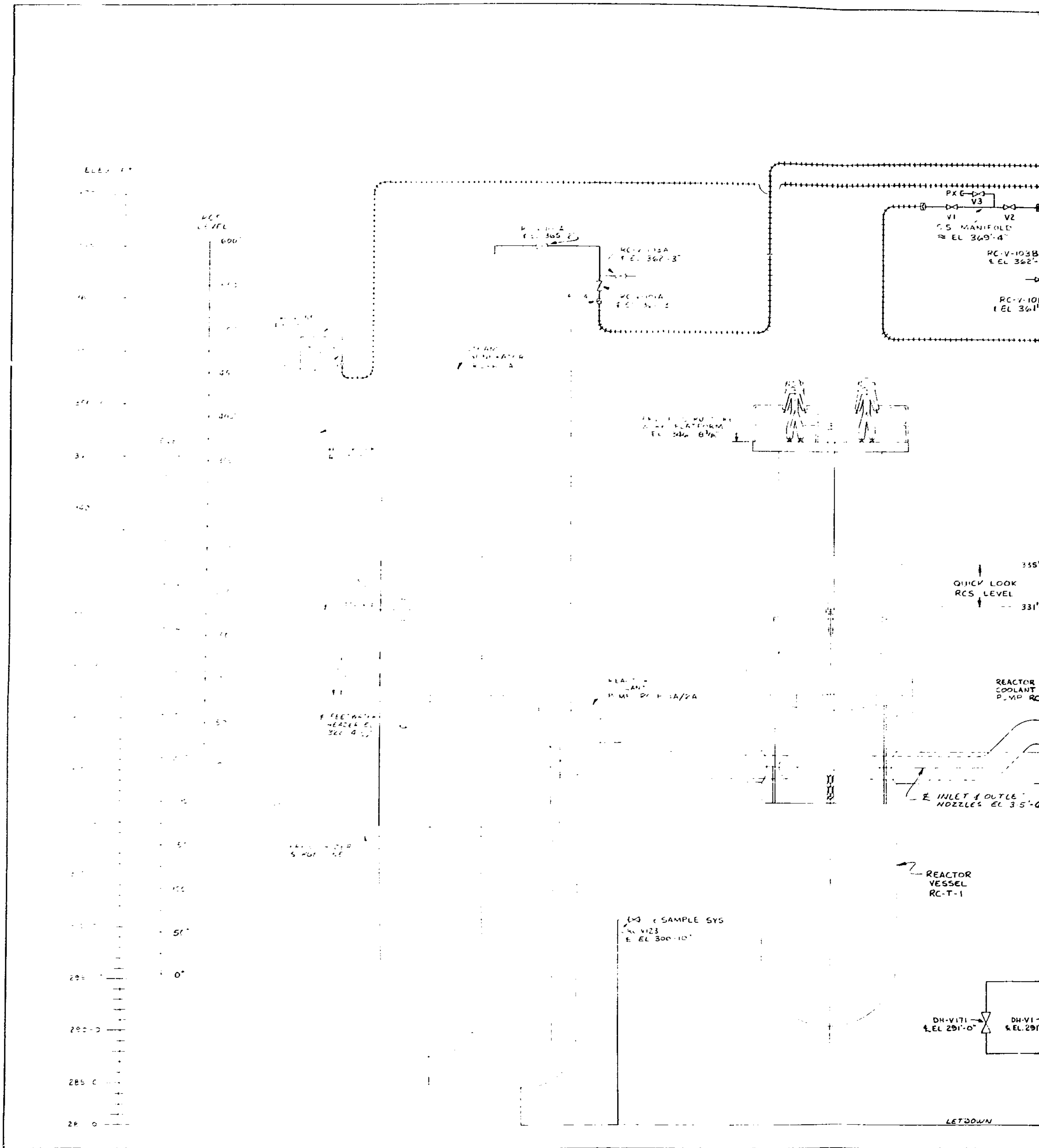
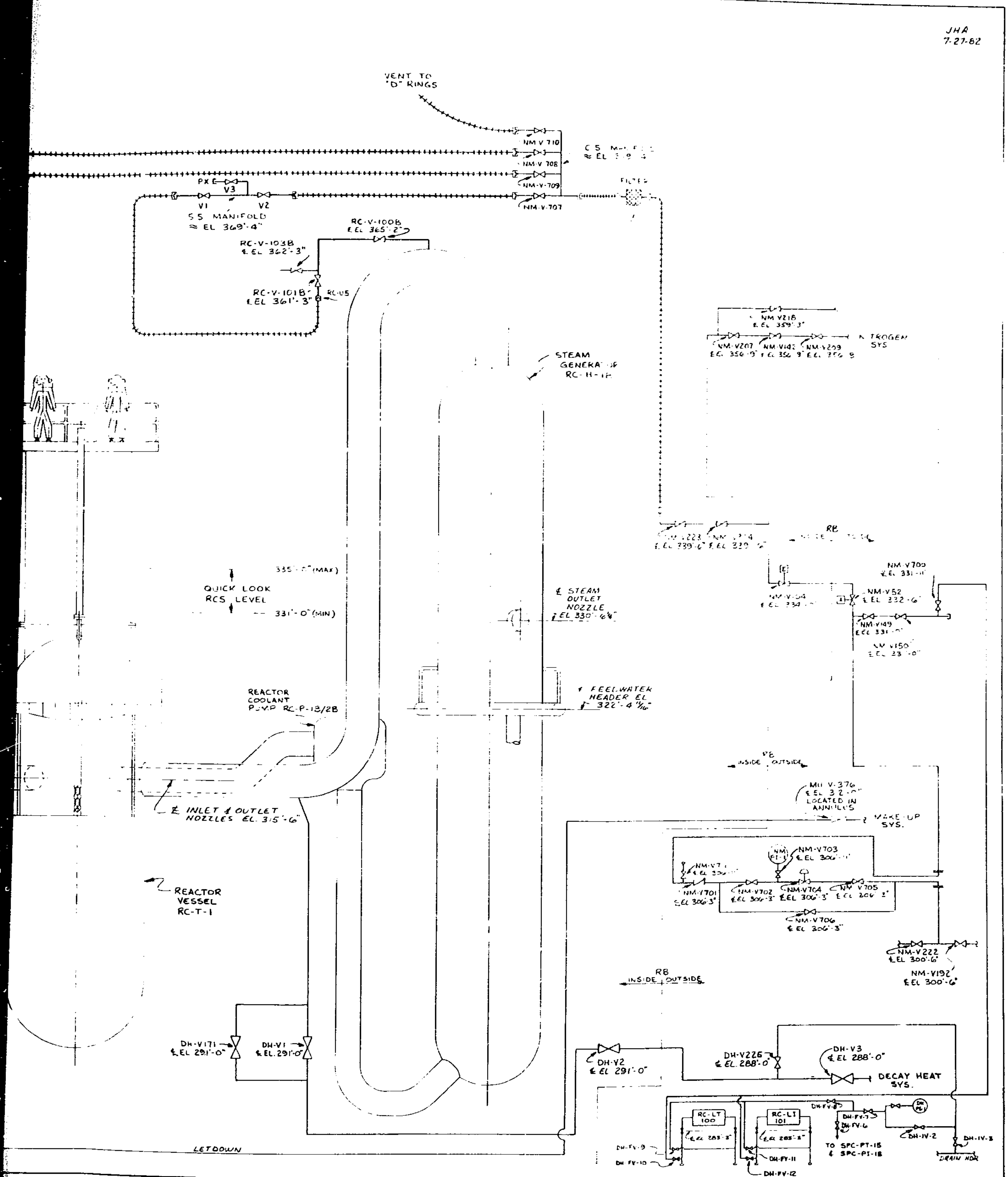


Figure 2-2. RCS level indication versus system elev



level indication versus system elevations.

3. EXECUTION

3.1 Containment Entries

Table 3-1 describes the accomplishments of each containment entry associated with the Quick Look. Man-hours and man-rem associated with each task are also given.

TABLE 3-1. QUICK LOOK CONTAINMENT ENTRIES

Entry Number	Entry Date	Accomplishments	Man-Hours[a]	Man-Rem[b]
62	5/13/82	Measured missile shield gap	2.1	0.354
62	5/13/82	Radiological survey of service structure	2.4	0.4
62	5/13/82	Remote survey of "B" D-ring	1.43	0.316
63	5/26/82	Remote survey of "B" D-ring	2.76	0.634
63	5/26/82	Survey of "A" D-ring	1.34	1.573
63	5/26/82	Walkdown of nitrogen system	1.46	0.171
64	6/3/82	Inventory of CRDM tools	1.14	0.165
64	6/3/82	Relocated CCTV Nos. 7 and 8 to D-ring catwalks	5.19	0.533
65	6/10/82	Performed operational check of the nitrogen system	3.26	0.462
65	6/10/82	Installed emergency lights on the service structure; Tested 110/480 V receptacles on elevation 347'	2.39	0.298
66	6/17/82	Staged lead blankets on elevation 347'	3.05	0.789

TABLE 3-1. (Continued)

Entry Number	Entry Date	Accomplishments	Man-Hours[a]	Man-Rem[b]
67	6/22/82	Installed portable power distribution center on elevation 347'; Installed portable lighting on D-ring catwalks	2.94	0.411
69	7/1/82	Installed CRDM work platforms	1.10	0.251
69	7/1/82	Installed hoist/trolley on the missile shields	3.03	0.502
69	7/1/82	Performed a high pressure flush of the "B" D-ring	4.35	0.731
69	7/1/82	Remote survey of "B" D-ring	1.26	0.215
70	7/8/82	Installed temporary nitrogen system manifolds and hoses	4.71	1.0
70	7/8/82	Remote survey of "B" D-ring	2.06	0.34
71	7/12/82	Low pressure flush of "A" and "B" D-rings	4.57	0.967
72	7/14/82	Surveyed SV-V-25A and SV-V-26A	1.14	0.232
72	7/14/82	Installed compound pressure gauge on the "A" loop; Connected the "B" loop to the vent manifold	2.85	0.963
72	7/14/82	Completed installation of service structure emergency lighting and extension cords; Attempted to relocate Earmark™ receive antenna	2.26	0.322
72	7/14/82	Depressurized secondary side - nitrogen blanket and vented the "A" loop	3.06	0.6
72	7/14/82	Vented the "B" loop and the pressurizer	2.67	0.707

TABLE 3-1. (Continued)

Entry Number	Entry Date	Accomplishments	Man-Hours[a]	Man-Rem[b]
72	7/14/82	Nitrogen blanketed "A" and "B" loops	1.0	0.225
73	7/15/82	Nitrogen blanketed the pressurizer and closed secondary side valves	0.6	0.187
73	7/15/82	Installed radiation detectors	1.06	0.174
73	7/15/82	Obtained CRDM gas samples and initiated venting	4.15	0.525
73	7/15/82	Completed venting and obtained CRDM liquid sample	5.51	0.719
74	7/14/82	Depressurized RCS nitrogen blanket	0.86	0.18
74	7/19/82	Installed PVC leadscrew sleeves and staged CRDM tools	4.85	0.753
74	7/19/82	Vented, uncoupled, and parked leadscrew (first team)	7.61	1.193
74	7/19/82	Vented, uncoupled, and parked leadscrew (second team)	4.54	0.594
75	7/21/82	Removed, cut, and rigged leadscrew off service structure	6.7	1.409
75	7/21/82	Replaced and relocated the Earmark™ receive antenna	2.90	0.502
75	7/21/82	Obtained an RCS liquid sample	4.23	0.582
75	7/21/82	Installed camera, video, and recording equipment	3.21	0.34
75	7/21/82	Performed Quick Look camera inspection	6.66	1.203
76	7/28/82	Radiological survey of service structure	0.67	0.105
76	7/28/82	Obtained three RCS liquid samples	3.54	0.546
77	8/4/82	Obtained an RCS liquid sample	2.16	0.268

TABLE 3-1. (Continued)

Entry Number	Entry Date	Accomplishments	Man-Hours[a]	Man-Rem[b]
77	8/4/82	Disconnected and removed the rod position indication cabling	4.5	0.612
77	8/4/82	Prepared six CRDMs for Quick Look II	1.6	0.19
77	8/4/82	Relocated radiation detector on service structure	1.5	0.178
77	8/4/82	Staged camera and video equipment	1.05	0.148
77	8/4/82	Relocated leadscrew sections that were previously cut and removed	3.15	0.397
77	8/4/82	Verified operability of Earmark™ communications system	0.86	0.15
78	8/5/82	Obtained an RCS liquid sample	0.99	0.25
78	8/5/82	Vented, uncoupled, and parked leadscrew 8B	8.3	0.95
78	8/5/82	Vented, uncoupled, and parked leadscrew 9E	6.92	0.719
78	8/5/82	Removed, cut, and rigged leadscrew 9E off service structure	5.06	2.316
79	8/6/82	Removed cut, and rigged leadscrew 8B off service structure	6.5	1.933
79	8/6/82	Installed camera, video, and recording equipment	2.79	0.481
79	8/6/82	Performed Quick Look II camera inspection	10.07	1.5
79	8/6/82	Removed video equipment and cleaned service structure	3.0	0.358
80	8/12/82	Obtained an RCS liquid sample	3.66	0.493
80	8/12/82	Installed camera, video, and recording equipment, and probe tool on service structure	1.39	0.163

TABLE 3-1. (Continued)

Entry Number	Entry Date	Accomplishments	Man-Hours[a]	Man-Rem[b]
80	8/12/82	Cut and removed about two-thirds of the CRDM lockwires	4.16	0.487
80	8/12/82	Performed Quick Look III camera inspection and core probe	13.87	1.487
81	8/13/82	Obtained gas samples from three CRDMs	2.43	0.273
83	8/18/82	Obtained an RCS liquid sample	2.0	0.243
83	8/18/82	Cut and removed remaining CRDM lockwires	2.0	0.242
85	8/23/82	Removed about one-half of the CRDM closures	4.0	0.448
85	8/23/82	Installed acoustical monitor in CRDM 9E	0.66	0.09
85	8/23/82	Uncoupled about one-half of the CRDMs	4.61	0.628
86	8/25/82	Obtained an RCS liquid sample	2.0	0.244
86	8/25/82	Removed remaining CRDM closures	5.28	0.644
86	8/25/82	Uncoupled remaining CRDMs (except for three)	5.68	0.783
89	9/1/82	Obtained an RCS liquid sample	1.98	0.299
90	9/3/82	Installed manometer on CRDM 8H and obtained gas sample	4.10	0.629
91	9/8/82	Obtained an RCS liquid sample	0.9	0.134
91	9/8/82	Obtained a CRDM gas sample	0.9	0.133
92	9/10/82	Obtained a CRDM gas sample	1.42	0.18

TABLE 3-1. (Continued)

Entry Number	Entry Date	Accomplishments	Man-Hours[a]	Man-Rem[b]
93	9/15/82	Obtained an RCS liquid sample	1.1	0.174
93	9/15/82	Obtained a CRDM gas sample	2.0	0.287
		TOTALS	243.2	40.684

a Man-hours were calculated based on the sum of the individual team member's man-hours.

b Man-rem were calculated based on the sum of the individual dosimeter reading recorded on each radiation work permit (RWP). These readings will not necessarily coincide with the TLD readings.

3.2 Preliminary Data Collected

3.2.1 Gas and Liquid Samples

Three CRDM samples were obtained during entry 73 on July 15, 1982. These samples consisted of two gas samples (one line purge sample and one system sample) and one liquid sample. All CRDM samples were obtained using evacuated, 150 ml sample bombs attached to the CRDM venting tool back-up valve. After obtaining the CRDM purge and gas samples, the CRDM venting tool was connected to the blower and ductwork assembly to dilute the remainder of the gas from the CRDM. Following the complete venting of the CRDM, a CRDM liquid sample was obtained by connecting an evacuated 150 ml sample bomb to the isolation valve of the venting tool. Tables 3-2, 3-3, and 3-4 present the analysis results for these samples.

TABLE 3-2. CRDM PURGE SAMPLE FROM 10H CRDM VENT
(July 15, 1982 - Sample No. 86548)

Analysis	Results	Units	Uncertainty	Units
Kr-85	1.1E0	μCi/cc	1.2E-2	μCi/cc
Cs-137	3.5E-5	μCi/cc	5.2E-6	μCi/cc
O_2	4	%		
N_2	21	%		
H_2	57	%		
Other	18	%		

NOTE: Positive particulate results on Marinelli beakers should only be considered as qualitative.

TABLE 3-3. CRDM GAS SAMPLE FROM 10H CRDM VENT
(July 15, 1982 - Sample No. 86547)

Analysis	Results	Units	Uncertainty	Units
Kr-85	1.1E0	μCi/cc	1.2E-2	μCi/cc
O_2	2	%		
N_2	14	%		
H_2	63	%		
Other	21	%		

TABLE 3-4. CRDM LIQUID SAMPLE FROM 10H CRDM VENT
(July 15, 1982 - Sample No. 86546)

Analysis	Results	LLD	Units	Uncertainty	Units
B	3820		ppm		
Cl	2.5		ppm		
Na	780		ppm		
pH	7.72				
H-3	4.6E-2		μCi/ml	7	%
Sr-90	9.5E0		μCi/ml	35	%
Turbidity (before filtration)	200		NTU[a]	20	NTU[a]
Turbidity (after filtration)	180		NTU[a]	20	NTU[a]
Cs-134	2.2E-1		μCi/ml	1.0E-3	μCi/ml
Cs-137	2.6E0		μCi/ml	3.1E-3	μCi/ml
Co-58		7.0E-4	μCi/ml		
Co-60	9.6E-3		μCi/ml	2.9E-4	μCi/ml
Ru-106	1.8E-2		μCi/ml	3.3E-3	μCi/ml
Sb-125	5.5E-2		μCi/ml	1.9E-3	μCi/ml
Ce-144	2.0E-1		μCi/ml	2.1E-3	μCi/ml
Mn-54	8.6E-4		μCi/ml	2.1E-4	μCi/ml
Gross alpha	8.9E-3		μCi/ml	1.5E-3	μCi/ml
Gross beta	1.47E+1		μCi/ml	6.24E-2	μCi/ml

a. NTU = normal turbidity units.

Contact RO-2A readings on the gas and liquid samples collected were as follows:

- CRDM gas samples:

  - Line purge: 150 mR/hour gamma and 400 mrad/hour beta

  - System vent: 150 mR/hour gamma and 520 mrad/hour beta

- CRDM liquid sample: 150 mR/hour gamma and 400 mrad/hour beta

One RCS liquid sample was obtained during entry 75 on July 21, 1982. The sample was obtained using a solenoid actuated, 150 ml sample bomb which was lowered into the reactor vessel through the CRDM, to a depth 28 feet below the top of the motor tube. The sample bomb was lowered into the motor tube using four 10-foot aluminum support tubes. Support tubes were connected as required to reach the prescribed depth and supported at that depth using a tripod assembly. The sample solenoid was energized by a power supply brought into the containment by the entry team. Table 3-5 presents the analysis results for this RCS sample.

RCS liquid samples were taken each week thereafter and similar analyses were conducted. After using evacuated sample bombs several times, the sampling technique was changed to the use of a manually operated pump that would draw RCS liquid up a suction hose inside the CRDM and discharge into a sample container.

During tasks involving the removal of CRDM closures, it became evident that gas was being generated under the reactor vessel head at unexpected rates. Gas samples were obtained from the tops of CRDMs at positions 2H, 7G, and 7K. Analysis of the samples indicated that when a CRDM closure was opened, the gas mixture in the motor tube changed from hydrogen with an oxygen deficiency to a mixture that had higher oxygen and nitrogen concentrations and a lower hydrogen concentration.

TABLE 3-5. RCS LIQUID SAMPLE ANALYSIS FROM REACTOR VESSEL (July 21, 1982 - Sample No. 86798)

Analysis	Results	LLD	Units	Uncertainty	Units
Cs-134	1.9E-1		µCi/ml	9.3E-4	µCi/ml
Cs-137	2.3E0		µCi/ml	2.9E-3	µCi/ml
Co-58		5.6E-4	µCi/ml		
Co-60	1.1E-3		µCi/ml	1.0E-4	µCi/ml
Ru-106		1.0E-2	µCi/ml		
Sb-125		5.4E-3	µCi/ml		
Ce-144		4.5E-3	µCi/ml		
Gross beta	9.94E0		µCi/ml	5.17E-2	µCi/ml
Gross alpha	6.26E-5		µCi/ml	4.33E-5	µCi/ml
pH	7.71				
B	3922		ppm		
Cl	1.9		ppm		
Na	790		ppm		
H-3	4.2E-2		µCi/ml	6.9	%
Sr-90	7.4E0		µCi/ml	35	%
Turbidity	14		NTU[a]	0.3	NTU[a]

a. NTU = normal turbidity units

After the CRDM uncoupling attempts were completed, a manometer was connected to the CRDM vent tool (see Figure 3-1) that was installed on the central CRDM (8H) (see Figure 3-2). The gases generated under the reactor vessel head collected in the central CRDM, where the gas buildup could be measured with the manometer. The CRDM and manometer were intially purged with nitrogen and gas samples were taken periodically. The analysis results of these CRDM gas samples are presented in Table 3-6. Observations of the manometer indicated that gas buildup was approximately 0.04 to 0.05 cubic foot per day.

TABLE 3-6. CRDM 8H GAS SAMPLE ANALYSES

Constituent	Sample 9/3/82 (%)	Sample 9/8/82 (%)	Sample 9/10/82 (%)	Sample 9/15/82 (%)	Sample 9/15/82 (%)
N_2	95.5	87.4	91.9	89.3	86.8
H_2	<0.1	6.3	8.0	11.8	12.5
O_2	4.3	4.3	1.6	1.7	1.0
Others	-	2.0	-	-	-

Contact RO-2A readings on the RCS liquid sample bomb were 100 mR/hour gamma and 240 mrad/hour beta.

3.2.2 Leadscrew Information

During removal of the leadscrews, no apparent warpage or deformities were observed. Except for the leadscrew bayonet couplings and the leadscrew at position 8B, the leadscrew surfaces were clean. The bayonet couplings and the leadscrew at position 8B were covered with a black powdery substance.

Dose rate profiles of the three leadscrews that were removed are presented in Figures 3-3, 3-4, and 3-5.

Three leadscrew-related samples were removed from the reactor building for analysis. These samples were:

- A scraping sample off the inside of CRDM 8B (#88905)
- A small fleck observed on the service structure after removing leadscrew 8B (#88906)
- A sample of the cutting remnants (shaving) of the leadscrews (mostly position 8B) (#88904).

The scraping sample only consisted of several small flecks. The 8B leadscrew sample was a single fleck approximately 1/8 inch in diameter, while the shavings sample consisted of several grams of miscellaneous shavings. Four sub-samples of each type of material were removed from the cuttings and placed in separate petri dishes. Microscopic examinations showed that portions of the cuttings sample had the same general appearance as the scraping and leadscrew samples.

Approximately 100 mg of the cuttings sample were tested for pyrophoric characteristics. First, the sample was heated on a hot plate to approximately 150 C for 10 minutes in air. No spontaneous ignition was observed. However, while the sample initially contained flecks of various sizes and colors, all the material changed to a uniform dark gray to black color after heating.

The heated sample was then exposed to a flint/steel spark source with no spontaneous ignition observed after several direct strikes. Approximately 10 mg of the heated sample were then directly heated with an alcohol flame for several minutes. There was no evidence of spontaneous ignition. A maximum temperature of 1000 C was estimated.

A small portion of the 150 C heated sample was then placed in a petri dish and a small portion of the flamed sample was placed in another petri dish, for visual comparison with the unheated samples. All eight of these petri dishes were then examined with a 60 power microscope prior to quantitative assay.

All samples were counted for gamma and beta activities. The results are summarized on Table 3-7. The data indicate a wide range of activities for these samples. The CRDM scrape sample had the lowest Cs-137 to Sr-90 ratio, while the crud sample that fell off during the 8B leadscrew removal had the highest ratio. For reference, the Cs-137 to Sr-90 ratio for a variety of samples is also given in this table. General conclusions are difficult to draw from these data.

3.2.3 Leadscrew Uncoupling Descriptions for Drive Locations 8H and 7K

During the first attempt to uncouple the leadscrew on drive 8H, there were indications of interferences or damage because the initial load reading was 350 pounds. The leadscrew nut rotated freely. Initially the leadscrew did not lower; therefore, the leadscrew would not rotate. After tapping on the light-weight leadscrew lifting tool, the leadscrew lowered enough to allow it to rotate 45 degrees to the uncoupled position.

At this point the leadscrew and tool weight should have been 170 pounds; however, the leadscrew would not lift above 1 inch without exceeding the administrative load limit of 350 pounds.

