TMI-2 Seminar

December 4-5, 1981

San Francisco, California

General Public Utilities

Electric Power Research Institute

Nuclear Regulatory Commission

Department of Energy

TMI-2 SEMINAR

San Francisco, California

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FOREWORD

Since the Three Mile Island Unit 2 (TMI-2) accident of March 28, 1979, major recovery and research efforts have been set in motion. Plant cleanup is progressing and significant research has already been performed, and the pace of work is increasing.

This volume reproduces presentations made at the TMI-2 Seminar held in San Francisco on December 4 and 5, 1981; the presentations indicate the status of the plant and of research efforts as of mid-November 1981.

TMI-2 SEMINAR AGENDA

DECEMBER 4

Welcoming Remarks and EPRI Perspectives	J. J. Taylor, EPRI
DOE Perspectives	F. Coffman, DOE
Regulatory Perspectives	W. Dircks, NRC
GPU Perspectives	R. Arnold, GPU
Current Plant Status and Future Plans	J. DeVine, GPU
Instrumentation and Electrical Equipment Survivability	R. Foulds, NRC: Moderator
IEES Program Plans	R. Meininger, EG&G Idaho
IEES Results	M. B. Murphy, Sandia National Labs
IEES SPND Results	N. Wilde, EG&G Idaho, Inc.
IEES Electrical Test Program	R. Cheyne, UE&C
Mechanical Components	R. Foulds, NRC: Moderator
Mechanical Components Program Plan	G. Sliter, EPRI
Primary System Pressure Boundary Characterization	S. Tagart, EPRI
Radiation and Environment	A. Carson, EPRI: Moderator
Radiation and Environment Program Plan	P. Yarrington, Sandia National Labs

TMI-2 SEMINAR AGENDA

Radiation and Environment Results to Date	G. R. Eidam, EG&G Idaho, Inc.
Decontamination and Dose Reduction	J. DeVine, GPU: Moderator
Decontamination and Dose Reduction Program Plans	D. Leigh, Bechtel

<u>DECEMBER 5</u>

Waste Management	J. Devine, GPU: Moderator
Utility Waste Processing Activities	P. Deltete, GPU
Utility Waste Plan	R. Daniels, Bechtel
Department of Energy Future Plans	N. Gerstein, DOE
Waste Immobilization Program	R. E. Holzworth, EG&G Idaho, Inc.
Data Bank	W. W. Bixby, DOE: Moderator
Data Bank Program Overview	F. J. Kocsis III, EG&G Idaho, Inc.
Reactor Evaluation and Core Examination Program	W. W. Bixby, DOE: Moderator
Core Examination Program Overview	A. C. Millunzi, DOE
Core Removal Approach	R. Freemerman, Bechtel
Reactor Evaluation Program Status	H. M. Burton, EG&G Idaho, Inc.
Core Examination Program Plan	J. E. Hanson, EG&G Idaho, Inc.
Pre-Head Lift Removal Reactor Evaluation	G. Kulynych, B&W

THREE MILE ISLAND UNIT 2 RECOVERY PROGRAM

J. Devine

General Public Utilities

TMI-2 RECOVERY PROGRAM
OBJECTIVES

1. MAINTAIN REACTOR IN A SAFE CONDITION.

2. COLLECT AND DISPOSE OF RADIOACTIVE FISSION PRODUCTS IN GAS AND WATER.

3. DECONTAMINATE PLANT FACILITIES.

4. DISASSEMBLE REACTOR, REMOVE AND DISPOSE OF FUEL.

ALL OF THE ABOVE MUST BE ACCOMPLISHED WITH HIGHEST REGARD TO WORKER/ PUBLIC HEALTH AND SAFETY AND FULL COMPLIANCE WITH THE LAW.

11/19/81

PLANT STABILITY

CORE COOLING

- DECAY HEAT GENERATION IS APPROXIMATELY 50 KW
- BULK TEMPERATURE (AVERAGED IN-CORE THERMOCOUPLES) IS 113^{O}F. LOOP TEMPERATURES ARE T_{HOT} 110^{O}F, T_{COLD} 68^{O}F.
- CORE COOLING IS VIA DIRECT LOSS TO CONTAINMENT AMBIENT. NO FLOW IS INDICATED, BUT THERE IS THERMAL COOLING DUE TO CORE ΔT'S.

CRITICALITY

- CORE IS MAINTAINED SUBCRITICAL VIA CHEMICAL POISON (3500 PPM BORON).
- TWO STARTUP RANGE NEUTRON DETECTORS (BFs) IN SERVICE.