TABLE 3-7. RADIOACTIVITY ANALYSES OF LEADSCREW SAMPLES

Sample Number	Total Activity (Ci) Cs-137	Cs-134	Sr-90	Cs-137/Sr-90
88905[a]	4 6E-2	3.6E-3	8.9E-3	5.2
88906	6.2E-1	4.8E-2	2.4E-3	258
88904-1	1.3E-1	1.1E-2	7.4E-4	176
88904-2	2.9E-3	1.7E-4	<2E-4	-
88904-3	1.3E-1	1.1E-2	1.2E-3	108
88904-4	4.2E-1	3.8E-2	5.7E-3	74
98904-heat	3.1E-2	2.4E-3	<5.5E-4	-
88904-flame	2.4E-1	2.2E-2	7.4E-4	324

a. Other activities detected in this sample only:
Co-60 = 2.8E-4, Ru-106 = 3.9E-3, Sb-125 = 3.7E-2, Ce-144 = 1.5E-3

For Reference	Cs-137/Sr-90
RB sump - typical range	10 to 20
RCS prior to processing	0.8
RCS prior to Quick Look	0.3
Air in containment	~20
Smears in containment	10 to 20
Filterable RCS	0.001 to 0.5
Filterable RB sump	0.5 to 1
CRDM purge filter sample	0.1

The leadscrew was raised, lowered, and rotated for several minutes until the decision was made to go to the next drive. During these movements of the leadscrew it was rotated beyond the 45-degree point; later analysis indicated that it was likely that the spider had fallen off. However, the interference still existed and the leadscrew could not be removed.

After an unsuccessful attempt to uncouple the leadscrew at CRDM 7K, another attempt was made at CRDM 8H. The nut was rotated clockwise to the hard stop in order to return the drive to its original position. The nut rotated 20 times in lieu of the 4 to 7 expected. This gave a positive indication that the leadscrew was in an uncoupled position and the nut was bottomed on the leadscrew engagement pins.

When the leadscrew was loaded it still did not move beyond the 1-inch mark without exceeding the 350-pound administrative load limit. In light of the positive indication of uncoupling, the operator was instructed to jar the tool in an attempt to determine where the problem was. During this step the leadscrew broke loose and the load reading was 170 pounds. The remainder of the leadscrew parking and removal process indicated that there was no detectable damage to the leadscrew.

As previously noted, after the first attempt to remove the leadscrew at CRDM 8H was unsuccessful, an attempt was made to remove the leadscrew at CRDM 7K. This leadscrew also had indications that there were interferences or damage because of the initial load reading of 350 pounds. Although the leadscrew nut rotated freely, initially the leadscrew did not move up or down; however, as with position 8H, after tapping on the leadscrew lifting tool, the leadscrew moved up, down, and rotated. The leadscrew was lifted after rotating it 45 degrees, although it would not move more than 1 inch without exceeding the 350-pound load limit.

After several up and down movements and several rotations (0 degrees to 45 degrees to 0 degrees) of the leadscrew lifting tool, the leadscrew was in a condition where it could not be rotated with the lightweight leadscrew lifting tool. At this point the lifting tool and nut runner were removed and the alternate uncoupling tool (see Figure 3-6) was tried.

When the jumping jack and alternate uncoupling tool were engaged, the jack was actuated and the torque tube (see Figures 3-7 and 3-8) was raised and lowered normally. The torque tube rotated only 30 to 35 degrees. In an attempt to gain a full 45-degree rotation, the torque tube was rotated back and forth several times. During these rotations it was observed that the reverse hard stop was approximately 25 degrees behind the normal uncoupled position. No clear conclusion could be drawn from these observations. After several unsuccessful attempts to gain the 45-degree rotation for uncoupling, the torque tube was returned to the coupled position and recoupled inside the motor tube. At this point operations on drive 7K were terminated.

3.3 Observations from the Camera Inspections

The Quick Look camera inspections were performed inside of the TMI-2 reactor vessel on July 21, August 6, and August 12, 1982. The camera revealed that the upper central portion of the reactor fuel has collapsed and forms a loose bed of rubble, whose upper surface is about 5 feet below the normal top of the core. This appears to support earlier studies of the accident that theorized severe damage in the upper central portion of the core where the temperatures were the highest.

The first look involved inserting the camera down the space vacated by the removal of the leadscrew drive from the central CRDM. The camera showed no visible damage to the plenum assembly above the core. However, when the camera was lowered to the point where the control rod and fuel assembly should have been, it was found that the core had slumped away from the plenum. The camera was then lowered an additional 5 feet where the top of the bed of rubble was observed. Only a very limited part of the core could be observed during this inspection due to water clarity and lighting conditions.

After removing two more control rod leadscrew drives at the edge of the core and at a point midway between the outer edge and the center, the second inspection was conducted. The pictures at the edge revealed that the control rod and the fuel assembly in this position were still in place. In the pictures taken at the midpoint between the edge and the center, more evidence of the bed of rubble could be seen. The top of the rubble at this point was also observed to be 5 feet below the plenum assembly, as was the case at the center position. These pictures revealed several recognizable components in the core, including fuel rod springs, intact or partially intact nonfuel bearing tubes, and several partial fuel assemblies hanging from their position in the plenum assembly. The quality of the pictures was improved due to the installation of a supplementary light into the center position (used for the first inspection) and possibly due to improved water clarity.

The third inspection included probing the rubble bed to determine its constituency. A steel rod was inserted down the same position between the edge and the center of the core as was used for the second inspection. The rod was lowered until it rested on the top of the rubble. It was then pushed into the rubble with relatively little force for a distance of 14 inches, indicating that at least the top layer at this point is loose rubble. The probe test was then conducted at the center of the core, where it was also found that the upper 14 inches of the rubble bed is loose material.

Several preliminary conclusions have been made based on a review of the camera inspections. The initial conclusions are limited only to areas explored by the camera:

- A significant portion of the Unit 2 fuel assemblies was severely damaged during the 1979 accident, with the result that some of them are in a bed of rubble.

- An approximately 5-foot-deep void exists in the upper portion of the core, extending from the core's center line about halfway to its edge.

- No evidence of melted fuel pellets was found; however, no generalized conclusions have been made on whether or not any of the fuel pellets within the core had melted.

- At two points, one at the center and the other midway to the edge, the rubble at the bottom of the void is composed of loose material to a depth of at least 14 inches, and in those two areas the rubble is not a fused mass.

- As expected, there appeared to be evidence of partial melting of nonfuel material, such as metal components that have melting points much lower than uranium oxide fuel.

- The plenum, a major reactor component just above the core, appeared to be substantially undamaged. At a point between the center and the periphery of the core, parts of fuel assemblies were seen hanging from the lower plate of the plenum.

A committee, the Quick Look Tape Review Group, which was composed of individuals who were familiar with the details of the construction of fuel and core internals, and with video technology, reviewed the videotapes. The details of the Quick Look Tape Review Group conclusions can be found in their report, Data Report - Quick Look Inspection Results (TPO/TMI-026), December 1982, GPU Nuclear Technical Planning Department. The following sections are a brief summary of some of the observations from the report.

3.3.1 Observed Condition of the Plenum

The interior surfaces of the CRDM guide tubes (8B, 8H, and 9E) were thoroughly examined and appeared to be in good condition. Nearly all of the setscrews, which fasten the guide tubes to the brazement support plates, were located. All screws had clearly visible, intact threads. Varying amounts of fine surface deposits, as well as some small flakes, were observed on the top surface of the screws. All support plates inspected were unbroken, free of distortion, and generally undamaged, although the top surfaces were covered with layers of flakes at every location inspected. The junctions of the support plates with the C-tubes and split tubes appeared to be normal with no evidence of melting. The bottom end of one of the split tubes at the 9E location showed evidence of minor wastage of metal. Some of the nearby C-tubes also showed signs of melting below the tenth support. Other C-tubes only centimeters away at 9E were undamaged.

Since markings on the camera cable allowed the depth of the camera lens to be known to within 1 inch, it was possible to determine that the grid plate had not sagged at any of the three locations examined. The brazement support plates, ends of the C-tubes and split tubes, grid plate surfaces, and pressure pads were all found in their normal locations.

At location 9E, the fuel element upper end fitting and the three adjacent upper end fittings (8D, 8E, and 9D) were suspended from the underside of the grid plate. The grillage was completely missing on the 9E upper end fitting. The spider, spring, and spring retainer were also missing. The grillage on the other three visible upper end fittings was present, but partially damaged. One of the upper end fittings had other identifiable components suspended from it. A spacer grid, stubs of control elements, and partial fuel pins were visible.

The 9E upper end fitting was scanned from inside with the right angle lens and appeared to be in its normal position with respect to the grid structure. Metal chips and debris were found in the tight space between the center tabs on the end fitting and the grid. This debris may be what is holding the end fitting in place, although the remainder of the fuel element was missing. Some areas of the 9E upper end fitting look like metal that has been cut by a torch, while adjacent areas appear to be in the as-manufactured condition.

3.3.2 Distribution of Core Debris

Flakes of debris 1/8 inch in diameter or less were observed on nearly every horizontal surface. The thickest layer of flakes seen was not more than 1/16 inch in depth. These layers were loosely deposited, since the motion of the camera in the water often disturbed the flakes.

Each support plate observed in the CRDM guide tube at location 9E had a layer of flakes, whose thickness increased with depth, on the top surface. The undersides of the horizontal surfaces were clean and free of loose debris. Vertical surfaces were clean and free of loose debris. Vertical surfaces of the CRDM guide tubes and C-tubes were relatively free of debris near the top of the plenum, although some slight deposit of material was evident as the camera was lowered.

Debris of larger characteristic size was lodged in the narrow space between the upper end fitting centering tabs and the plenum grid plate. This debris appeared to be metal chips or fragments, rather than tiny flakes. One piece of debris looked like a fuel pellet fragment.

Whenever the camera impacted the rubble bed, a cloud of very fine particles, which settled or dispersed quickly, was generated. The turbidity of the water varied from one camera inspection to the next. During the first camera inspection, the water was quite cloudy with visibility limited to 3 inches beyond the camera at most. The visibility increased to about 9 inches beyond the lens during the second camera inspection; however, it appeared that visibility was limited by available light rather than by turbidity. During the third camera inspection, available light also appeared to be the factor limiting visibility, causing objects to be indistinct, although discernible, from 1 or 2 feet beyond the camera.

3.3.3 Extent of Core Damage

A void exists in the upper central portion of the core. At position 8H, the center of the core, the void extends from the bottom of the plenum to a rubble bed, the top surface of which is 5 feet below the bottom of the plenum. This void includes at least the central nine fuel locations. At the 9E location, the void also extends 5 feet below the lower surface of the plenum. It was not possible to rotate the camera 360 degrees, as was done at position 8H, since the camera was prevented from turning on every attempt. Stubs of rods were seen extending upward from the rubble at position 9E. Rod stubs were also observed hanging downward along the west edge of the core at the 8D location. They were suspended from the remains of the upper end fitting, which was still in place.

At position 8H the entire upper end fitting was missing, as was an adjacent one. At positions 8D, 8E, 9C, and 9E, the upper end fittings were still suspended from the plenum grid plate. The spider assemblies were encountered in their normal positions at location 8B and one adjacent location, which indicates that the fuel bundles in these locations were sufficiently intact to support the spiders.

3.4 Core Probe

The rubble bed was probed by inserting a 1/2-inch-diameter steel rod into the reactor vessel through the 8H CRDM guide tube until it touched the rubble. It was then rotated and allowed to penetrate the debris by the force of its own weight (about 30 pounds). The probe easily penetrated the debris to a depth of 14 inches, where it was stopped by an unyielding obstruction. The rod penetrated the debris to the same depth at location 9E.

3.5 Leadscrew Uncoupling Activities

3.5.1 Description

CRDM uncoupling and core mapping were planned to obtain the earliest possible data on the condition of the CRDMs. The uncoupling consisted of a series of operations that attempted to disconnect drive mechanism leadscrews from core control elements. The goals of these operations were to:

- Obtain data that can be used to assess the condition of the core
- Uncouple CRDM leadscrews from control rod assemblies to permit leadscrew parking and CRDM removal (if required)
- Obtain data on the condition of individual CRDMs in order to develop the most efficient plan for contingency uncoupling and parking.

The uncoupling sequence was set up to obtain six major data items and any associated data that may be pertinent to the data evaluation process. These data consisted of four pressure gauge readings taken from a hydraulic pressure gauge on the jumping jack tool, the extent of leadscrew rotation, and whether or not the hard stops were felt by the operator. Other information, such as the operator's feel for the rotation, the inability to rotate back to the coupled position, or whetrer the drop of the spider was felt, was also recorded.

Alternate uncoupling of the CRDM is performed by rotating the majority of the drive's internals. When leadscrew removal is not required (e.g., head removal, normal plant outages, etc.), alternate uncoupling is used to reduce the time and man-rem associated with CRDM uncoupling and parking. The difference between the normal uncoupling (used during the Quick Look leadscrew uncoupling and removal) and the alternate uncoupling is:

- o Normal uncoupling unthreads the leadscrew nut (see Figure 3-9) and then uncouples the leadscrew from the spider and torque taker simultaneously, thus allowing the leadscrew to be removed from the drive

- o Alternate uncoupling uncouples the torque tube from the motor tube and rotates the entire internals assembly (i.e., torque tube, torque taker, and leadscrew), thus uncoupling the leadscrew from the spider without disturbing the leadscrew-torque taker connection. The leadscrew can then be parked by hanging the torque taker inside the torque tube. Without subsequent operations (i.e., unthreading of the leadscrew nut), the leadscrew cannot be removed from the drive using this method.

The alternate uncoupling tool is normally used in conjuction with an air-operated jumping jack to perform the lifting and lowering. In order to facilitate weighing the drive components at various intervals in the uncoupling sequence, the jumping jack was modified to be hydraulically operated. The tool was then calibrated for weighing. During calibration, it was determined that there was a constant 30-pound error in the weight conversion; the conversion factor is 5.3 pounds to 1 psi. For example, 53 psi equals 250 pounds. In addition to the 30-pound constant weight error, the actual psi gauge readings could only be recorded to ±3 psi. This added additional uncertainties into the actual weight indications; however, the weighing capabilities were sufficient for determining trends in the data accumulated. This data analysis is discussed in detail later.

Another major portion of data accumulated relates to the rotation of the leadscrew. These data were determined based on the design of the bayonet connection between the leadscrew and spider. This connection is a flat bayonet with no J-slots. There are four male tabs on the leadscrew and four female slots in the spider's coupling. There is a 2-inch engagement length between the tabs and slots which, when mated, allows very little (less than 5 degrees) relative rotation. The characteristics of the rotation of this coupling are discussed in detail later.

APSRs were also uncoupled using the alternate uncoupling method. Because the leadscrew's weight is supported by the APSR roller nuts, the weight indications throughout will be different than shim safety drives. The major difference between APSR and shim safety drives stems from their function in the reactor. Because the APSRs never scram, their torque tubes do not have belleville springs and their roller nuts and leadscrew are always engaged. Different uncoupling plans were required only for APSR 10N, where the torque taker was bottomed on the torque tube during insertion tests. For the remaining seven APSRs, there was sufficient clearance between the torque tube and torque taker to allow the torque tube to be lifted and alternate uncoupling to be performed.

For APSR leadscrew parking, the stators will have to be energized to withdraw the leadscrew from the constraints of the spider's coupling (approximately 2 inches). Once this has been performed, the APSR leadscrews can be parked manually by rotating the torque tube and leadscrew using the alternate uncoupling tool. This method requires 168 revolutions of the torque tube (for drives with the APSRs in the fully inserted position). Stators could be used to park the leadscrews; however, without stator cooling water the risk of overheating is possible. In run speed, it takes 4½ minutes to drive the leadscrew to the park position. During the APSR insertion tests, cooling water was not used. To part the shim safety drives, the leadscrew is engaged using a leadscrew lifting tool and the leadscrew is lifted through the roller nuts. Additional information concerning leadscrew parking will be discussed later.

3.5.2 Data Explanation

The first gauge reading was taken after the lift of the entire assembly. This included the control rod assembly, leadscrew, torque tube, torque taker, and uncoupling tool. Their combined weight was 390 pounds. For a normal drive (the assembly moved up freely and the entire control rod assembly was present), this pressure reading should have been approximately 75 psi. Since combinations of crud buildup and missing control elements could also cause a normal reading (75 psi), the combination of all readings and rotations was the only way of determining a truly normal assembly uncoupling. It should also be noted that if the first gauge reading exceeded about 90 psi, it indicated that the belleville springs were being compressed in order to gain the upward torque tube motion required.

The second gauge reading was taken after lowering the entire assembly and prior to rotation of the assembly. The vertical position of the torque tube was just below its seated position for this reading. Again, for a normal assembly this reading should have been about 75 psi. However, if the leadscrew or spider was stuck (and thus their weight was being supported in the drive or by the control rod pin damage), the second reading should have been about 28 psi. This corresponded to the weight of the alternate uncoupling tool and the torque tube. If the leadscrew was stuck it was still possible for the torque tube to slide down the leadscrew.

The third gauge reading was taken after rotation of the assembly. The vertical position of the torque tube was the same as for the second reading. This reading determined if the control rod assembly or any weight dropped off the leadscrew. A normal uncoupling would have a gauge reading of about 53 psi at this point. In cases where only the spider assembly may have been present, the drop of 10 to 15 pounds (equivalent to 2 to 3 psi on the hydraulic gauge) was undetectable, due to the accuracy of the load measuring device.

The fourth gauge reading was taken after the leadscrew and torque tube were lifted and prior to recoupling the torque tube to the motor tube. For a normal drive uncoupling, this reading should also have been 53 psi. There were several drives which uncoupled (as indicated by the leadscrew rotation and/or a drop in weight indication) but required more than 53 psi to lift the assembly. This increase in load seems to be a result of the same types of interferences that were detected during Quick Look I and II uncoupling and parking. These higher readings are used to identify potential parking problems at CRDM locations.

It should be noted that vertical downward movement of the torque tube was limited to 5/8 inch during the uncoupling attempt.

There were four different rotational conditions that were observed during CRDM uncoupling: (a) no rotation, (b) rotation back and forth with hard stops at approximately -10 and +55 degrees, (c) rotation to the uncoupled position with no further rotation back or forth, and (d) 360-degree rotation.

- o The three drives that did not uncouple fall into the category of no rotation. During the actual uncoupling attempt there was minor rotation; however, this is representative of the clearances built into the torque tube, torque taker, and leadscrew interface.

- o A continued rotation back and forth with hard stops indicates that the spider (and possibly the control rods) did not move down after uncoupling.

- o Rotation to the uncoupled position with no further rotation back or forth indicated that the spider (and possibly the control rods) moved down greater than 0 inches and less than 2 inches. The inability to rotate back and forth was likely caused by the interference of the male tabs of the leadscrew bayonet and the female slots of the spider hub. A normal uncoupling would give this indication, because the spider would fall and be supported by the end fitting. However, this rotational indication, in addition to the normal load readings, would be required to clearly identify an undamaged CRDM.

- o Finally, the 360-degree rotation indicated that the spider dropped greater than 2 inches. This indication was verified by the uncoupling of the 8H and 9E leadscrews during Quick Look I and II followed by the subsequent camera inspections. This indication does not verify that the spider dropped into the core, only that it dropped greater than the 2 inches required to clear the tabs of the leadscrew and spider hub.

The remarks section of the data sheet was used to report unusual types of information, such as a stuck torque tube support ring, the operator's opinion of how the rotation of the leadscrew felt (compared to other B&W plants and training facilities), and clues as to what may have caused the indications that were recorded. In most cases, these comments were real time assessments of what the data indicated.

3.5. Results of Leadscrew Uncoupling Activities

The following summary of results categorizes the data into more usable information.

Based on analysis of the data obtained during leadscrew uncoupling, there are several categories into which the leadscrews can be grouped (the categories are not mutually exclusive).

- Locations where the control rod spiders never moved up or down (see Figure 3-10).
- Locations where the spiders moved down less than 2 inches after uncoupling (see Figure 3-11).
- Locations where the spiders moved up when lifted, but did not move down after uncoupling (see Figure 3-12).
- Locations where the spiders dropped greater than 2 inches after uncoupling (see Figure 3-13).
- Locations where the leadscrew has been uncoupled but parking the leadscrew may be difficult (see Figure 3-14).

- Locations where the leadscrew and torque taker are not bottomed on the torque taker belleville springs (see Figure 3-15).

- Locations where lack of leadscrew movement will not allow a potentially stuck leadscrew to be identified (see Figure 3-16).

Following is an explanation of how each of these conditions was identified.

3.5.3.1 <u>Spiders Did Not Move Up or Down</u>. Locations where the spiders never moved up or down (see Figure 3-10) were identified based on the following:

1. The first gauge reading was greater than 90 psi, indicating that the leadscrew was stuck in the drive or that the spider was holding it down. In these cases the belleville springs were compressed to gain the upward movement of the torque tube.

2. The second gauge reading was approximately 28 psi, which indicated that only the torque tube was lowered and not the leadscrew and spider.

3. During rotation, the leadscrew moved back and forth between hard stops repeatedly, which indicated that the spider was not moving down when the leadscrew was in the uncoupled position. In this position there was no mechanism in the drive to support the spider, and it should have fallen.

4. The third gauge reading remained near 28 psi, which indicated that the leadscrew was still supported. This support could have been from the spider or interferences in the drive.

5. The fourth gauge reading was less than the first reading, which indicated that the major interferences (stuck leadscrew) in the first reading were caused by the engagement of the leadscrew with the frozen spider assembly.

3.5.3.2 Spiders Moved Down Less Than 2 Inches. Locations where the spiders moved down less than 2 inches after uncoupling (see Figure 3-11) were identified based on the following:

1. The first gauge reading was less than 90 psi (75 psi is normal), which indicated that there were no significant interferences and the leadscrew was moving up.

2. The second gauge reading was about the same as the first, which indicated again that the assembly was moving up and down without interference from below. As this reading approached 53 psi it could be assumed that large portions of the control rod assembly were missing; however, this determination was not as positive as others because of inaccuracies in the weighing system.

3. During rotation, the leadscrew rotated to the uncoupled position and could not be rotated back or forth, which indicated that when the leadscrew was rotated to the uncoupled position the spider dropped off the leadscrew and was supported 0 to 2 inches below the leadscrew rotating position. In this position the spider coupling and leadscrew were interlocked and the spider was supported by something (e.g., the end fitting). If an undamaged drive was uncoupled with this equipment and procedure, this condition would be expected.

4. The third gauge reading should have been in the range of 53 psi, which would indicate that the leadscrew was not supported from the spider (or drive).

5. The fourth gauge reading should have been the same. If the reading was higher, this could have been attributed to interferences inside the drive mechanism since the spider dropped down when uncoupled.

3.5.3.3 Spider Moved Up When Lifted but Did Not Move Down When Uncoupled. Locations where the spiders moved up when lifted, but did not move down after uncoupling (see Figure 3-12), were identified based on the following:

1. The first gauge reading was greater than 60 psi and less than 90 psi, indicating that the leadscrew was lifted but the belleville springs were compressed.

2. The second gauge reading (although not important for the overall conclusion) gave additional information. If the reading was greater than 53 psi, the entire assembly was lowering. If the reading was about 28 psi, again this indicated something (e.g., the spider) was supporting the leadscrew weight.

3. During rotation, the leadscrew rotated back and forth between the hard stops repeatedly, which indicated that the spider did not drop when the leadscrew was in the uncoupled position.

4. The third gauge reading was the same as the second, which indicated that nothing had changed due to rotation.

5. The fourth gauge reading was the same as the first, which indicated that the interferences were in the drive; or the gauge reading was less than the first, which indicated that some interferences were lost when the leadscrew was uncoupled from the spider.

3.5.3.4 Spiders Dropped More Than 2 Inches. Locations where the spiders dropped more than 2 inches after uncoupling (see Figure 3-13) were identified based on the following: during rotation the leadscrew rotated greater than 55 degrees, which indicated that the spider had fallen away and therefore there were no hard stops. This indication was verified at locations 8H and 9E during the Quick Look CRDM leadscrew uncoupling and removal.

3.5.3.5 Uncoupled but Leadscrew May be Sticking. Locations where the leadscrew has been uncoupled but future parking of the leadscrew may be difficult (see Figure 3-14) were identified by the following:

1. The first gauge reading was greater than 75 psi, which indicated that some interferences existed or the spider was stuck.

2. The second gauge reading was around 28 psi, which indicated that the leadscrew was not lowered.

3. During rotation the leadscrew was rotated to the uncoupled position, which indicated that it was uncoupled from the spider.

4. The third gauge reading was around 28 psi, which indicated that the leadscrew was still supported.

5. The fourth gauge reading was greater than 60 psi, which indicated that the force required to move the leadscrew up was greater than 350 pounds (the design capacity of the leadscrew lifting tool).

3.5.3.6 Torque Taker Not Bottomed on Springs. Locations where the leadscrew and torque taker were not bottomed on the torque tube belleville springs (see Figure 3-15) were identified by the following: all four gauge readings were approximately 28 psi, which indicated that the bottom of the torque taker was a minimum of 3/8 inch above the top of the belleville springs. This indication was verified by the gauge readings of APSR uncouplings. In the case of APSRs the leadscrews were held in this position by the CRDM roller nuts and the only component lifted and lowered was the torque tube (i.e., 28 psi). Because the leadscrew rotation on these drives indicated that the spider was still present, it was concluded that something was holding the spider (and control rod assembly) greater than 3/8 inch higher than the CRDM scram position. The exact height of the leadscrew was not known, although it could be determined by placing a dipstick in the top of the motor tube and measuring the distance from the top of the leadscrew to the top of the motor tube.

3.5.3.7 <u>Locations Where Potentially Stuck Leadscrews Cannot Be Identified</u>. Locations where a lack of leadscrew movement will not allow a potentially stuck leadscrew to be identified (see Figure 3-16) can be divided into two categories:

1. APSR leadscrews are supported throughout the uncoupling sequence by the roller nuts; therefore, movement of the torque tube does not permit direct weighing of the leadscrew and/or its attachments or interferences. Because the APSR leadscrews were not moved or weighed during uncoupling operations, potential problems have not been identified; however, they may exist.

2. Locations where the torque taker was not bottomed on the belleville springs (see Section 3.5.3.6) because these leadscrews were supported during the uncoupling operations and were not moved or weighed during the uncoupling operations. Although parking problems have not been identified (due to lack of sufficient data), problems may exist.

3.5.4 <u>Explanation of Each Uncoupling</u> (see Figure 1-8)

10P - Belleville springs compressed (165 psi)
- Leadscrew did not lower (30 psi)
- Rotation felt smooth
- Hard stops were felt several times
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

11O - Leadscrew uncoupling attempted four times
- Uncoupling was successful on the fourth attempt
- Weights indicated leadscrew was stuck two out of four attempts
- Hard stops were felt several times
- Rotation felt stiff and sticky
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

12N - Leadscrew uncoupling attempted four times
- Belleville springs compressed four times (168 psi average)
- Leadscrew did not lower four times (31 psi average)
- Leadscrew did not rotate
- Leadscrew was not uncoupled
- Parking problems cannot be identified due to lack of data
- Damage could be between CRDM and leadscrew or between the leadscrew and spider

13M - Belleville springs were compressed (190 psi)
- Leadscrew did not lower (37 psi)
- Hard stops felt several times
- Rotation felt smooth
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

14L - Belleville springs were compressed (190 psi)
- Leadscrew did not lower (29 psi)
- Hard stops felt several times
- Rotation felt smooth
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

14H - Torque tube and leadscrew were moving up and down
- Control assembly weight less than normal
- Spider did not move down when uncoupled
- Rotation felt smooth
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

13K - Torque tube and leadscrew were moving up and down
- Control assembly weight less than normal
- Spider fell less than 2 inches when uncoupled
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

12L - APSR (4 percent withdrawn during insertion tests)
- Torque tube weight indications normal
- Spider fell less than 2 inches
- Parking problems cannot be identified due to lack of data
- Stator must raise leadscrew a minimun of 2 inches in order to park
- Leadscrew was uncoupled from spider

11M - Torque tube and leadscrew were moving up and down
- Control rod assembly weight less than normal
- Spider fell greater than 2 inches
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

10N - APSR (0 percent withdrawn during insertion tests)
- Torque taker bottom on torque tube
- First attempt, torque tube could not be lifted
- Leadscrew nut backed off three turns, creating clearance to lift torque tube
- Second attempt, torque tube was uncoupled
- High first reading indicated that clearances between roller nuts and leadscrew had to be used to create the clearance needed to uncouple the torque tube from the motor tube
- Once torque tube was uncoupled, readings were normal
- Spider did not drop
- Stator must raise leadscrew a minimum of 2 inches in order to park
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

90 - First reading was less than normal (65 psi)
- Second and third readings indicated stuck leadscrew (35 psi)
- Rotation felt smooth
- Spider did not drop
- Parking problems are anticipated (65 psi)
- Leadscrew was uncoupled from spider

8P - Drive was uncoupled during Quick Look II
- Leadscrew could not be parked with 350 pounds
- Leadscrew lifted, indicating a stuck leadscrew; did not indicate compressing of bellevilles (75 psi)
- Second and third readings indicated stuck leadscrew
- Hard stops were felt
- Spider did not drop
- Parking problems are anticipated (and proven via Quick Look II activities)
- Leadscrew was uncoupled from spider

6P - Belleville springs were compressed
- Leadscrew supported (30 psi)
- Rotation never moved
- Parking problems are anticipated (60 psi)
- Leadscrew was uncoupled from spider

70 - Belleville springs were compressed (140 psi)
- Leadscrew supported (30 psi)
- Spider never moved
- Rotation felt smooth
- Parking problems are anticipated (75 psi)
- Leadscrew was uncoupled from spider

8N - Belleville springs were compressed (170 psi)
- Leadscrew supported (30 psi)
- Rotation felt smooth
- Spider never moved
- Parking problems are anticipated (90 psi)
- Leadscrew was uncoupled from spider

9M - Belleville springs were compressed (225 psi)
- Leadscrew supported (30 psi)
- Rotation felt smooth
- Spider never moved

9M - Parking problems are anticipated (60 psi)
(Cont) - Leadscrew was uncoupled from spider

10L - Leadscrew and torque tube moving up and down
- Control rod assembly weight less than normal
- Spider dropped greater than 2 inches
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

11K - Leadscrew and torque tube moving up and down
- Control rod assembly weight less than normal
- Spider dropped less than 2 inches after two hard stops were felt
- No parking problems are anticipated (55 psi)
- Leadscrew was uncoupled from spider

12H - Leadscrew and torque tube moving up and down
- Control rod assembly weight less than normal
- Spider dropped greater than 2 inches
- Parking problems are anticipated (60 psi)
- Leadscrew was uncoupled from spider

13G - Leadscrew and torque tube moving up and down
- Control rod assembly weight less than normal
- Spider dropped less than 2 inches
- Parking problems are anticipated (60 psi)
- Leadscrew was uncoupled from spider

14F - Belleville springs were compressed (125 psi)
- Leadscrew was supported prior to rotation
- Spider never moved
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

13E - First attempt, the torque tube support ring was stuck to the torque tube

13E - Tapping with the rubber mallet freed the binding

(Cont) - Second attempt, compressed belleville springs (245 psi)

- Leadscrew seemed to move down (60 psi)
- Leadscrew was supported after rotation (30 psi)
- Spider did not move down when uncoupled
- Parking problems are anticipated (65 psi)
- Leadscrew was uncoupled from spider

12F - APSR (1 percent withdrawn during insertion tests)

- Weight indication normal
- Rotation felt hard (could be due to leadscrew rotating through roller nuts)
- Spider did not drop
- Stator must raise leadscrew a minimum of 2 inches prior to park
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

11G - Leadscrew and torque tube moved up and down

- Control rod assembly weight less than normal
- Rotation felt smooth
- Spider dropped greater than 2 inches
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

10H - Leadscrew and torque tube moved up and down

- Control rod assembly weight less than normal
- Spider dropped less than 2 inches
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

9K - Leadscrew and torque tube moved up and down

- Control rod assembly weight less than normal
- Spider dropped less than 2 inches
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

8L - Belleville springs were compressed (165 psi)
- Leadscrew supported before and after rotation
- Spider never moved
- Rotation felt smooth
- Parking problems are anticipated (72 psi)
- Leadscrew was uncoupled from spider

7M - Leadscrew and torque tube moved up and down
- Control rod assembly weight less than normal
- Spider did not drop after uncoupling
- Rotation felt smooth
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

6N - APSR (25 percent withdrawn during insertion tests)
- Weight indications were normal
- Rotation felt rough (probably due to rotation of leadscrew in roller nuts)
- Spider did not drop after uncoupling
- Stator must raise leadscrew a minimum of 2 inches in order to park
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

5O - Leadscrew weights were low throughout, indicating that the leadscrew and torque taker were not bottomed on the belleville springs
- Spider did not drop after uncoupling
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

4N - Leadscrew weight lower than normal (65 psi)
- Leadscrew supported prior to rotation (30 psi)
- Rotation felt rought (little interference)
- Spider did not drop after uncoupling
- Leadscrew not supported after rotation (55 psi)

4N - Parking problems are anticipated (66 psi)
(Cont) - Leadscrew was uncoupled from spider

5M - Leadscrew weights were low throughout, indicating that the leadscrew and torque taker were not bottomed on the belleville springs
- Rotation was rough
- Spider did not drop after uncoupling
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

6L - Belleville springs were compressed
- Leadscrew was supported (35 psi)
- Rotation smooth
- Spider never moved
- Parking problems are anticipated (80 psi)
- Leadscrew was uncoupled from spider

7K - Uncoupling was attempted during Quick Look I
- Second attempt, leadscrew weight indication was low, indicating no control elements present (verified by Quick Look inspection)
- Approximately 20-degree rotation
- Parking problems cannot be identified due to lack of data
- Leadscrew was not uncoupled from spider

8H - Uncoupled and removed during Quick Look I (see Section 3.2.3)

9G - Leadscrew and torque tube moved up and down
- Control rod weight less than normal
- Rotation felt smooth
- Spider did not move down after uncoupling
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

10F - Leadscrew and torque tube moved up and down

10F - Control rod weight less than normal

(Cont) - Rotation felt sticky at 180-degree rotation

- Spider dropped greater than 2 inches
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

11E - Leadscrew and torque tube moved up and down

- Control rod assembly weight less than normal
- Rotation was sticky at 180 degrees
- Spider dropped greater than 2 inches
- No parking problems can be anticipated
- Leadscrew was uncoupled from spider

12D - Leadscrew weight greater than normal (85 psi)

- Leadscrew was supported prior to rotation
- Rotation smooth
- Spider did not move down after uncoupling
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

11C - Belleville springs were compressed

- Leadscrew was supported before and after rotation
- Spider never moved
- Rotation felt smooth
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

10D - APSR (23 percent withdrawn during insertion tests)

- Weights normal
- Rotation sticky clockwise (probably because of interface between leadscrew and roller nuts)
- Spider did not move down after uncoupling
- Stator must raise leadscrew a minimum of 2 inches in order to park
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

10F - Control rod weight less than normal
(Cont) - Rotation felt sticky at 180-degree rotation
- Spider dropped greater than 2 inches
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

11E - Leadscrew and torque tube moved up and down
- Control rod assembly weight less than normal
- Rotation was sticky at 180 degrees
- Spider dropped greater than 2 inches
- No parking problems can be anticipated
- Leadscrew was uncoupled from spider

12D - Leadscrew weight greater than normal (85 psi)
- Leadscrew was supported prior to rotation
- Rotation smooth
- Spider did not move down after uncoupling
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

11C - Belleville springs were compressed
- Leadscrew was supported before and after rotation
- Spider never moved
- Rotation felt smooth
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

10D - APSR (23 percent withdrawn during insertion tests)
- Weights normal
- Rotation sticky clockwise (probably because of interface between leadscrew and roller nuts)
- Spider did not move down after uncoupling
- Stator must raise leadscrew a minimum of 2 inches in order to park
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

9E - Leadscrew uncoupled and removed during Quick Look II

8F - Leadscrew weights were low through, indicating that the leadscrew and torque taker were not bottomed on the belleville springs
- Rotation rough and got easier with additional rotations
- Spider did not drop after uncoupling
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

7G - Leadscrew and torque tube moved up and down
- Control rod assembly weight less than normal
- Rotation was rough, then stopped, then free
- Spider dropped greater than 2 inches
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

6H - Leadscrew and torque tube moved up and down
- Control rod assembly weight less than normal
- Rotation felt smooth
- Spider dropped greater than 2 inches
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

5K - Leadscrew and torque tube moved up and down
- Control rod assembly weight less than normal
- Rotation was rough at 180 degrees
- Spider dropped greater than 2 inches
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

4L - APSR (19 percent withdrawn during insertion tests)
- Weight indications normal
- Spider did not drop after uncoupling
- Stator must raise leadscrew a minimum of 2 inches in order to park
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

3M - Leadscrew did not uncouple during first attempt
- Leadscrew and torque tube moved up and down during both attempts
- First attempt, no rotation
- Second attempt, stiff rotation
- Spider dropped greater than 2 inches
- No parking problems anticipated
- Leadscrew was uncoupled from spider

2L - Belleville springs were compressed (170 psi)
- Leadscrew was supported before and after rotation
- Rotation was rough with little change
- Spider never moved
- Parking problems are anticipated (125 psi)
- Leadscrew was uncoupled from spider

3K - Leadscrew and torque tube moved up and down
- Control rod assembly weight less than normal
- Rotation was smooth
- Spider dropped greater than 2 inches
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

4H - Leadscrew weight normal
- Assembly seemed to move up and down
- Control assembly weight may be low
- Rotation a little rough
- Spider dropped greater than 2 inches
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

5G - Leadscrew and torque tube moved up and down
- Some interferences noticeable
- Rotation felt smooth
- Spider dropped greater than 2 inches
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

6F - Leadscrew and torque tube moved up and down
- Control rod assembly weight less than normal
- Rotation felt smooth
- Spider dropped greater than 2 inches
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

7E - Leadscrew and torque tube moved up and down
- Control rod assembly weight seemed normal for first reading
- Spider did not drop after uncoupling
- Rotation felt smooth
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

8D - Leadscrew weights were low throughout, indicating that the leadscrew and torque taker were not bottomed on the belleville springs
- Rotation felt smooth
- Spider did not drop after uncoupling
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

9C - Belleville springs were compressed
- Leadscrew was supported before and after rotation
- Rotation felt a little rough
- Spider never moved
- Parking problems are anticipated
- Leadscrew was uncoupled from spider

10B - Leadscrew weights were low throughout, indicating that the leadscrew and torque taker were not bottomed on the belleville springs
- Spider did not drop after uncoupling
- Rotation felt smooth
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

8B - Uncoupled and removed during Quick Look II

7C - Leadscrew and torque tube moved up and down
- Some interferences detected
- Rotation felt a little rough
- Spider dropped greater than 2 inches
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

6D - APSR (26 percent withdrawn during insertion tests)
- Weight indications normal
- Rotation a little rough (due to leadscrew roller nut interface)
- Spider did not drop after uncoupling
- Stator must raise the leadscrew a minimum of 2 inches in order to park
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

5E - Leadscrew and torque tube moved up and down
- Control rod assembly weight less than normal
- Spider dropped less than 2 inches after uncoupling
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

4F - APSR (5 percent withdrawn during insertion tests)
- Weight indications normal
- Spider dropped less than 2 inches after uncoupling
- Stator must raise the leadscrew a minimum of 2 inches prior to park
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

3G - Leadscrew and torque tube moved up and down
- Control rod assembly weight less than normal
- Spider dropped less than 2 inches after two hard stops were felt
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

2H - Leadscrew weights were low throughout, indicating that the leadscrew and torque taker were not bottomed on the belleville springs
- Rotation felt spongy
- Spider did not drop after uncoupling
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

2F - Leadscrew weights were low throughout, indicating that the leadscrew and torque taker were not bottomed on the belleville springs
- Excessive amount of torque was applied to the tool and the leadscrew would not rotate
- Rotation attempts may have increased interferences
- Leadscrew was not uncoupled from the spider

3E - Belleville springs were compressed
- Leadscrew supported before and after rotation
- Rotation felt smooth
- Spider never moved
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

4D - Belleville springs were compressed
- Leadscrew supported before and after rotation
- Spider never moved
- Rotation felt smooth
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

5C - Belleville springs were compressed
- Leadscrew supported before and after rotation
- Spider never moved
- Rotation felt smooth
- No parking problems are anticipated
- Leadscrew was uncoupled from spider

6B - Leadscrew weights were low throughout, indicating that the leadscrew and torque taker were not bottomed on the belleville springs
- Rotation felt smooth
- Spider did not drop after uncoupling
- Parking problems cannot be identified due to lack of data
- Leadscrew was uncoupled from spider

3.6 Descriptions of Photographs

Figure 3-17 - This photograph shows the cutting of the leadscrew by band saw. The band saw is mounted to three CRDM motor tubes and is being operated from 3 feet away.

The leadscrew is wrapped in Herculite for contamination control. In addition, a chip deflector is mounted over the motor tube so that filings from the cut do not fall into the motor tube during cutting.

The cut was completed in less than 1 minute.

Figure 3-18 - This photograph shows the operators transporting the wrapped leadscrew from the CRDM motor tube to a storage pipe at the side of the service structure. The leadscrew is hanging from an overhead hoist and is being directed into the storage tube by a long-handled tool to keep distance between the operator and the leadscrew.

Figure 3-19 - This photograph shows the camera being lowered into the CRDM motor tube. Work platforms are provided for ease of access around the array of motor tubes.

Figure 3-20 - This photograph shows either a control rod spring or a fuel rod spring lying in the core debris bed. More specific identification of the spring could not be made because the only difference between the two springs is the length, which could not be determined.

Figure 3-21 - This photograph shows a portion of the spider found during the initial inspection at location 8H. This portion of the spider is an extreme close-up of the 'web," i.e., the connection of two of the spider arms (see Figure 1-6).

Figure 3-22 - This is a photograph of the debris or rubble bed found ~5' below the normal top of the core. Material of this type was found at both the 8H and 9E locations.

Figure 3-23 - The right-angle viewing attachment used with the camera during Quick Look III allowed for inspection of debris deposited on the horizontal surfaces in the guide tubes at location 9E.

Figure 3-24 - This photograph shows a broken fuel rod among an array of otherwise intact rods.

Figure 3-25 - This photograph shows a burnable poison rod pellet. It is not a fuel pellet, since fuel pellets are manufactured with dished ends.

Figure 3-26 - The top of a spring retainer plug (Figure 3-29) is visible in the far right center of the picture. Debris is lodged between the ears of an upper end fitting, above the spring retainer plug, and against the plenum grid pad.

Figure 3-27 - This photograph shows a corner between four end fittings. The fourth end fitting is barely visible in the lower left center of the picture.

Figure 3-28 - This photograph is a view up from the void area at a split tube in the last (tenth) brazement. The tube provides guidance for the inner control rods and is fabricated from 304 stainless steel.

Figure 3-29 - This photograph shows an end fitting spring retainer plug (location 9E). The debris shown in Figure 3-26 is barely visible. A small gas bubble is trapped between the spring retainer plug and end fitting car.

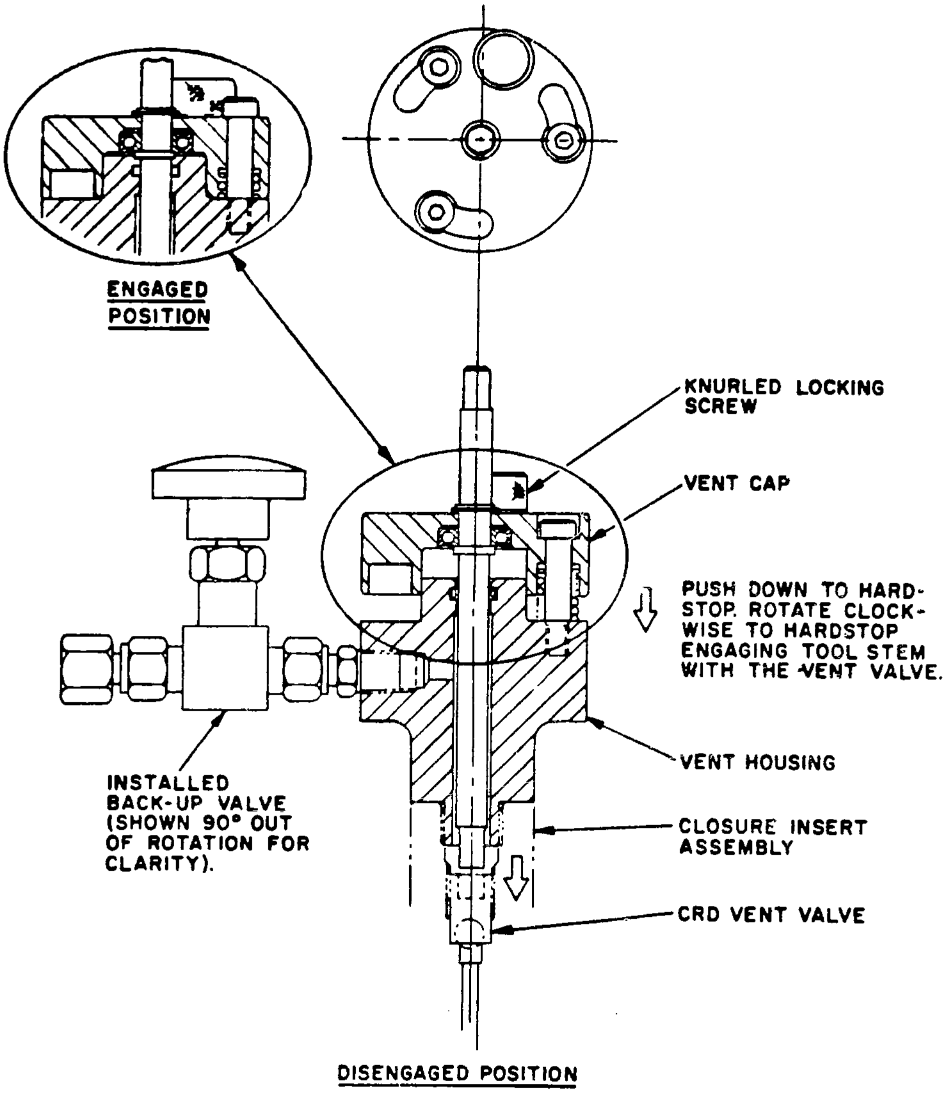


Figure 3-1. CRDM venting tool.

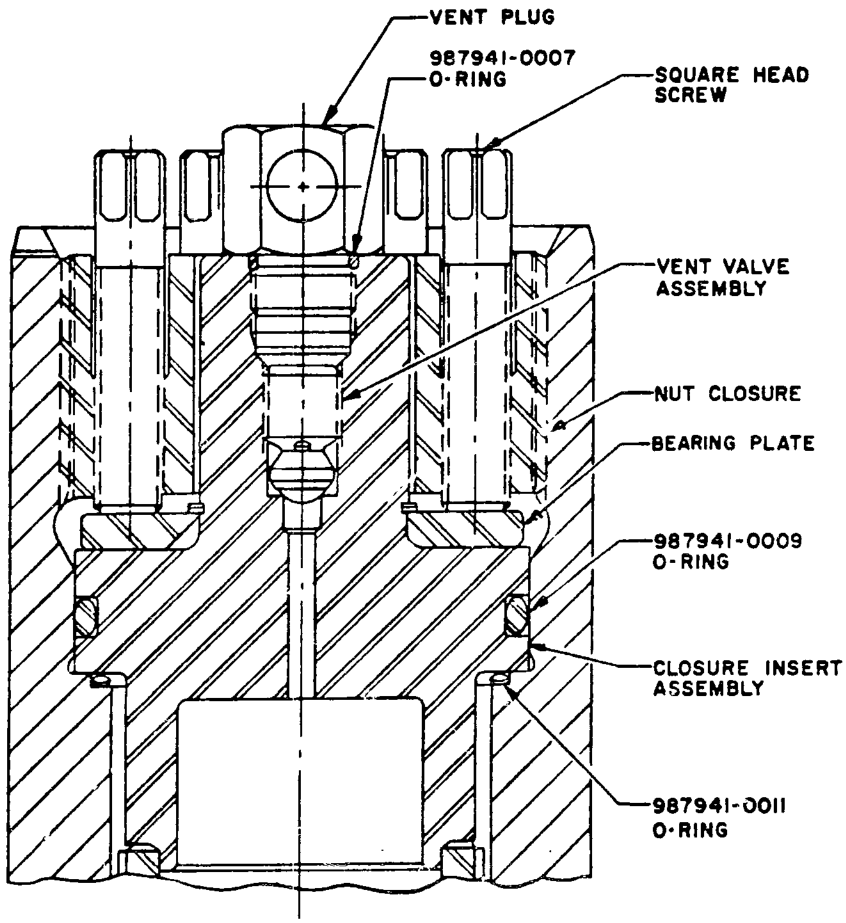
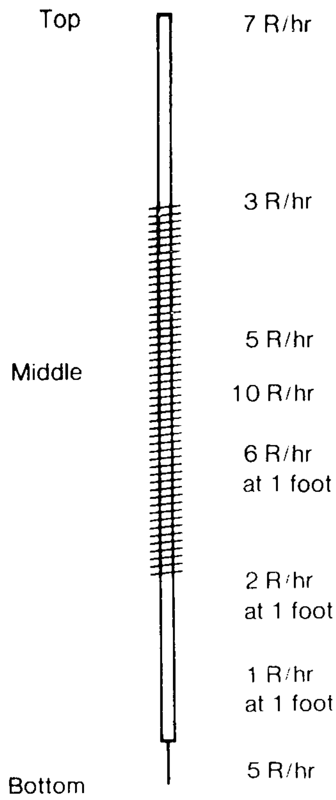
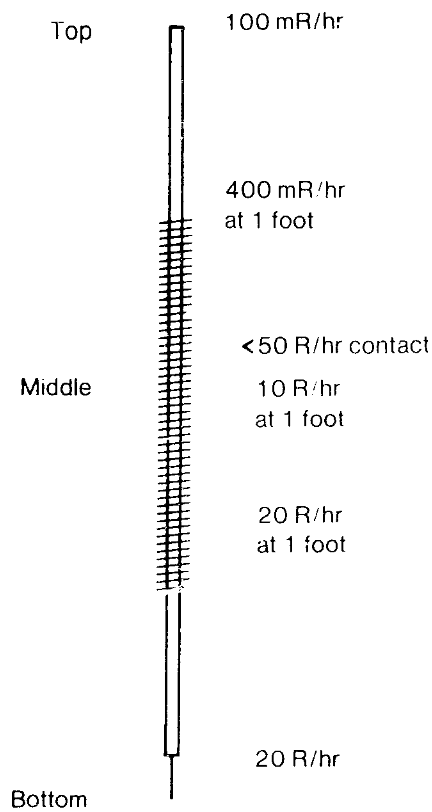


Figure 3-2. CRDM top closure parts.



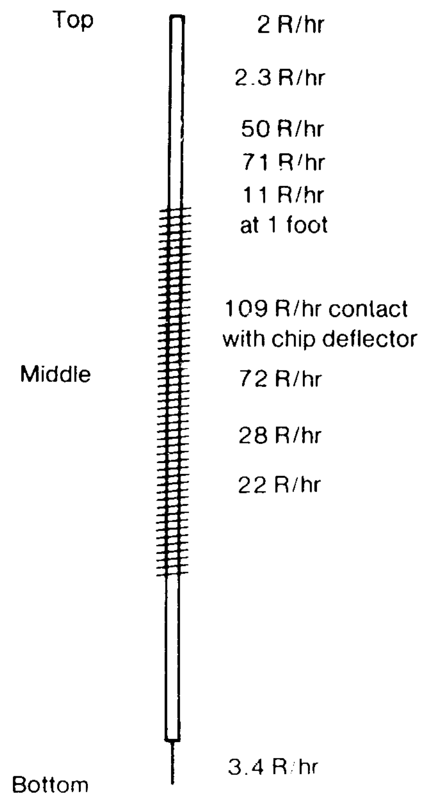
Note: Unless noted otherwise, all dose rates are contact dose rates.

Figure 3-3. Leadscrew 8H dose rates.



Note: Unless noted otherwise, all dose rates are contact dose rates.

Figure 3-4. Leadscrew 9E dose rates.



Note: Unless noted otherwise, all dose rates are contact dose rates.

Figure 3-5. Leadscrew 8B dose rates.

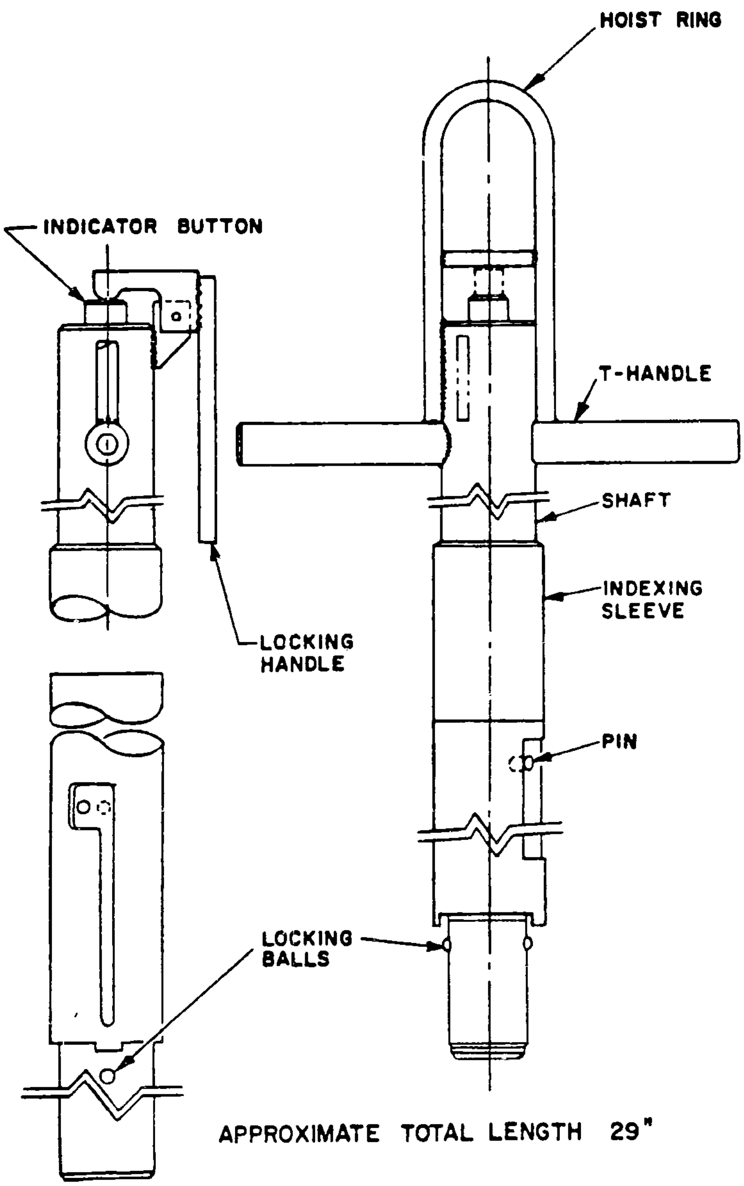


Figure 3-6. Alternate uncoupling tool.

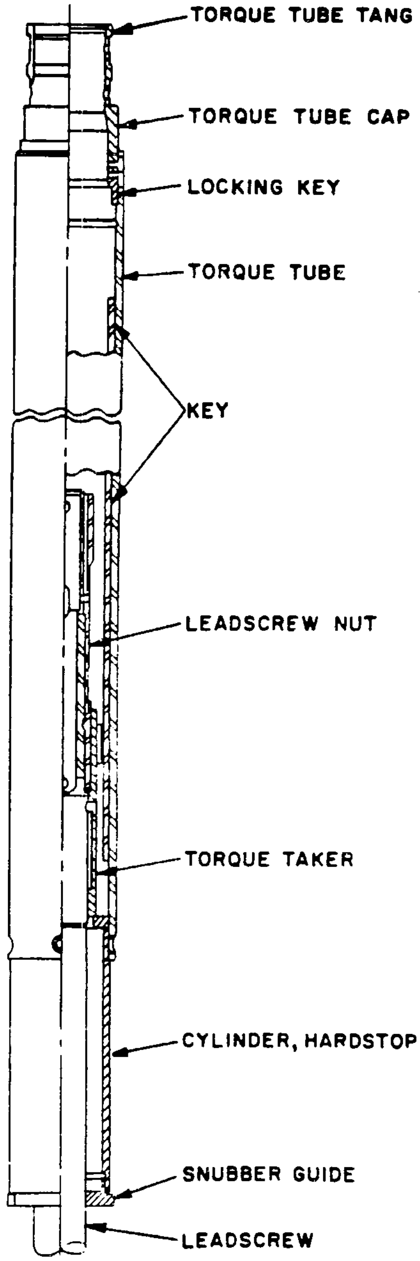


Figure 3-7. CRDM torque tube assembly.

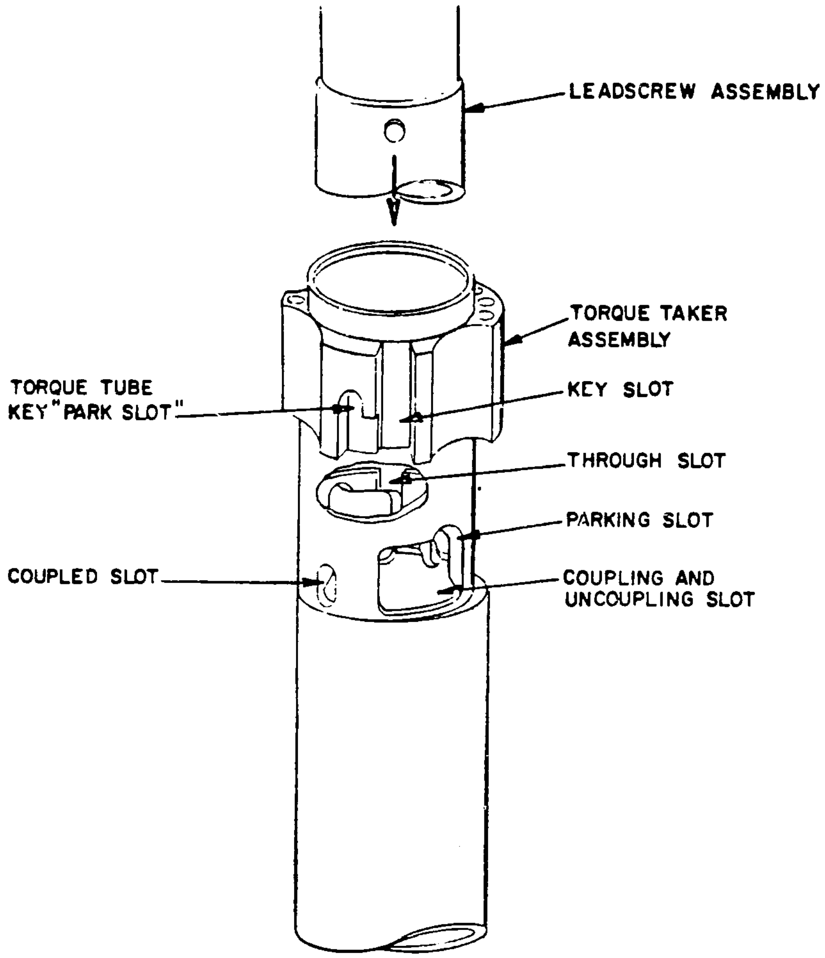


Figure 3-8. Torque taker installation on leadscrew.

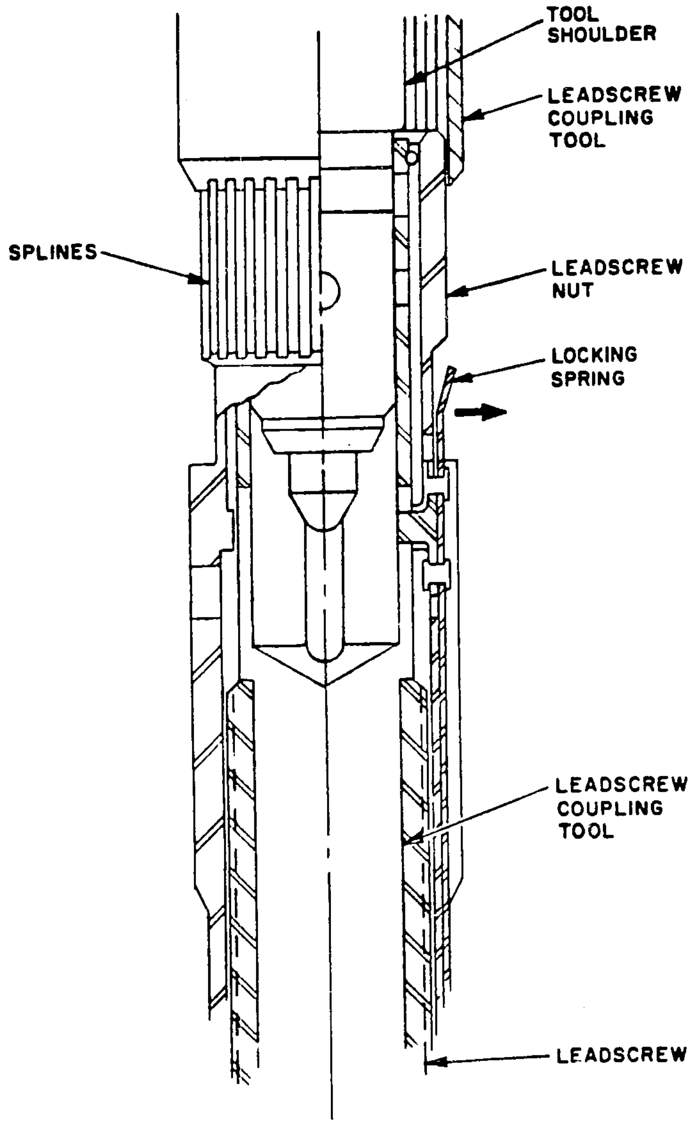
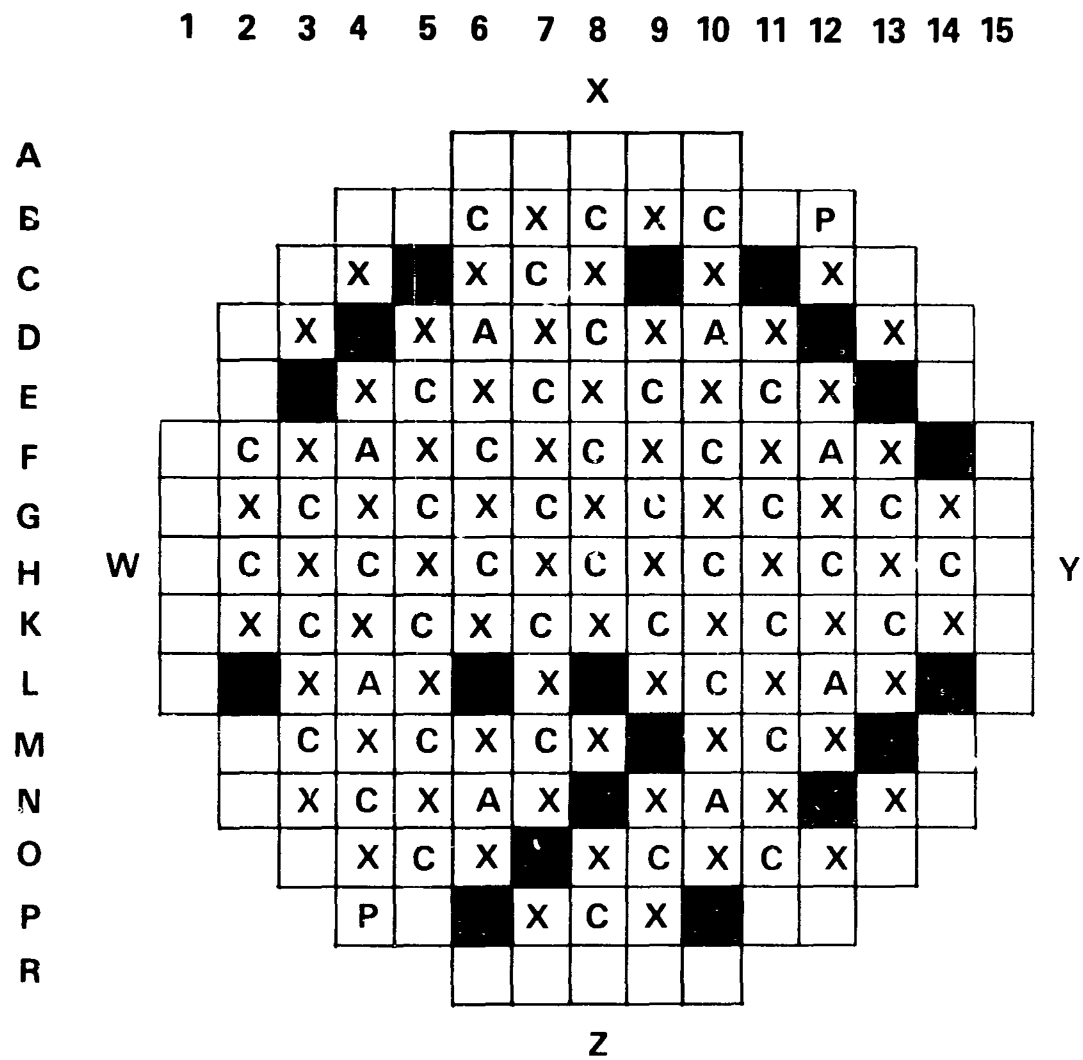


Figure 3-9. Leadscrew nut assembly.



CONTAINS NO CONTROL COMPONENT

C CONTROL ROD ASSEMBLIES

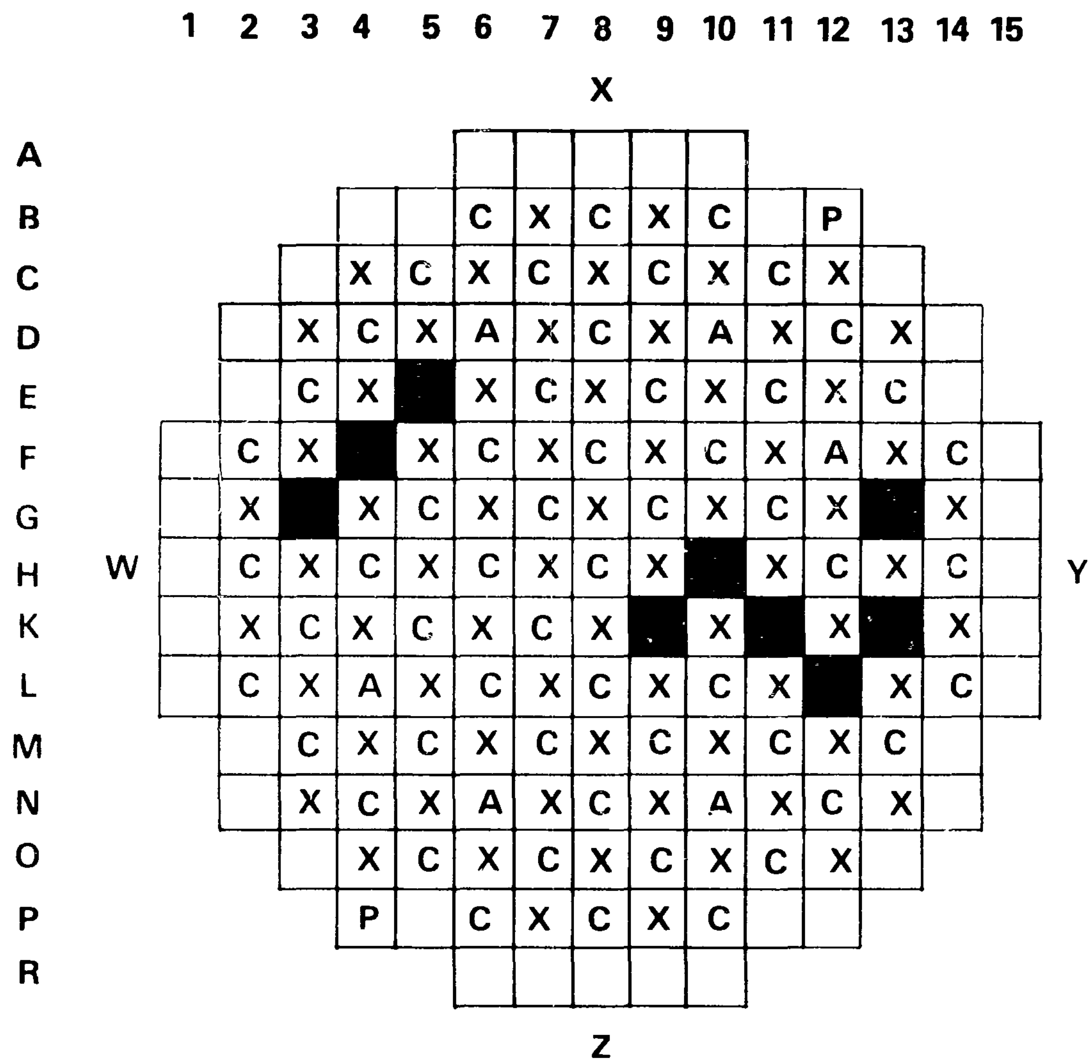
A AXIAL POWER SHAPING ROD ASSEMBLIES

X BURNABLE POISON ROD ASSEMBLIES

P PRIMARY NEUTRON SOURCES

LOCATIONS WHERE SPIDERS NEVER MOVED UP OR DOWN

Figure 3-10. Locations where the control rod spiders never moved up or down.



CONTAINS NO CONTROL COMPONENT

C CONTROL ROD ASSEMBLIES

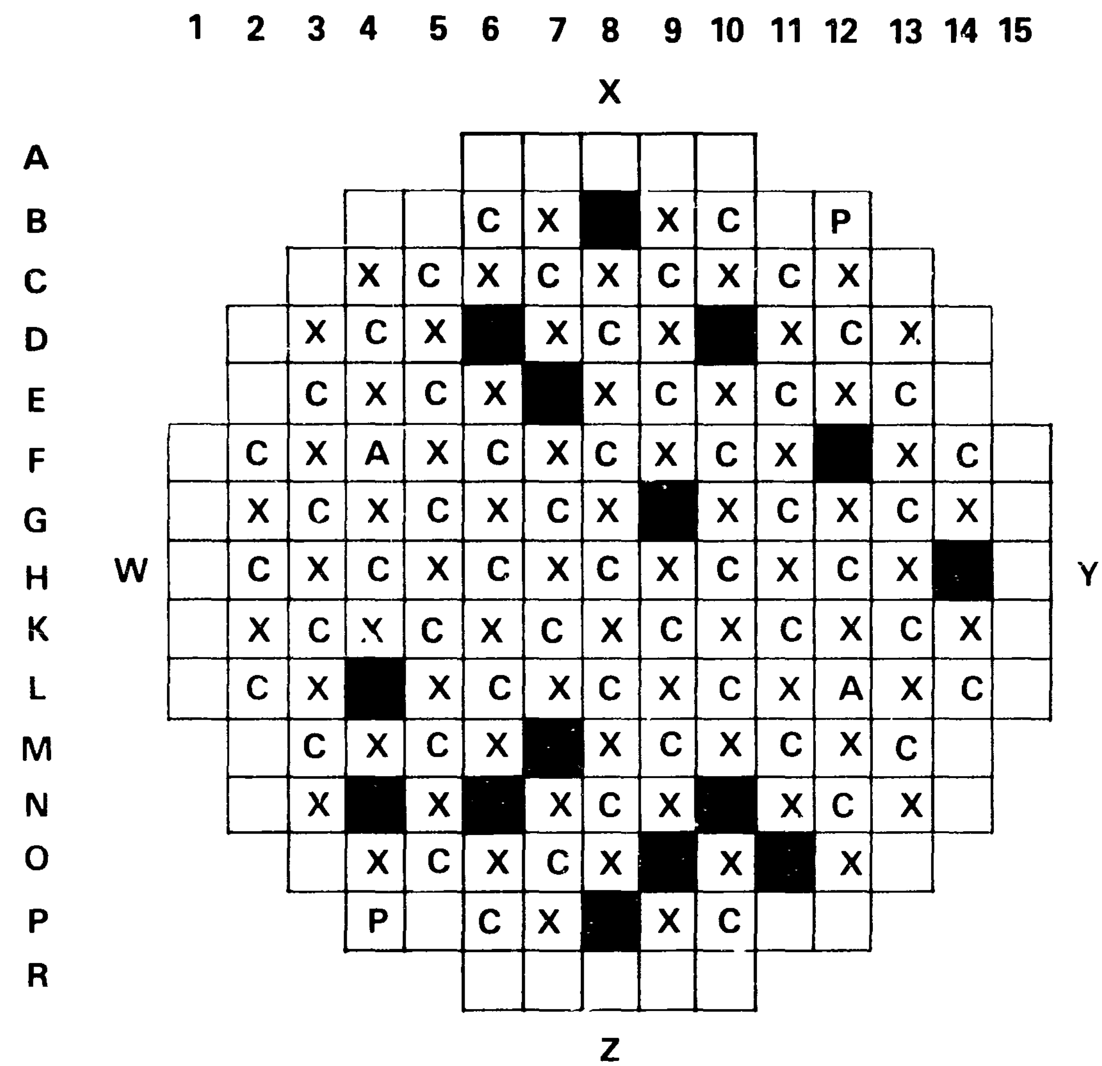
A AXIAL POWER SHAPING ROD ASSEMBLIES

X BURNABLE POISON ROD ASSEMBLIES

P PRIMARY NEUTRON SOURCES

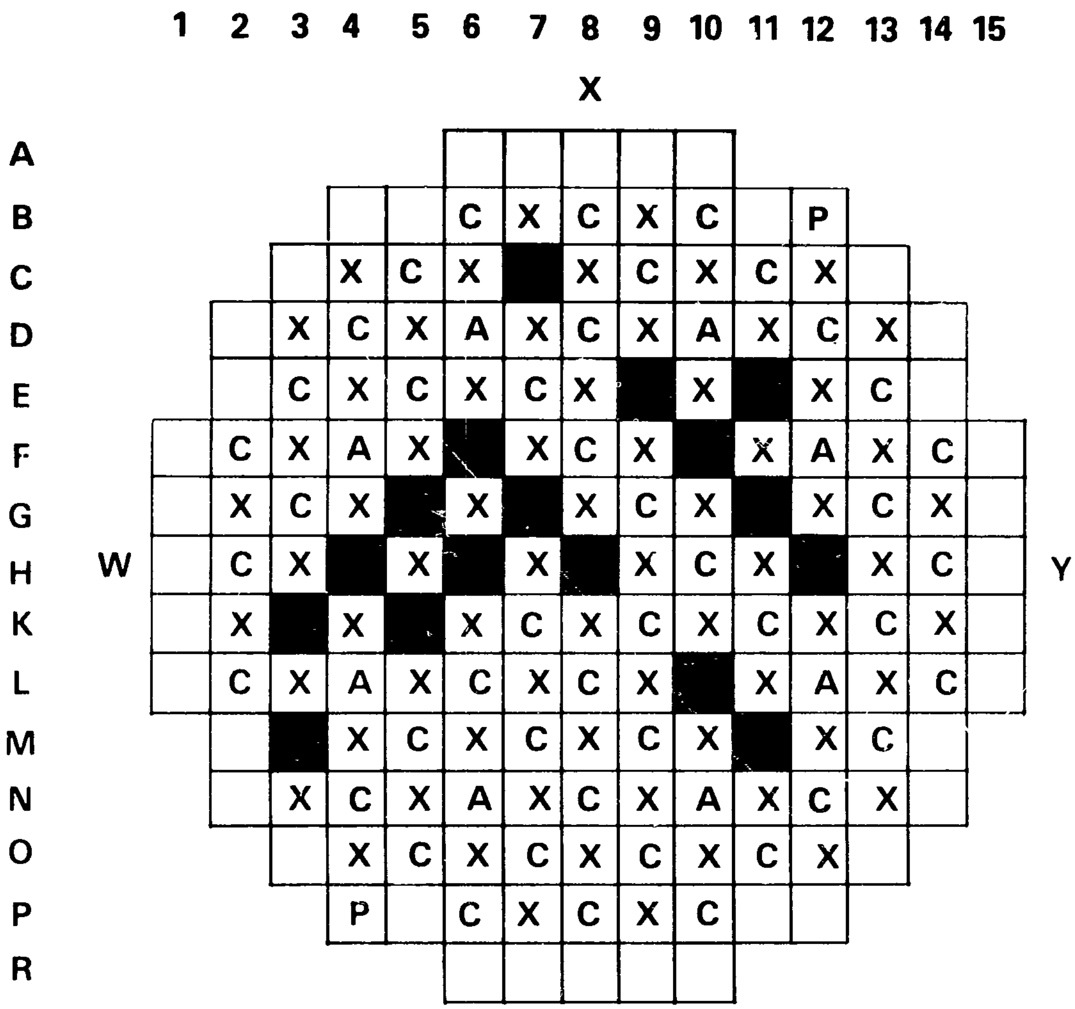
LOCATIONS WHERE THE SPIDERS MOVED DOWN LESS THAN 2 INCHES AFTER UNCOUPLING

Figure 3-11. Locations where the spiders moved down less than 2 inches after uncoupling.



- CONTAINS NO CONTROL COMPONENT
- C CONTROL ROD ASSEMBLIES
- A AXIAL POWER SHAPING ROD ASSEMBLIES
- X BURNABLE POISON ROD ASSEMBLIES
- P PRIMARY NEUTRON SOURCES
- LOCATIONS WHERE THE SPIDERS MOVED UP WHEN LIFTED, BUT DID NOT MOVE DOWN AFTER UNCOUPLING

Figure 3-12. Locations where the spiders moved up when lifted, but did not move down after uncoupling.



CONTAINS NO CONTROL COMPONENT

C CONTROL ROD ASSEMBLIES

A AXIAL POWER SHAPING ROD ASSEMBLIES

X BURNABLE POISON ROD ASSEMBLIES

P PRIMARY NEUTRON SOURCES

LOCATIONS WHERE THE SPIDERS DROPPED GREATER THAN 2 INCHES AFTER UNCOUPLING

Figure 3-13. Locations where the spiders dropped greater than 2 inches after uncoupling.

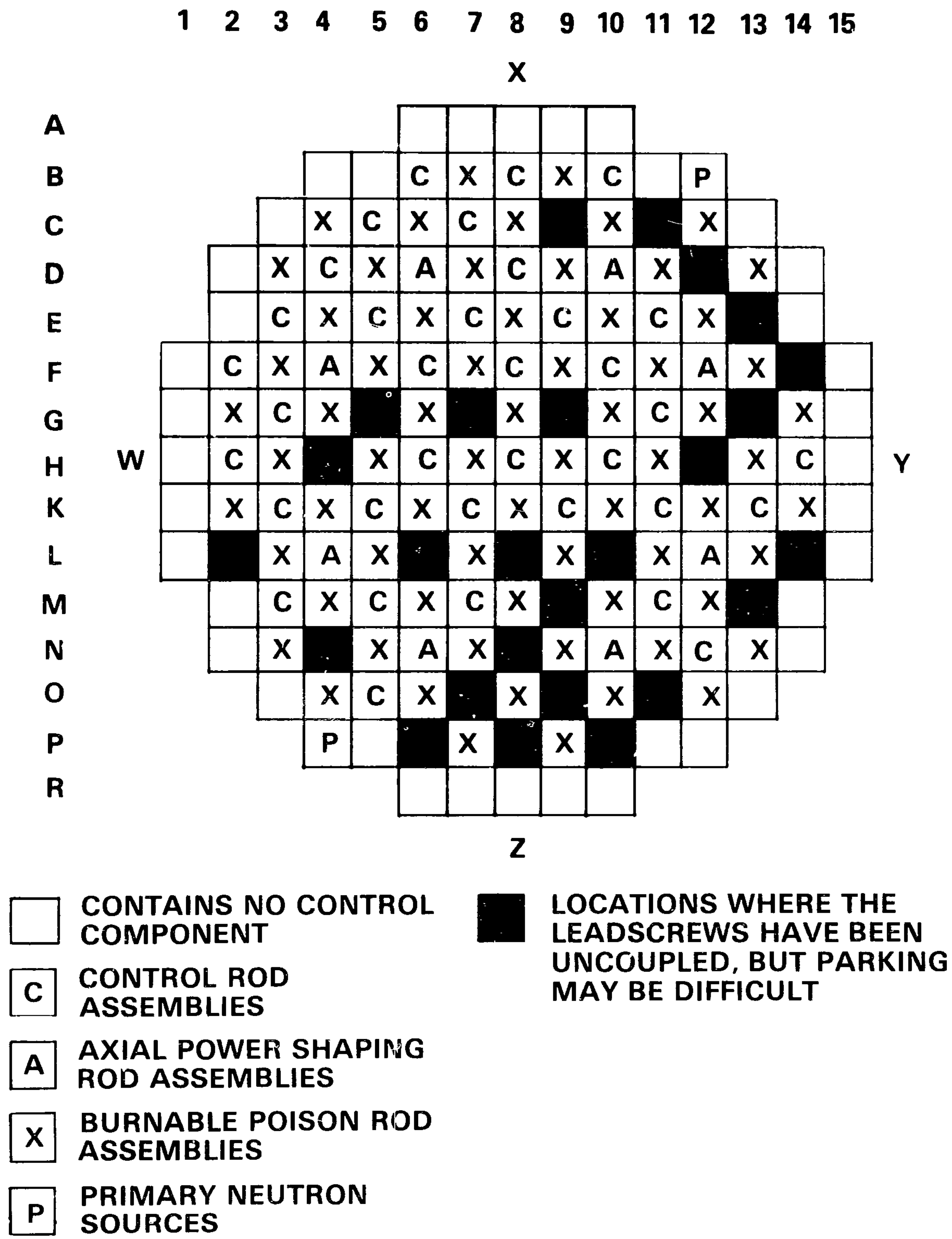
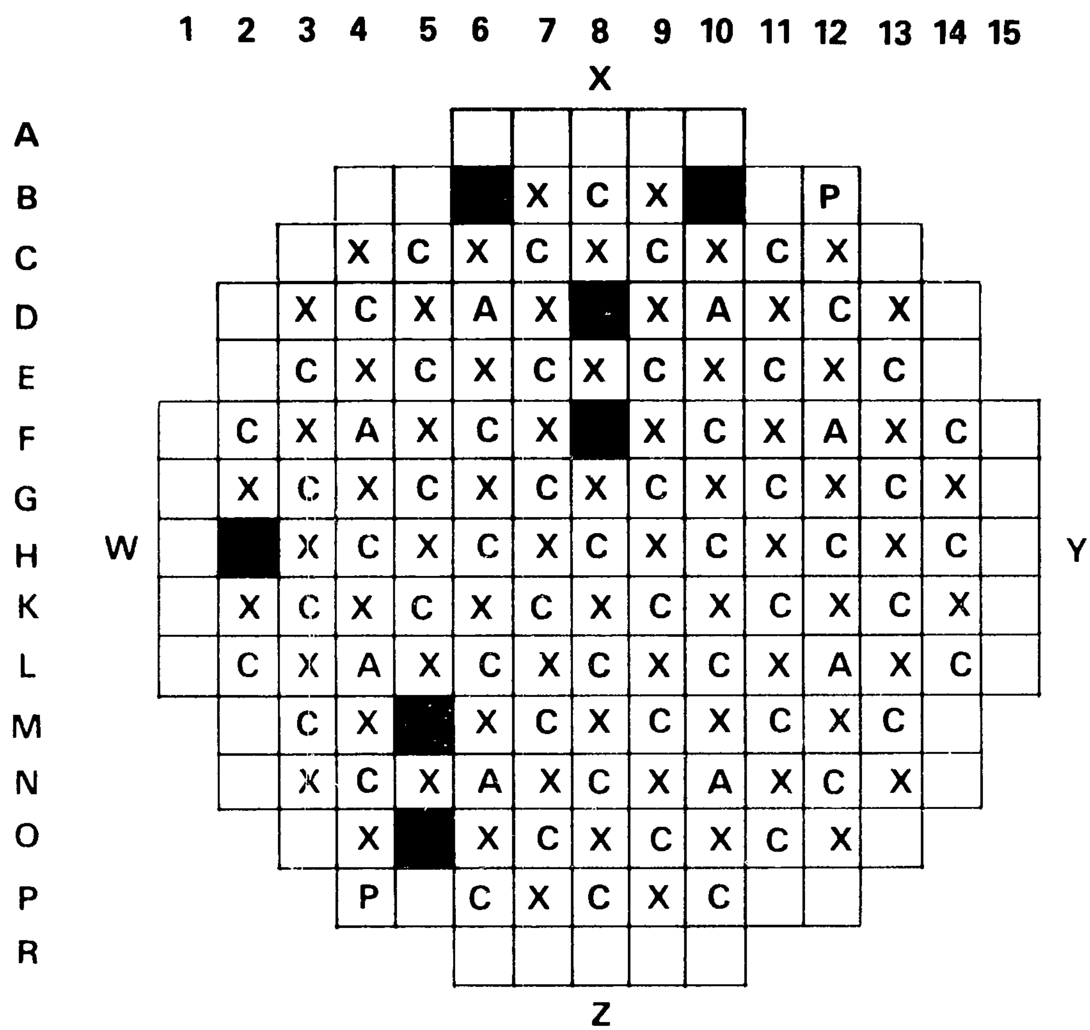


Figure 3-14. Locations where the leadscrews have been uncoupled, but parking the leadscrews may be difficult.



☐	CONTAINS NO CONTROL COMPONENT
C	CONTROL ROD ASSEMBLIES
A	AXIAL POWER SHAPING ROD ASSEMBLIES
X	BURNABLE POISON ROD ASSEMBLIES
P	PRIMARY NEUTRON SOURCES
■	LOCATIONS WHERE THE LEADSCREWS AND TORQUE TAKERS ARE NOT BOTTOMED ON THE TORQUE TUBE BELLEVILLE SPRINGS

Figure 3-15. Locations where the leadscrews and torque takers are not bottomed on the torque tube belleville springs.

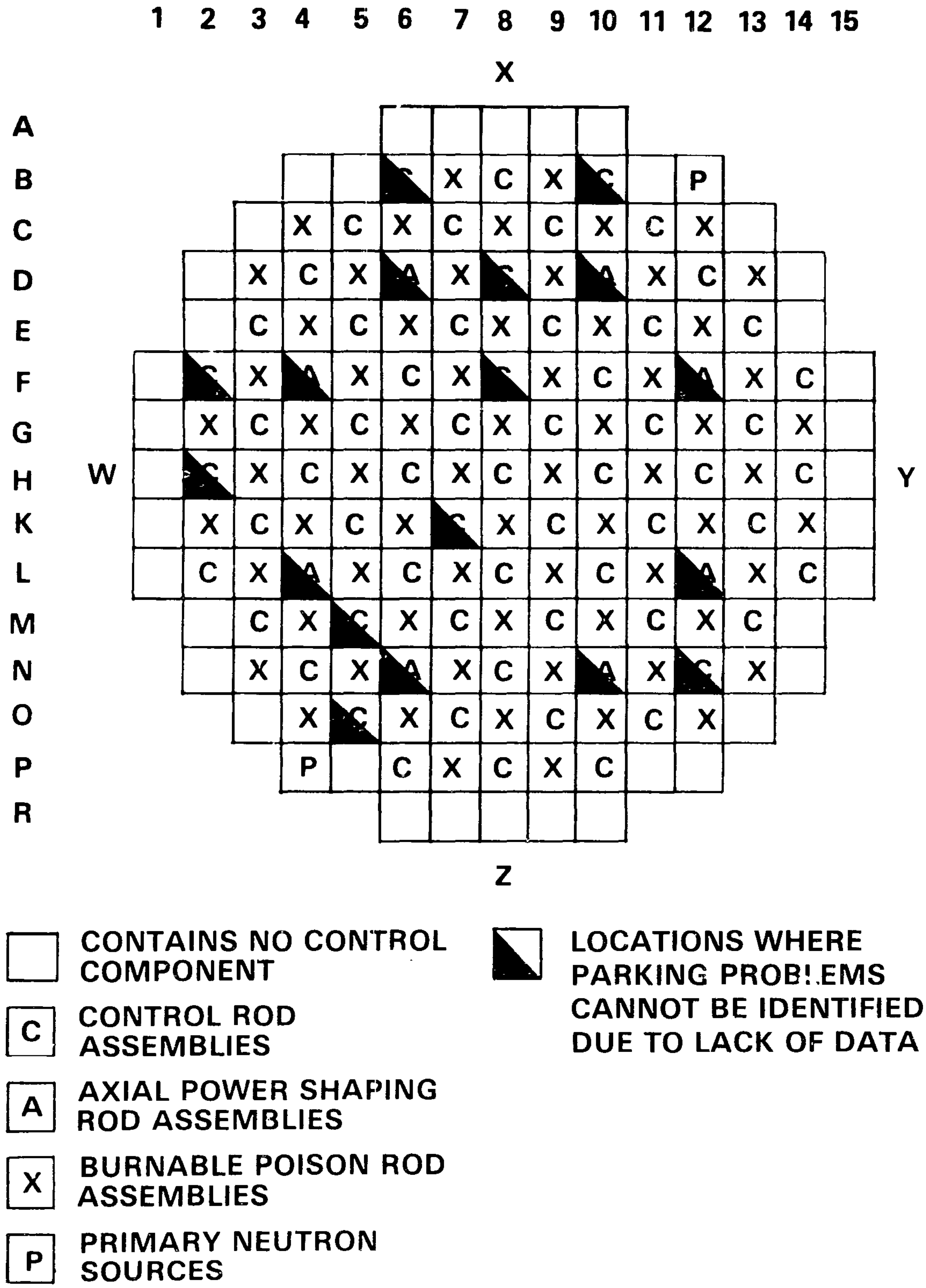


Figure 3-16. Locations where parking problems cannot be identified due to lack of data.

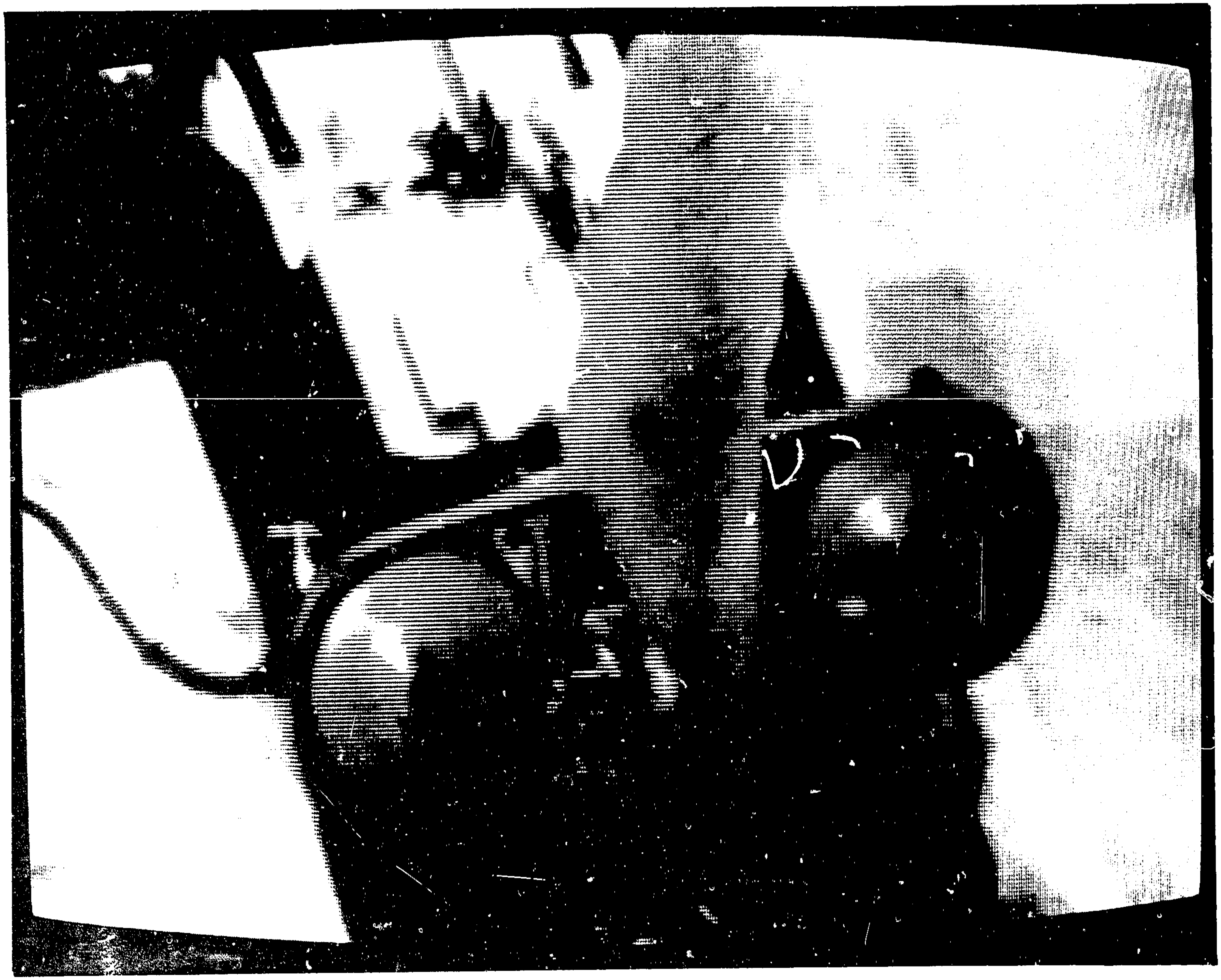


Figure 3-17. Cutting of the leadscrew by the band saw.

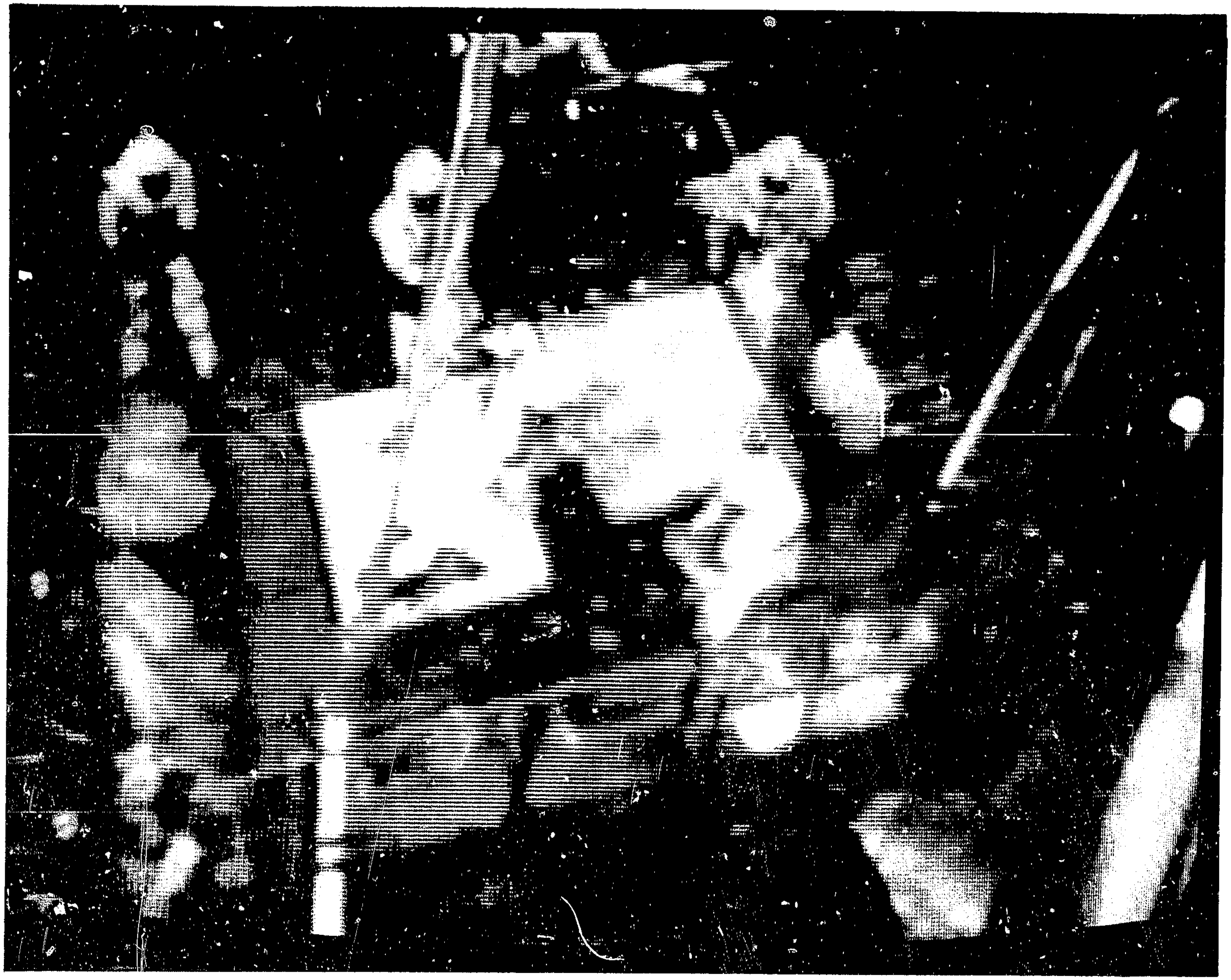


Figure 3-18. Removing the wrapped leadscrew from the service structure to a storage tube at the side of the service structure.

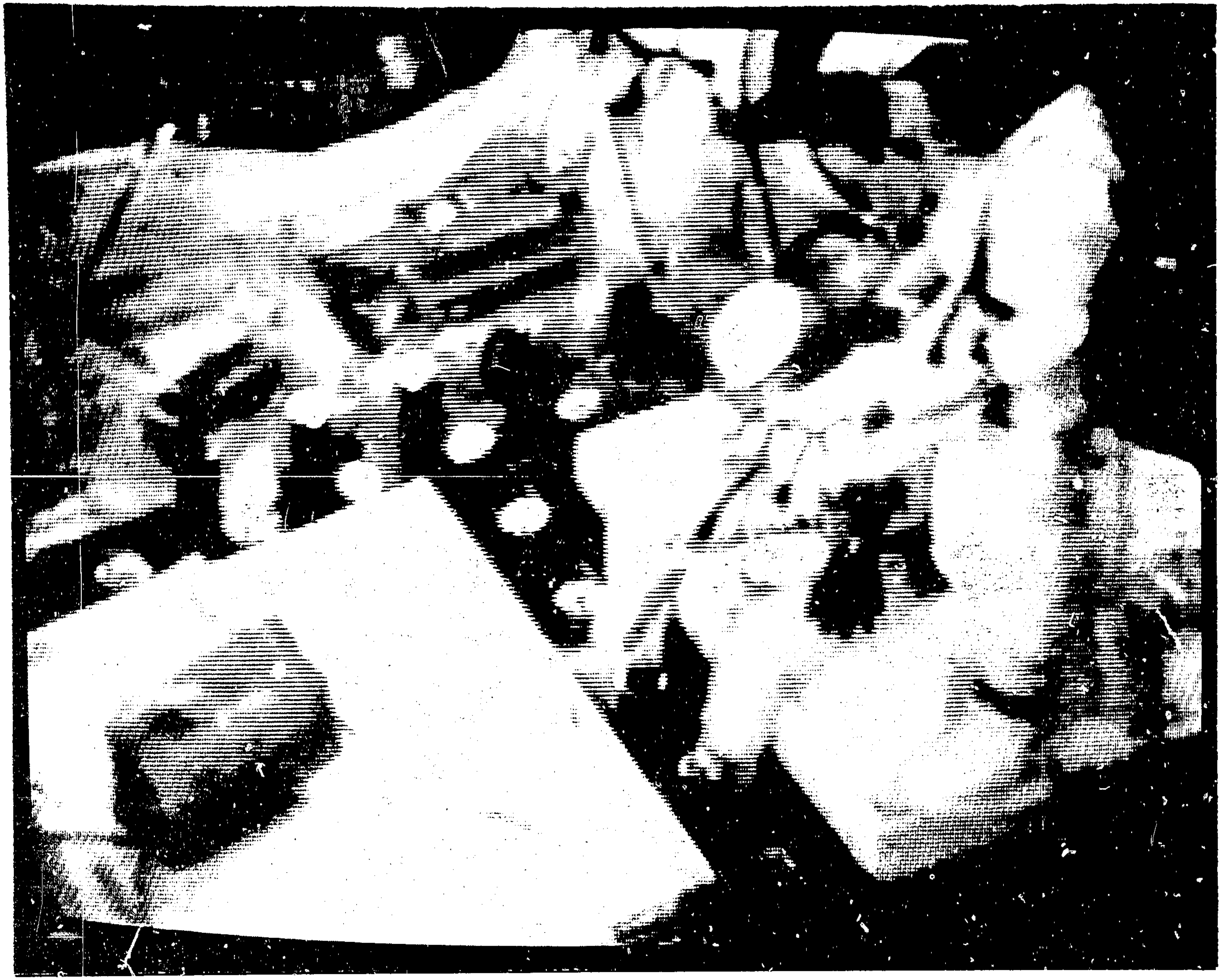


Figure 3-19. Insertion of the camera into a CRDM motor housing.

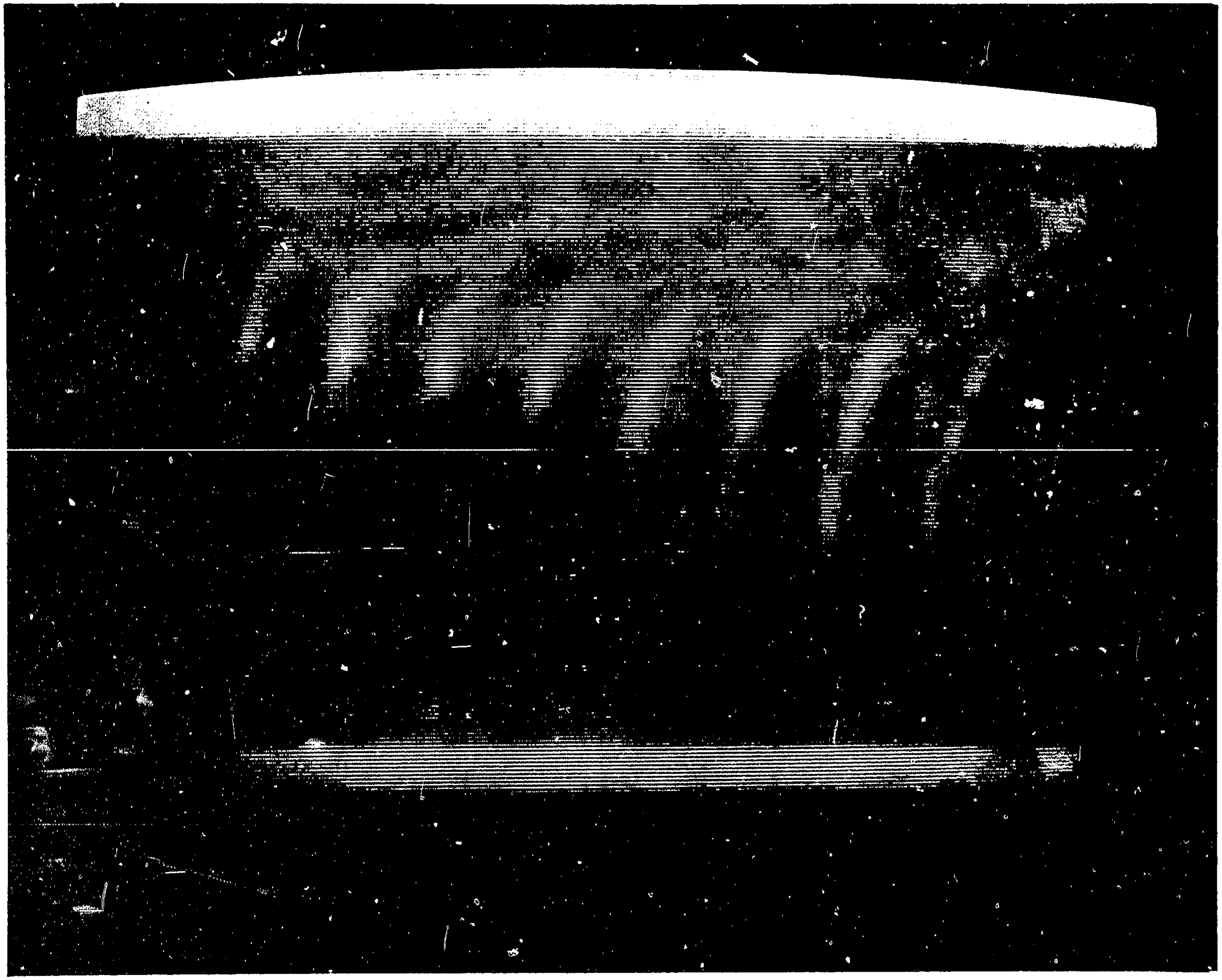


Figure 3-20. Spring of undetermined length lying on the debris bed near the 8H position. Depending on the length, this is a control rod or fuel rod spring.

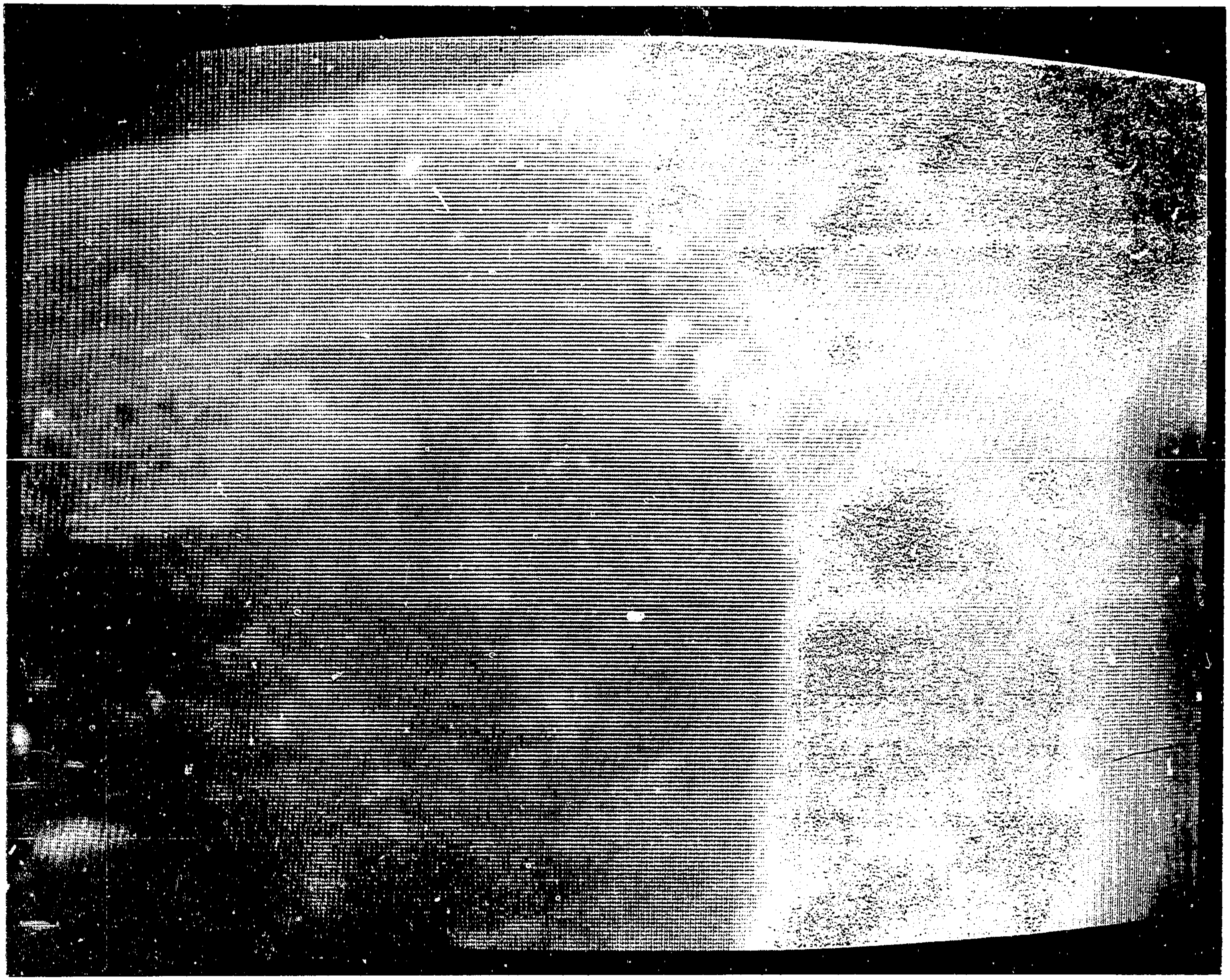


Figure 3-21. Portion of a control assembly spider which was resting on the debris bed near the 8H position.

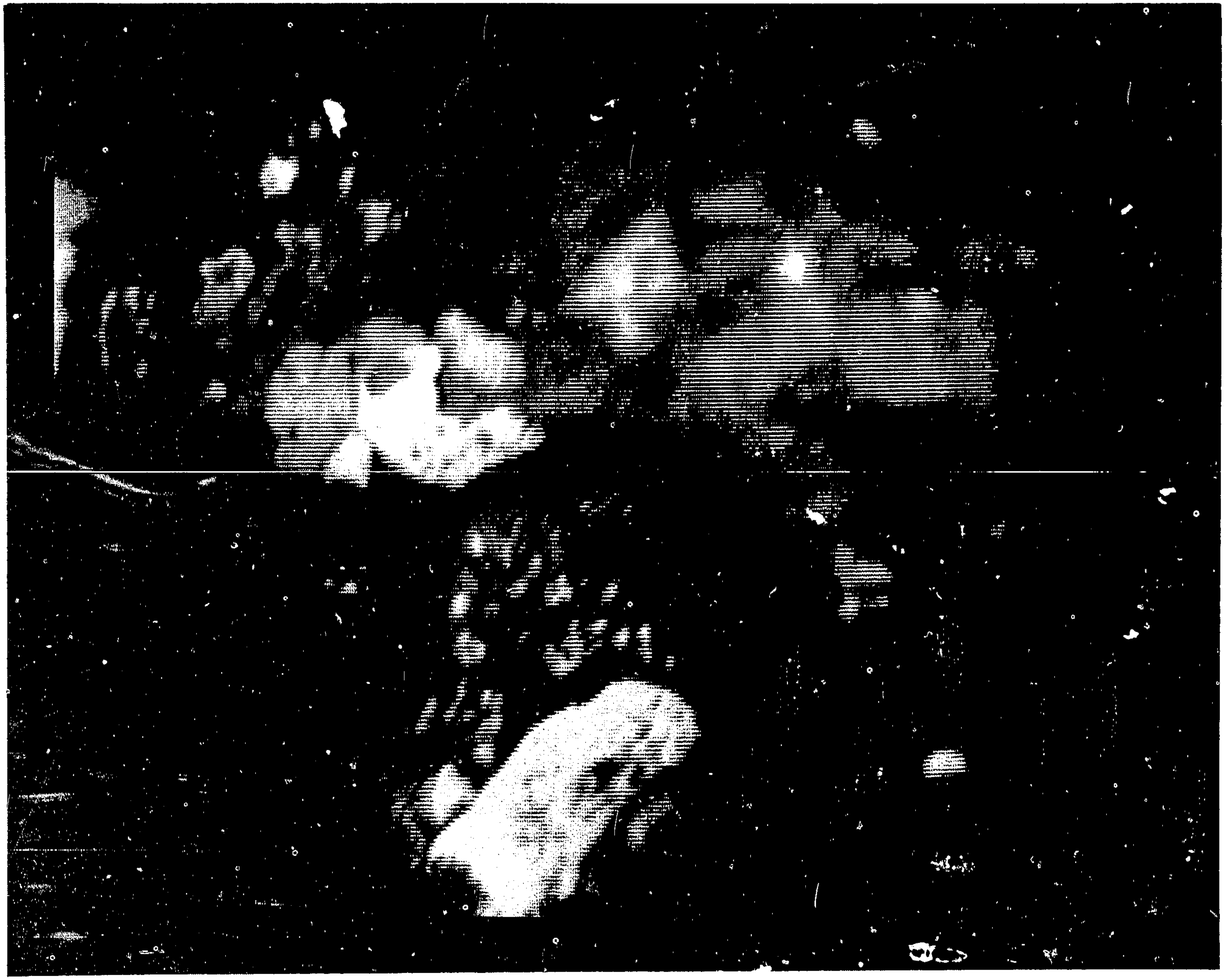


Figure 3-22. The debris bed as observed during Quick Look I near the 8H position.

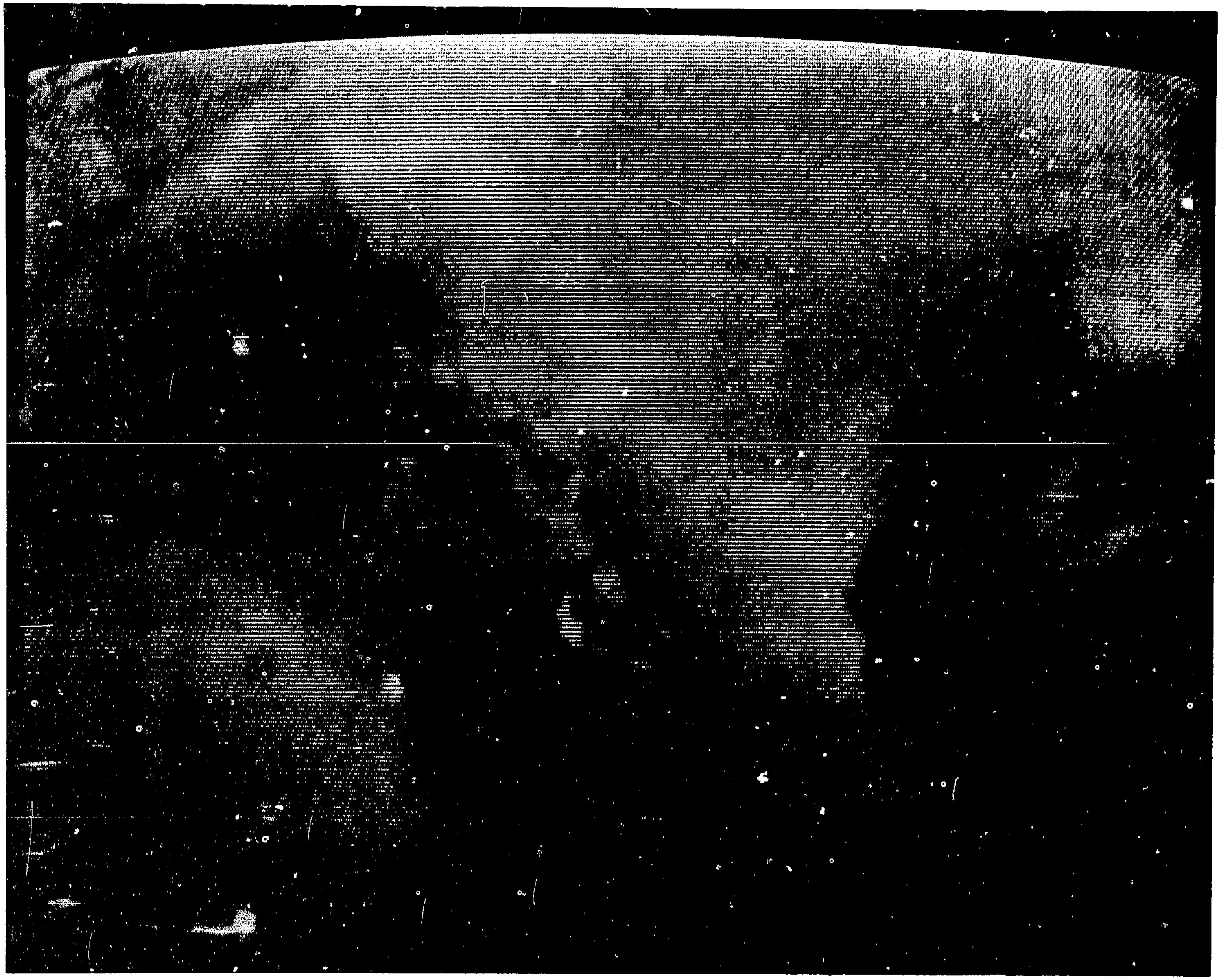


Figure 3-23. Debris on top of a guide tube support plate in the 9E position (lower left is up).

Figure 3-24. Fuel rods at location 8D as viewed from below from location 9E.

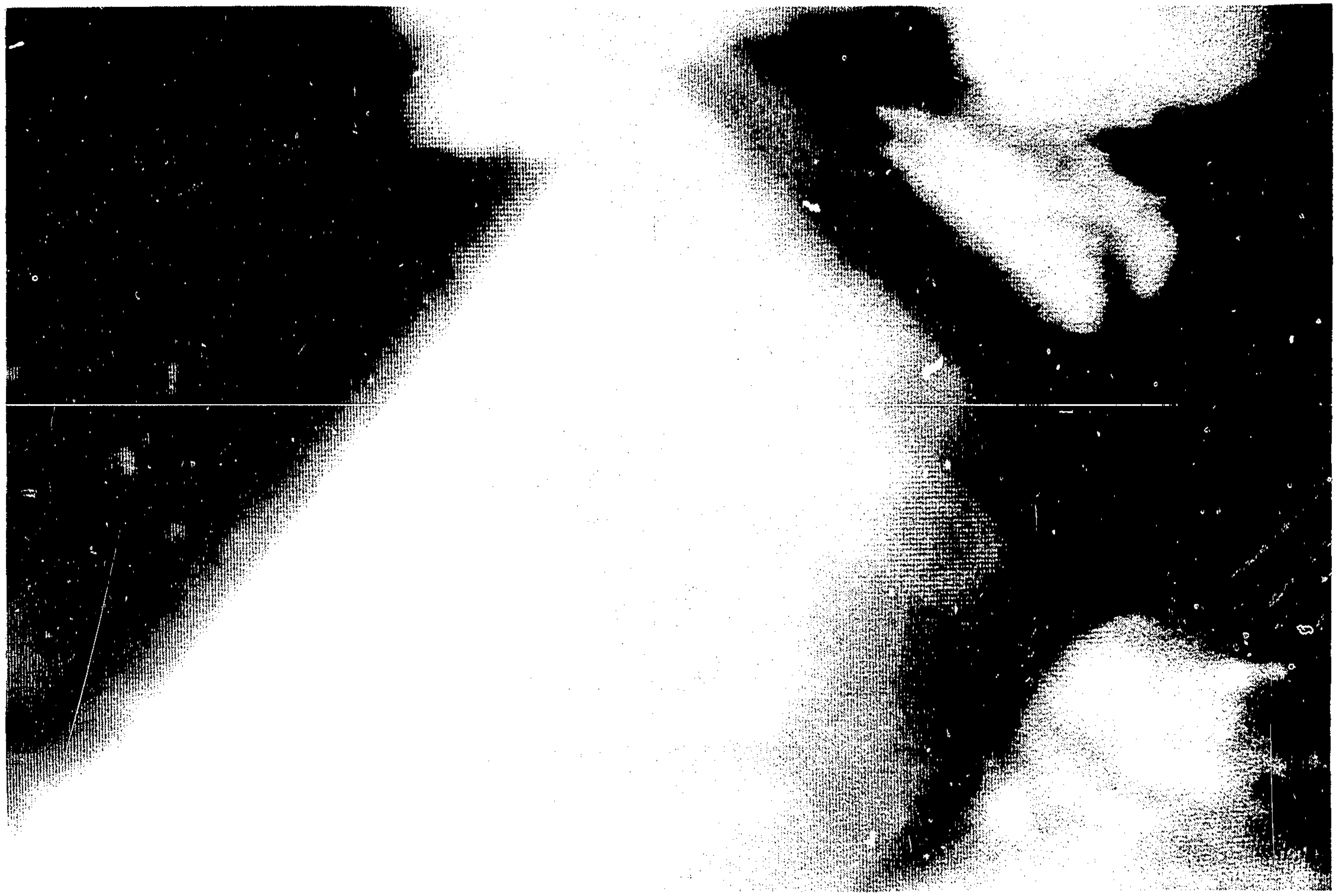


Figure 3-25. Burnable poison rod pellet on the debris bed near the 8H position.

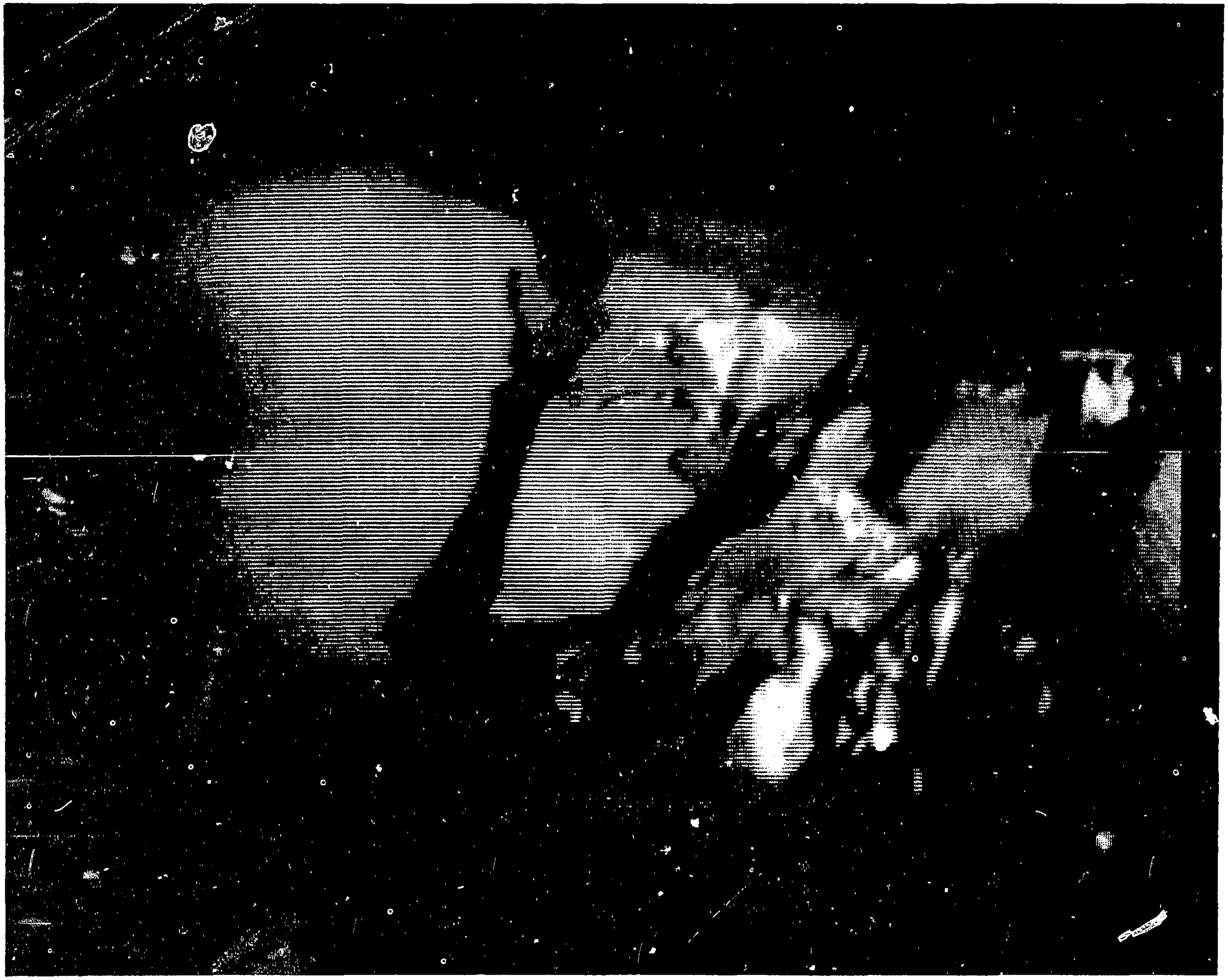


Figure 3-26. Debris lodged in upper end fitting in the 9E position (left is up).

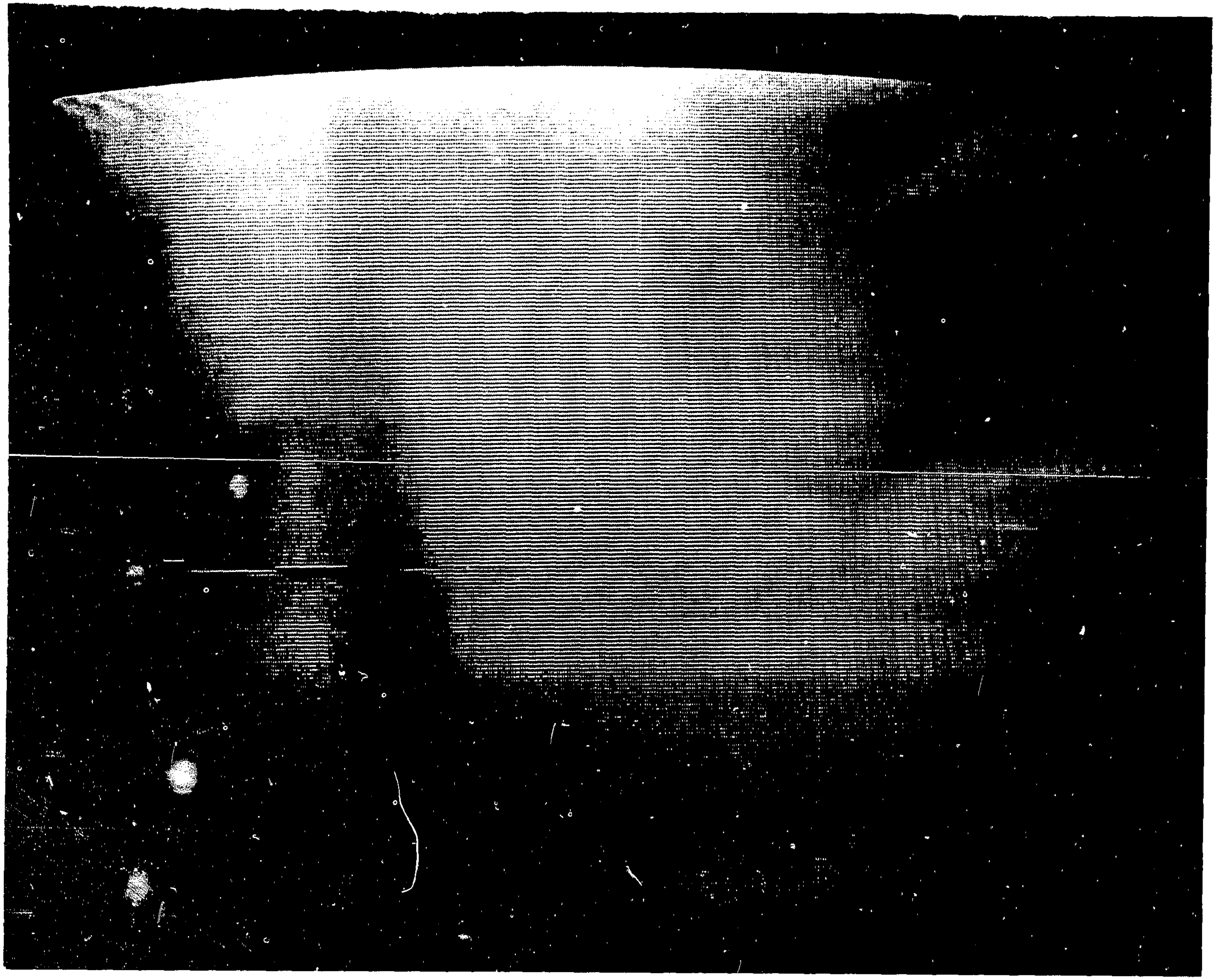


Figure 3-27. Looking up at the upper grid with camera at the 9E position (note eroded grillage at upper right).

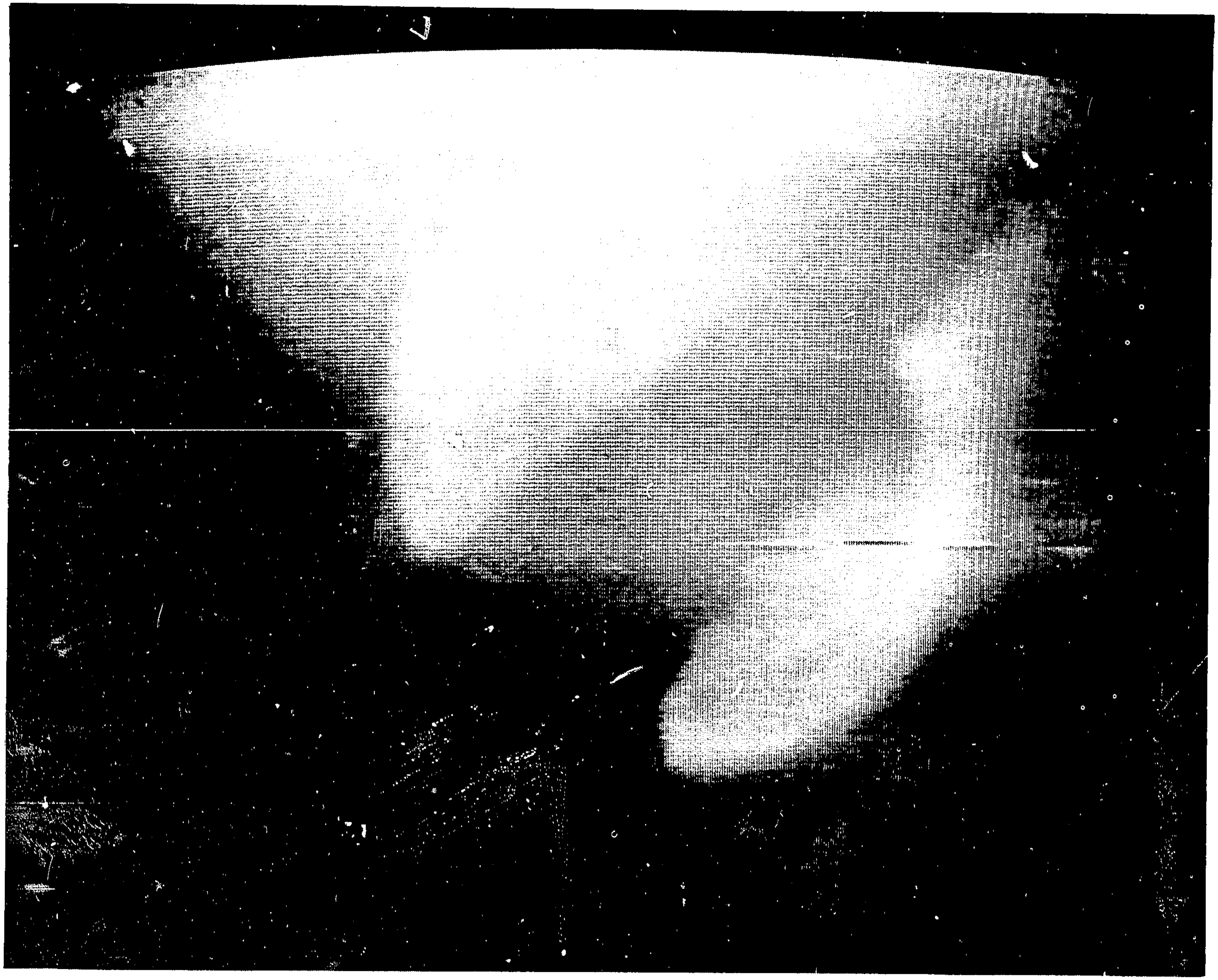


Figure 3-28. Looking up at a split tube of a control rod guide assembly in the 9E position.

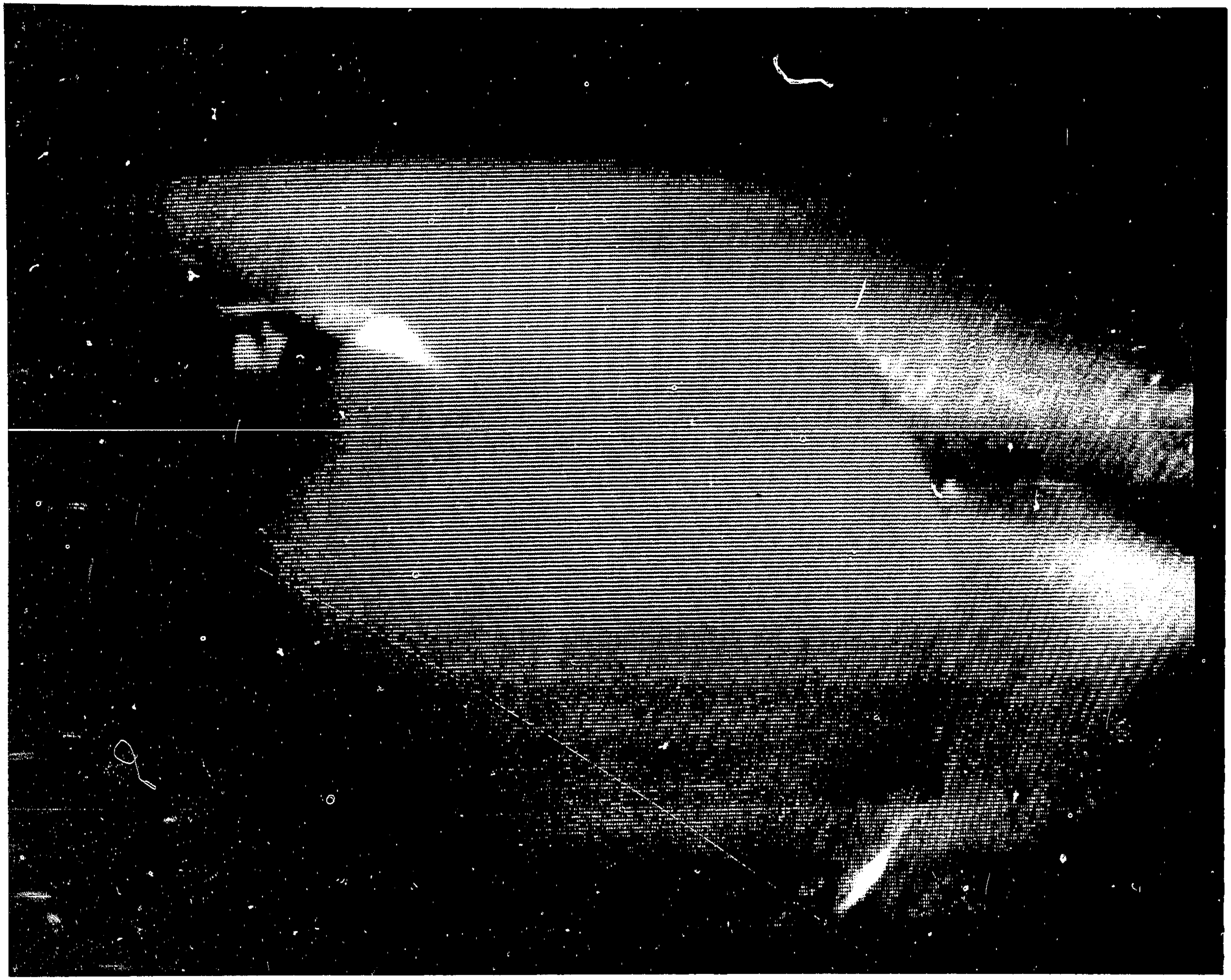


Figure 3-29. Spring retainer plug (approximately 1 inch in diameter) in the 9E upper end fitting (left is up).

4. SUMMARY

4.1 Quick Look Objectives and Schedule

The Quick Look was designed to provide the first visual information on the condition of the core and upper internals by inspecting the control rod guide tubes, a portion of the upper grid, the tops of fuel assemblies, and, in the event that the upper end-fittings were missing, the reactor core. This information was to be obtained by inserting a radiation-tolerant underwater CCTV camera through an opening created by the removal of a leadscrew from a CRDM. The initial inspection was conducted on July 21, 1982, as originally scheduled. Additional inspections were conducted on August 5 and 12, 1982.

As a follow-up to the core inspections, leadscrew uncoupling was completed on August 23 and 25, 1982.

4.2 Methods and Approach

Preparations had to be made in the following areas:

- Supporting studies and licensing documents development
- Uncoupling and removal tool design and methods planning
- Plant modifications and additions
- Operator training
- Procedure preparation
- Radiological predictions and ALARA provisions

For the most part, these activities took place concurrently.

4.2.1 Supporting Studies and Licensing Documents

Several studies were performed whose results were applicable to the safety concerns of this activity. The B&W report, "Methods and Procedures of Analysis for TMI-2 Criticality Calculations to Support Recovery Activities Through Head Removal," was prepared to document criticality safety results from the analyses of various geometrical configurations of moderator, reflector, and fuel. The assessment demonstrated that, during all of the proposed activities that could produce fuel rearrangements or otherwise affect the subcriticality of the fuel system, the TMI-2 reactor would be maintained in a safe shutdown condition.

The thermal status of the core and predictions of the thermal response of the system to partial draindown of the RCS were discussed in the B&W report, "TMI-2 Decay Heat Removal Analysis." The results of the analysis showed that lowering the reactor water level and isolating the system components might cause an increase in reactor water equilibrium temperature at a rate of less than 5 F per day in mid-1982. This increase was dependent upon the containment air temperature. If enhanced heat removal was required, it could be accomplished by existing systems.

An analysis was performed to determine the quantities of hydrogen and Kr-85 in the RCS available for release to the containment and the environment. The total amount of Kr-85 available for release was conservatively calculated to be approximately 30 Ci, which would result in an increased dose rate at the nearest residence of 2.1×10^{-5} mrem (total body dose). It was concluded that all radioactive releases from the containment as a result of the Quick Look would be well within the limits of the TMI-2 Technical Specifications. The gas vented from the RCS was assumed to be 100 percent hydrogen. To prevent the discharge of a flammable hydrogen mixture to the containment atmosphere, the RCS was vented into a dilution air stream.

The rate of hydrogen offgassing via the open CRDM motor tube was conservatively calculated at approximately 0.03 scfm. Although appropriate precautions were taken, it was determined that such a low release rate would not have presented a hydrogen flammability hazard when vented directly to the containment.

The results of analyses identified above were used in the "Safety Evaluation for Insertion of a Camera into the Reactor Vessel Through a Leadscrew Opening" (Quick Look Safety Evaluation), which was the primary licensing document for this activity. The report also evaluated the potential for inadvertent boron dilution, occupational exposure, and the effects on RCS chemistry as a result of breaching the RCPB. The conclusions of this report, which were accepted by the NRC, were that the activities associated with the Quick Look would not present an unreviewed safety issue, nor would they present undue risk to the health and safety of the public.

4.2.2 Leadscrew Uncoupling Plan and Tool Development

The basic approach was to uncouple a central leadscrew using one of two normal uncoupling techniques: the leadscrew nut method, or if that was unsuccessful, the torque tube method. After successful uncoupling, the leadscrew was to be lifted into the parked position. Once the cutting tools were staged, the leadscrew would be cut to remove it, since it was too long to be completely withdrawn under the missile shields.

To perform leadscrew uncoupling, removal, and subsequent camera inspection with the missile shields in place, existing tools had to be modified and new tools developed. Criteria reflecting such concerns as ALARA, space and material constraints, and manual transportation of tools were established for the development effort. To ensure safe and proper operation, proof-of-principle testing was performed on all new or modified tools.

4.2.3 Plant Modifications and Additions

Modifications or additions were made to existing systems for venting and draining, water level monitoring, leadscrew rigging and handling, and communications. Only those modifications or additions necessary for the Quick

Look were made, so as to minimize the man-rem and man-hours expended on this task.

4.2.4 Operator Training and Procedure Preparation

Operators were trained in the use of the CRDM tools and in the operation of the special video camera. This training included all aspects of the equipment, activities to be performed with the equipment, and the interfacing systems. In addition to this equipment-specific training, dress rehearsals were performed on a full-scale mock-up of the service structure. The mock-up included a CRDM, the missile shields, and the hoisting mechanism.

Sixteen new operating and emergency procedures were generated and six procedures were modified for the Quick Look. Subsequent to Quick Look I, five Temporary Change Notices to procedures were required, and two special operating procedures were written.

4.2.5 Radiological Predictions and ALARA Considerations

Approximately 50 to 150 man-rem were estimated for the Quick Look. These figures were arrived at by estimating the in-containment man-hours that would be required for the task and assuming general area dose rates. It was also necessary to determine the dose rate from the leadscrew so that adequate shielding for the leadscrew could be provided once it was removed to prevent unneccessary personnel exposure.

ALARA provisions were implemented in procedures and tool design. These provisions included long-handled tools, mock-up testing, contingency procedures, increasing equipment maneuverability, and time-saving devices.

Detailed radiological control measures were included in the work packages rather than the procedures. Appropriate stay times or special instructions were written into the work package based on anticipated radiological conditions. This was done to permit flexibility in allowing work to continue if significant changes in radiation levels were encountered.

During leadscrew removal and cutting the radiological controls technician monitored the beta and gamma dose rates. Radiation detectors were also located on the service structure to continuously monitor radiation levels.

Protection from beta radiation was provided by the use of shielding and clothing requirements, as necessary. Additional protection from beta radiation was provided by the ice vests used for body cooling, lineman's gloves, and eye protection.

4.3 Execution

4.3.1 Containment Entries and Data Collection

A total of 27 containment entries and 243 in-containment man-hours were required to prepare for and perform the Quick Look. The accomplishments of these entries included primary and secondary side venting and draining, gas and liquid sample collection, leadscrew removal, performance of the Quick Look camera inspections, and leadscrew uncoupling.

During entry 73, two gas samples (one line purge sample and one system sample) and one liquid sample were obtained from the CRDM. Contact RO-2A readings on the gas samples were 150 mR/hour gamma from both, and 400 mrad/hour beta from the line purge and 520 mrad/hour beta from the system vent. The contact reading on the liquid sample was 150 mR/hour gamma and 400 mrad/hour beta.

One RCS liquid sample was obtained during entry 75. The sample was obtained by lowering a 150 ml sample bomb into the reactor vessel through the

CRDM to a depth 28 feet below the top of the motor tube. Contact RO-2A readings on the RCS liquid sample bomb were 100 mR/hour gamma and 240 mrad/hour beta.

When the leadscrew was removed no warpage or other deformity was noted. The highest radiation reading from the leadscrew was 6.0 R/hour gamma at a distance of 1 foot from the second half of the leadscrew.

4.3.2 Leadscrew Uncoupling Descriptions for Drive Locations 7K and 8H

During the first attempt to uncouple the leadscrew on CRDM 8H, there were indications of interference or damage because the initial load reading of 350 pounds exceeded the anticipated load reading. Although the leadscrew nut rotated freely, the leadscrew would not lower or rotate. Finally, the leadscrew was tapped down far enough to allow rotation through approximately 45 degrees. The leadscrew still could not be lifted without exceeding the administrative load limit of 350 pounds. In the continuing attempts to uncouple the leadscrew it was rotated beyond the 45-degree point, which, according to later analysis, indicated that the spider had probably fallen off.

Since no apparent progress was being made, the uncoupling of the leadscrew at CRDM 7K was attempted; however, these attempts were also unsuccessful and efforts were resumed on the leadscrew at CRDM 8H. The leadscrew nut was rotated clockwise in order to return the drive to its original position. When the nut rotated 20 times instead of the expected 4 to 7 times, it was taken as an indication that the leadscrew was in fact uncoupled and the nut was bottomed on the leadscrew engagement pins.

The leadscrew would still not move when loaded to the administrative limit of 350 pounds, so the operator was instructed to jar the tool in an attempt to determine the location of the hang-up. At this point the leadscrew broke free and the load reading was 170 pounds as expected. The removal process then continued as planned.

4.3.3 Observations from the Camera Inspections

The Quick Look camera inspections were performed inside the TMI-2 reactor vessel on July 21, August 6, and August 12, 1982. The camera revealed that the upper central portion of the reactor fuel has collapsed and forms a loose bed of rubble, whose upper surface is about 5 feet below the normal top of the core.

The Quick Look Tape Review Group report, Data Report - Quick Look Inspection Results (TOP/TMI-026), December 1982, GPU Nuclear Planning Department, documents the review group's observations from their review of the videotapes of the camera inspections.

4.3.4 Core Probe Experiment

The core probe experiment was conducted concurrently with the Quick Look III camera inspection. The core probe was inserted into the 8H and 9E positions. At both positions, the probe was inserted about 14 inches into the rubble bed.

4.3.5 Leadscrew Uncoupling Activities

The uncoupling of each leadscrew is described in Section 3.5. Based on analysis of the data obtained during uncoupling, the leadscrews can be grouped into the following categories, which are not mutually exclusive:

1. Locations where the control rod spiders never moved up or down.

2. Locations where the spiders moved down less than 2 inches after uncoupling.

3. Locations where the spiders moved up when lifted but did not move down after uncoupling.

4. Locations where the spiders dropped greater than 2 inches after uncoupling.

5. Locations where the leadscrew has been uncoupled but leadscrew parking may be difficult.

6. Locations where the leadscrew and torque taker are not bottomed on the torque taker belleville springs.

7. Locations where lack of leadscrew movement will not allow a potentially stuck leadscrew to be identified.

5. REFERENCES

1. J. R. Worsham III et al., Methods and Procedures of Analysis for TMI-2 Criticality Calculations to Support Recovery Activities Through Head Removal, BAW-1738, June 1982. (This report is Appendix A of Reference 3.)

2. TMI-2 Decay Heat Removal Analysis, April 1982. (This report is Appendix B of Reference 3.)

3. Safety Evaluation for Insertion of a Camera into the Reactor Vessel Through a Leadscrew Opening, Revision 2, July 1982. (This report was submitted to the U.S. Nuclear Regulatory Commission by GPU Nuclear letter 4400-82-L-0110, July 6, 1982.)

APPENDIX A

DESIGN FUNCTIONAL CRITERIA AND DRAWINGS FOR NEW AND MODIFIED TOOLS

DESIGN FUNCTIONAL CRITERIA

MODIFIED LIGHTWEIGHT LEADSCREW LIFTING TOOL

1. Pick up leadscrew by engaging leadscrew nut.
2. Rotate leadscrew while lifting in order to uncouple from spider and torque taker.
3. Pull test to minimum of twice leadscrew weight, 350 pounds minimum.
4. Work within geometric constraints of CRDM, i.e., fit in torque tube.
5. Designed to be hand carried to the service structure.
6. Material compatible with RCS.
7. Work in conjunction with leadscrew nut runner tool, i.e., fit through the nut runner and the leadscrew jacking device simultaneously.
8. All potential loose parts captured.
9. Equipment shall be designed to facilitate installation and operation by personnel performing under the constraints imposed by protective clothing.
10. Maximize use of design features of the existing DPSC lightweight leadscrew lifting tool.
11. No painted parts.
12. Smooth surfaces wherever practical for ease of decontamination.
13. Burr-free with no sharp edges.
14. Ball lock mechanism does not release upon loss of air.
15. Capable of engaging a leadscrew in the full up or down position with nut runner installed.
16. Compatible with C-washers.
17. Designed to lift and hold the leadscrew during nut unthreading operations.
18. Tool design shall address ALARA.

Specific design functional criteria were established for each new or modified tool. These criteria and drawings for these tools are included in this appendix.

DESIGN FUNCTIONAL CRITERIA

LEADSCREW NUT RUNNER

1. Engage and turn leadscrew nut in both directions.
2. Capable of exerting a minimum of 50 foot-pounds torque on leadscrew nut.
3. Work within geometric constraints of CRDM, i.e., fit in torque tube.
4. Break down as necessary to fit through personnel hatch, if easily achievable.
5. Be designed to be hand carried to the service structure.
6. Material compatible with RCS.
7. Work in conjunction with modified lightweight leadscrew lifting tool, i.e., I.D. greater than O.D. of same.
8. All potential loose parts captured.
9. Equipment shall be designed to facilitate installation and operation by personnel performing under the constraints imposed by protective clothing.
10. No painted parts.
11. Smooth surfaces wherever practical for ease of decontamination.
12. Burr-free with no sharp edges.
13. Tool design shall address ALARA.
14. Capable of engaging a leadscrew in the full up or down position.
15. Designed to work with jacking device in place.

DESIGN FUNCTIONAL CRITERIA

LEADSCREW CUTTING EQUIPMENT

1. Equipment shall enable an operator to perform cutting operations under manual control at a distance of not less than, and preferably greater than, 3 feet from the leadscrew.

2. Equipment design will be such that it shall be possible to access and cut any selected leadscrew by changing the stand location.

3. Saw mount construction will incorporate quick change features to permit rapid removal and installation of saw units (less than 60 seconds) while using no tools.

4. Rapid blade changes shall be possible on the saw units and will require no tool usage.

5. The saw stand will be designed to mount on adjacent motor tubes. It shall mount without using tools and shall incorporate quick change features.

6. All cutting equipment components will be designed to be hand carried to the service structure and will use lightweight materials of construction as much as is consistent with required characteristics of durability and strength.

7. The cutting equipment must be designed such as not to interfere with the holding/lifting clamps that will be installed during cutting operations.

8. The saw blade must not require lubrication prior to or during cutting.

9. Break down as necessary to fit through the personnel hatch, if easily achievable.

10. Equipment shall be designed to facilitate installation and operation by personnel performing under the constraints imposed by protective clothing.

11. No support services other than a source of 120 V, 60 Hz electricity will be required.

12. All potential loose parts captured.

13. Must be designed to work with jacking device and jacking clamps.

14. Must cut through the leadscrew in less than 2 minutes.

15. No painted parts.

16. Smooth surfaces wherever practical for ease of decontamination.

17. Burr-free with no sharp edges.

18. Tool design shall address ALARA.

DESIGN FUNCTIONAL CRITERIA

LEADSCREW LIFTING CLAMP

1. Must be capable of being installed from at least 3 feet away.

2. Ability to be installed with saw and stand in operating position.

3. Contain integral lifting bail with 500 pounds minimum load carrying capability.

4. Clamp both threaded or unthreaded portions of leadscrew.

5. Material compatible with RCS.

6. All potential loose parts captured.

7. Clamping force sufficient to provide lifting capability of 500 pounds minimum.

8. Equipment shall be designed to facilitate installation and operation by personnel performing under the constraints imposed by protective clothing.

9. Must fit within 5-inch I.D. pipe after installation on leadscrew.

10. Remote clamping capabilities (at least 3 feet away) must be developed as contingency.

11. No painted parts.

12. Smooth surfaces wherever practical for ease of decontamination.

13. Burr-free with no sharp edges.

14. Clamps shall prevent leadscrew from falling inside motor tube.

15. Tool design shall address ALARA.

DESIGN FUNCTIONAL CRITERIA

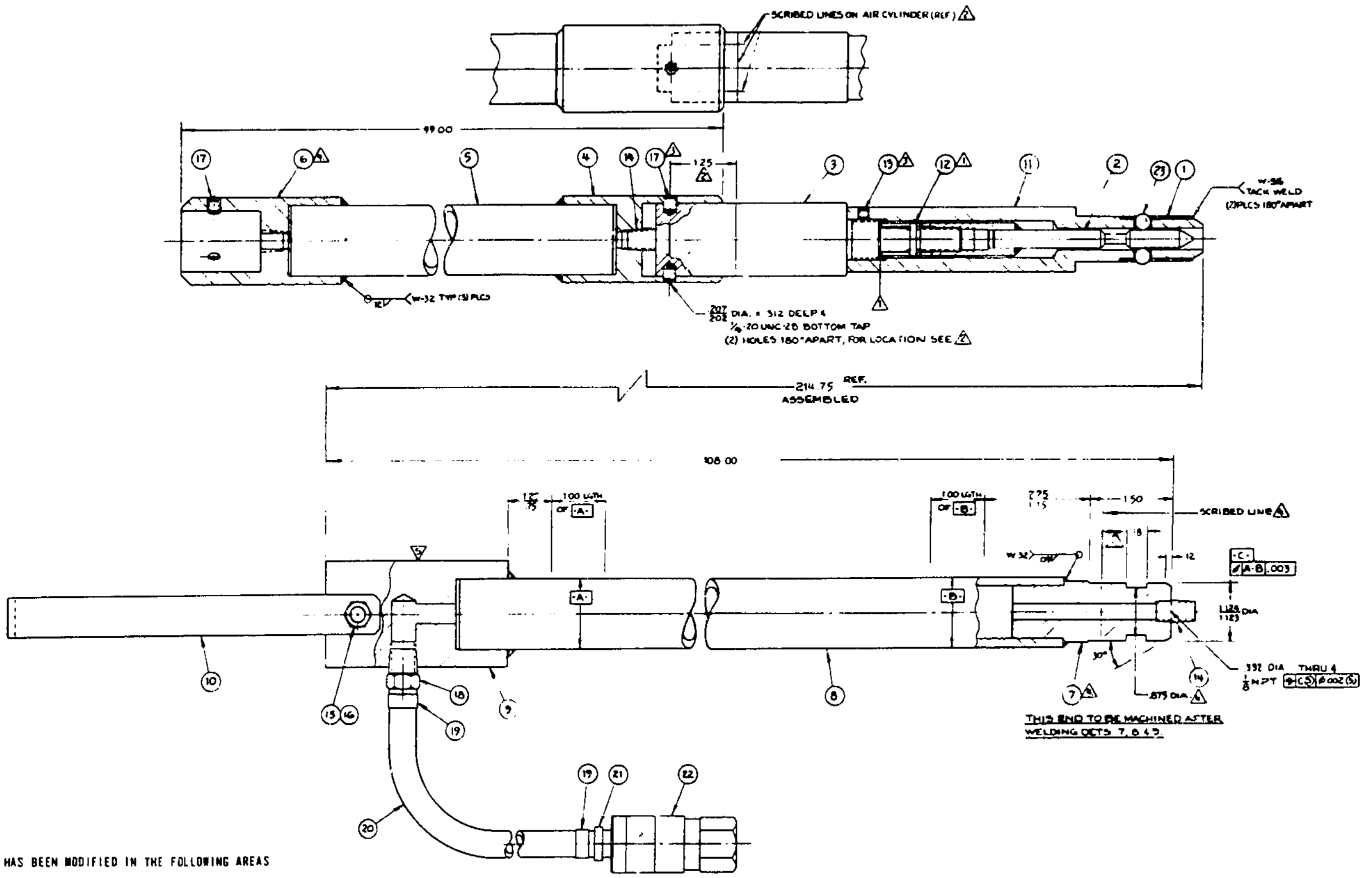
MODIFIED JUMPING JACK FOR UNCOUPLING

1. Work in conjunction with alternate uncoupling tool.
2. Capable of exerting lifting force of 3000 pounds minimum with direct load readout accurate to within ±5 percent.
3. Work within geometric constraints of CRDM.
4. Designed to be hand carried to the service structure.
5. All hydraulic connections designed for quick assembly and leak-free operation.
6. Hand pump to be of sufficient capacity to allow full extension of cylinders with adequate reserve.
7. Hose to be long enough to allow operation at a reasonable distance from CRDM, 5 feet minimum.
8. All potential loose parts captured.
9. Equipment shall be designed to facilitate installation and operation by personnel performing under the constraints imposed by protective clothing.
10. Hydraulic fluid to be compatible with RCS.
11. No painted parts.
12. Smooth surfaces wherever practical for ease of decontamination.
13. Burr-free with no sharp edges.
14. Tool design shall address ALARA.

DESIGN FUNCTIONAL CRITERIA

QUICK LOOK CHIP DEFLECTOR

1. Shall be designed for rapid installation around the leadscrew to permit installation while the leadscrew is suspended by a hoist.
2. The interface between the chip deflector and the leadscrew will be designed to accommodate the variations present in leadscrew geometry during its withdrawal from the motor tube.
3. All chip deflector parts are to be captured or fastened to prevent entry into the motor tube.
4. Design shall consider the constraints imposed by protective clothing and will allow installation and removal without the use of tools.
5. Shall be constructed of lightweight materials for ease of transport.
6. Tool design shall address ALARA.
7. Smooth surfaces wherever possible for ease of decontamination.
8. Burr-free with no sharp edges.
9. No painted parts.
10. Material compatible with the RCS.



TOOL HAS BEEN MODIFIED IN THE FOLLOWING AREAS

1) COUPLING, PT. 6, AND CONNECTOR, AIR CYLINDER, PT 4 HAVE BEEN TURNED DOWN TO 1.500 ± .005 DIAMETER

2) LENGTHS OF THE UPPER AND LOWER LIFT TUBES, PT. 8 & 5 RESPECTIVELY, HAVE BEEN REDUCED BY 1 1/2 FEET EACH. TWO PARTS SEAL WELDED TOGETHER.

3) HANDLES HAVE BEEN ADDED AS PER B&W DWG.

4) CUT 6" FROM UPPER END 8 & WELD AGAIN TO END CAP 9
CUT 6" FROM LOWER END 5 & WELD AGAIN TO COUPLING 6

Figure A-1. Modified lightweight leadscrew lifting tool.

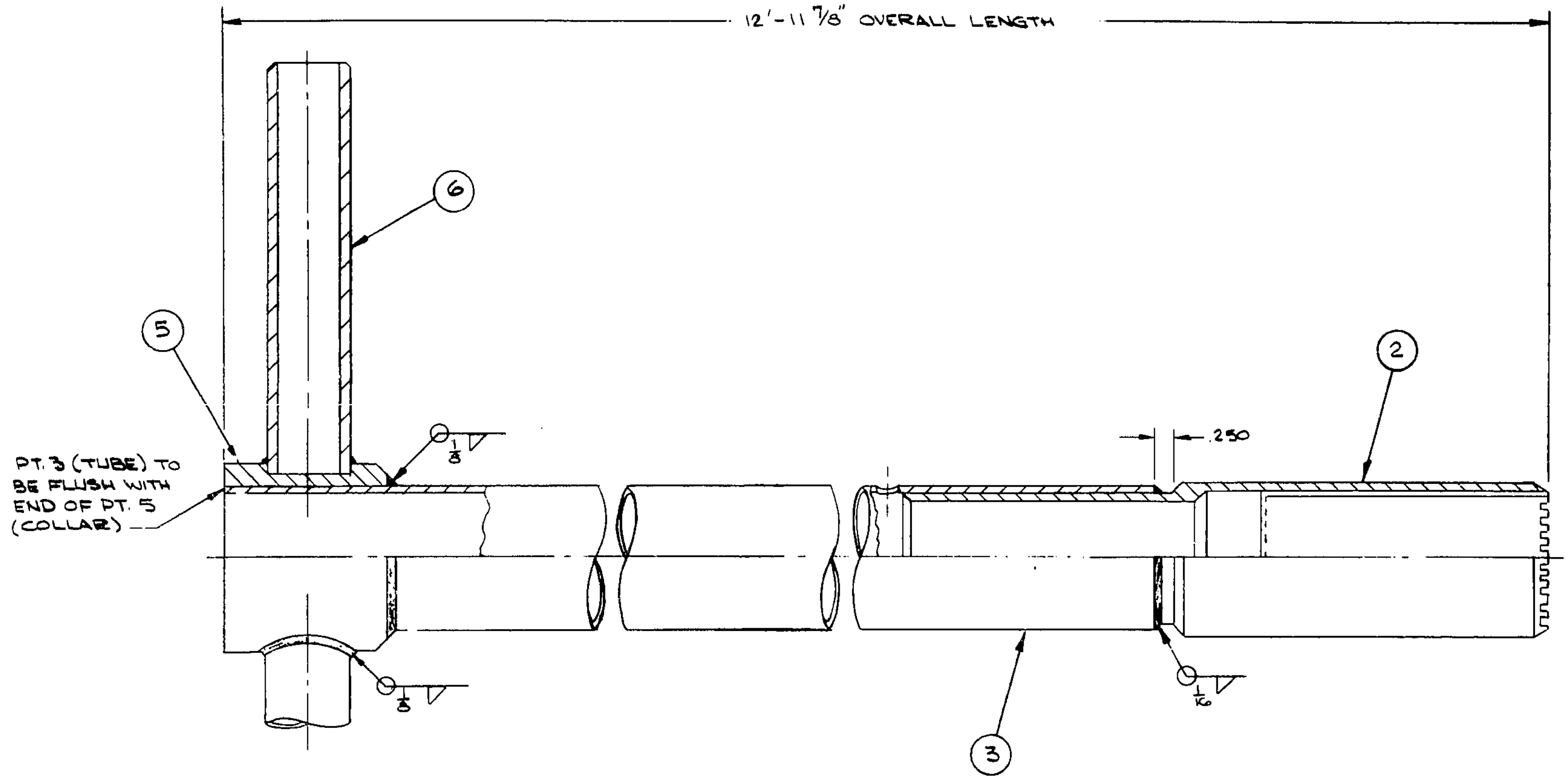


Figure A-2. Leadscrew nut runner.

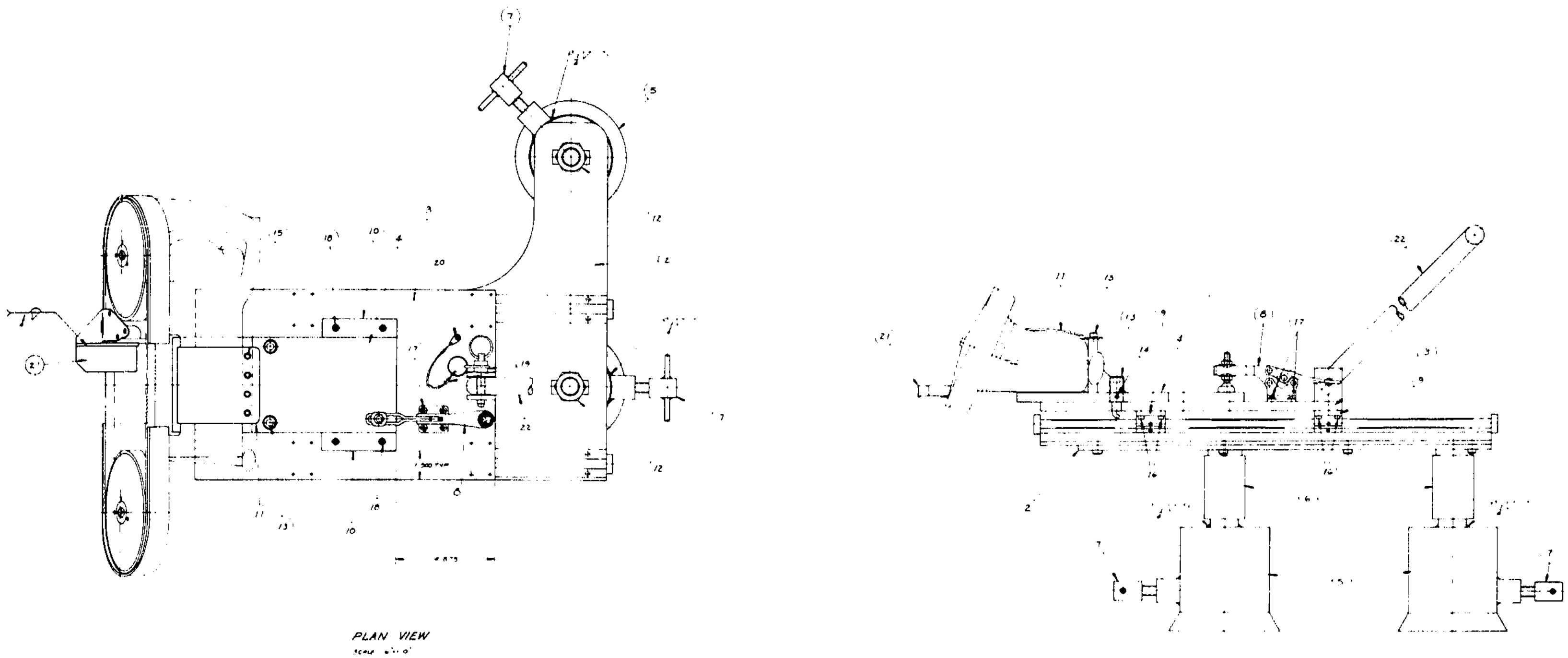
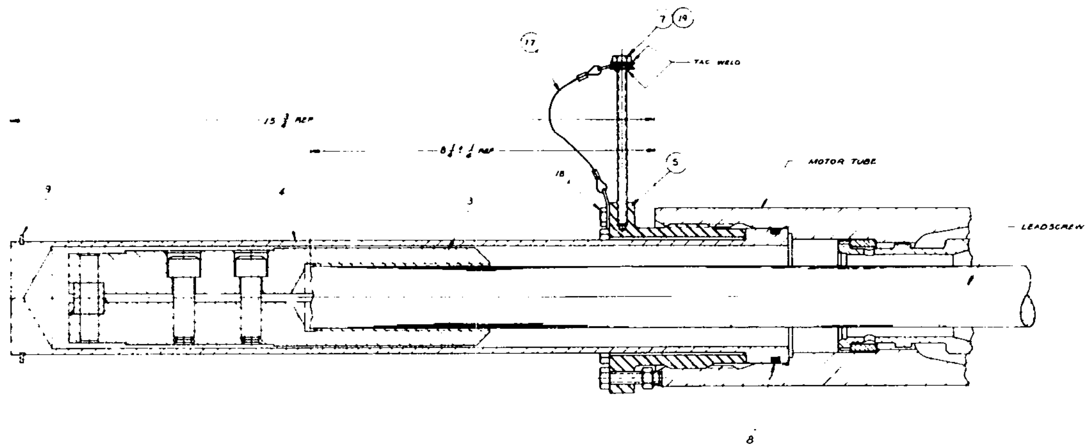
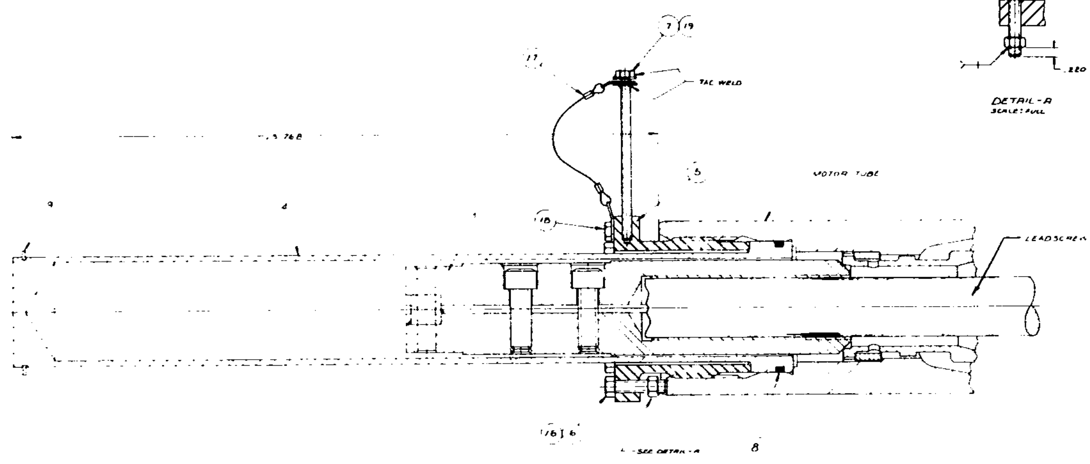


Figure A-3. Leadscrew cutting equipment.



LEADSCREW CLAMP & CLOSURE ARR'GT - B



LEADSCREW CLAMP & CLOSURE ARR'GT - A

Figure A-4. Leadscrew lifting clamp.

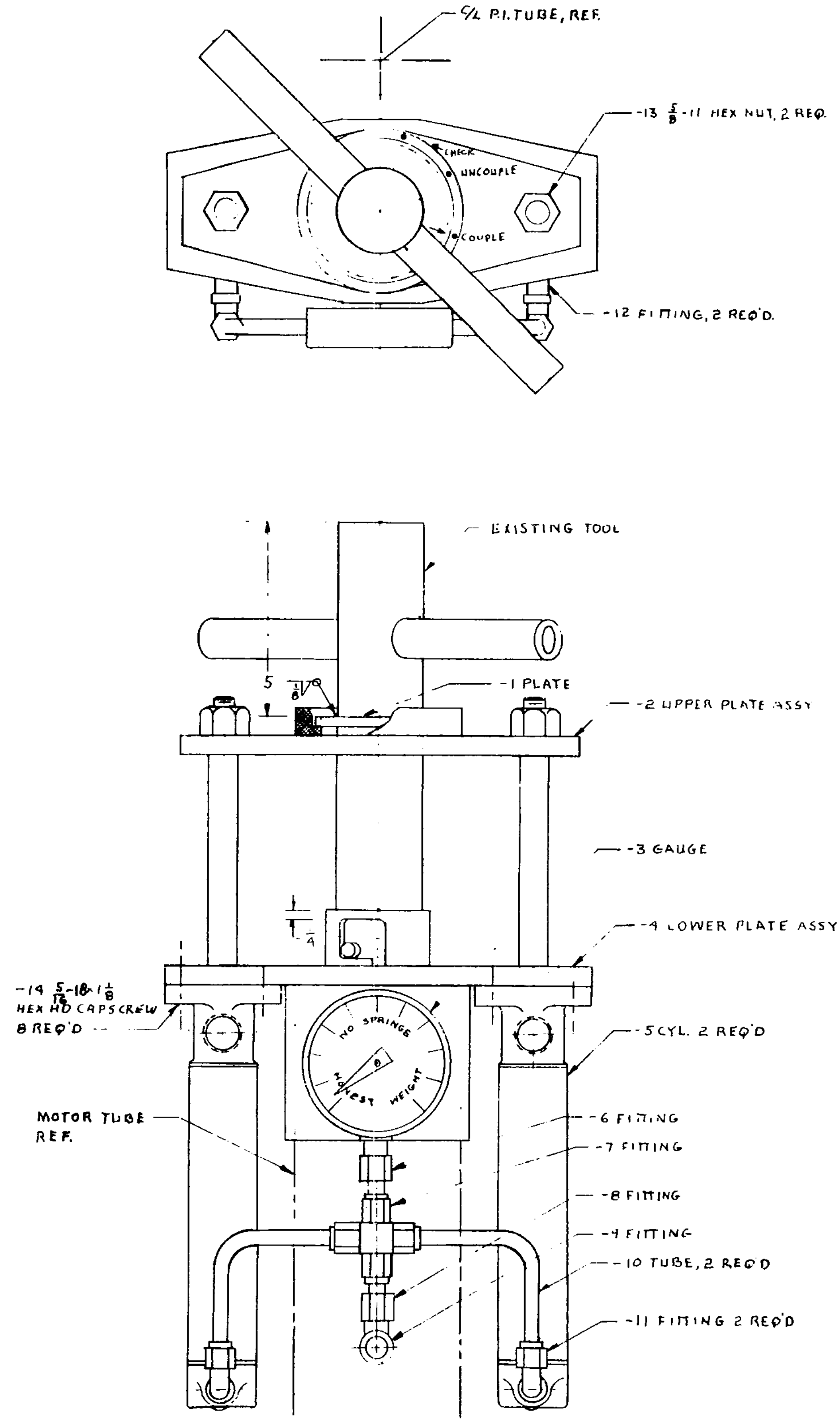


Figure A-5. Modified jumping jack for uncoupling.

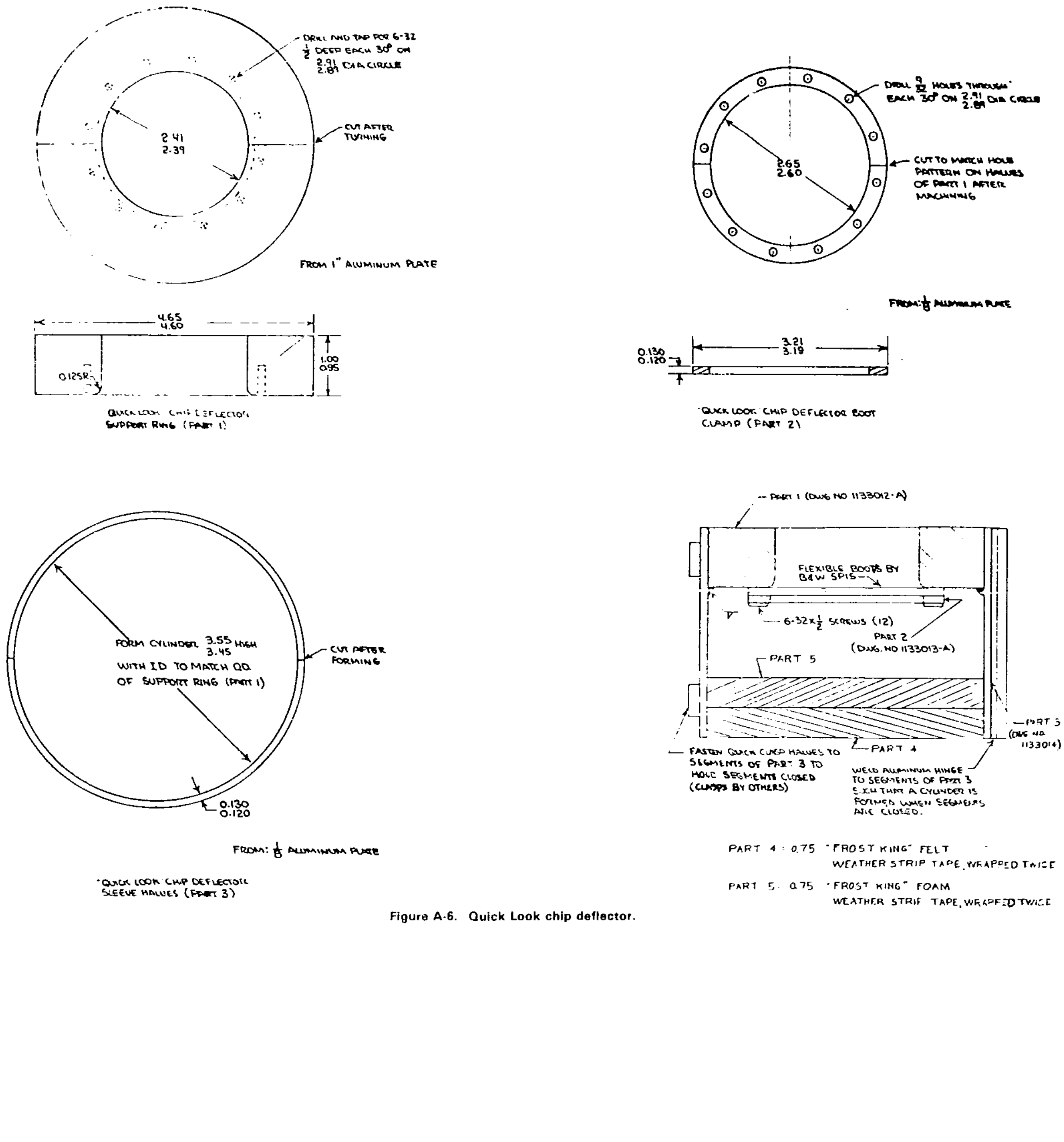


Figure A-6. Quick Look chip deflector.