PRESSURE AND INVENTORY CONTROL

- RCS PRESSURE MAINTAINED AT 90 ($\pm$ 10) PSIG, VIA STANDBY PRESSURE CONTROL SYSTEM (SPC).
- RCS LEAK RATE IS APPROXIMATELY 0.1 GPM.

BOUNDARY INTEGRITY

- RCS BOUNDARY IS INTACT
- CONTAINMENT BOUNDARY IS INTACT AND BUILDING IS MAINTAINED AT SUBATMOSPHERIC PRESSURE AND POTENTIAL LEAK PAHTS ARE MONITORED.

11/19/81

PLANT STABILITY

OVERVIEW

BY ALL INDICATIONS, REACTOR REMAINS STABLE AND THERE HAS BEEN NO RECENT DEGRADATION OF INSTRUMENTATION OR EQUIPMENT. THE INSTALLATION OF SPC AND OTHER SYSTEMS HAS SUBSTANTIALLY IMPROVED PLANT CONTROL, COMPARED TO EARLIER POST-ACCIDENT CONDITION.

11/19/81

DECONTAMINATION OF AUXILIARY AND FUEL HANDLING BUILDINGS

- OPEN AREAS HAVE BEEN DECONTAMINATED (90% UNRESTRICTED AREAS).
- CUBICLE CONTAMINATION IS APPROXIMATELY 50% COMPLETE.
- LIMITED WORK IN 1981.

* *

OVERVIEW

AUXILIARY AND FUEL HANDLING BUILDING DECONTAMINATION HAS BEEN ACCOMPLISHED TO AN EXTENT PERMITTING REASONABLE ACCESS TO THE BUILDING AND OPERATION/SURVEILLANCE OF NECESSARY EQUIPMENT. THE MAJOR EFFORT AT THIS POINT IS TO MAINTAIN THE STATUS QUO IN THESE AREAS.

11/19/81

DECONTAMINATION OF CONTAINMENT

MAJOR ACCOMPLISHMENTS TO DATE INCLUDE:

- CONTAINMENT ACCESS WAS REGAINED IN AUGUST, 1980. SINCE THEN, NUMEROUS CONTAINMENT BUILDING ENTRIES HAVE BEEN MADE, FOR THE PURPOSES OF:

    INSPECTION AND CHARACTERIZATION

    DATA ACQUISITION

    DECONTAMINATION PLANNING (INCLUDING TWO MAJOR DECONTAMINATION TESTS)

- 43,000 CURIES OF KRYPTON-85 GAS WERE RELEASED TO THE ENVIRONMENT IN JULY, 1980.

- A SYSTEM HAS BEEN INSTALLED FOR REMOVAL OF THE HIGHLY CONTAMINATED WATER IN THE CONTAINMENT BASEMENT. AS OF NOVEMBER 15, APPROXIMATELY 250,000 GALLONS (OF AN ESTIMATED 600,000 GALLON TOTAL) HAD BEEN REMOVED.

- DETAILED PLANNING AND ENGINEERING, IN SUPPORT OF CONTAINMENT DECONTAMINATION, ARE PROCEEDING.

11/19/81

DECONTAMINATION OF CONTAINMENT

OVERVIEW

SUBSTANTIAL PROGRESS HAS BEEN MADE IN PREPARATION FOR CONTAINMENT BUILDING DECONTAMINATION. CONDITIONS IN THE BUILDING ARE WELL UNDERSTOOD. THE DECONTAMINATION SCHEDULE DEPENDS ON FUNDING, BUT SHOULD BE COMPLETED THROUGH PHASE I (GROSS DECON) DURING 1982.

11/19/81

REACTOR EXAMINATION, DISASSEMBLY, AND DEFUELING

CORE CONDITION

THE TMI-2 CORE IS SEVERELY DAMAGED, ALTHOUGH TO A DEGREE NOT PRECISELY KNOWN (SEE GEND-007 FOR DETAILS). FOR PLANNING PURPOSES, IT IS ASSUMED TO BE COMPRISED OF THREE REGIONS:

1. A RUBBLE BED, INCLUDING FUEL FINES, PELLETS, AND SMALL FRAGMENTS OF CORE MATERIAL.

2. AN AGGLOMERATED MASS OF PARTIALLY MELTED CORE-COMPONENTS OF VARIOUS MATERIALS.

3. WEAKENED, BUT INTACT (OR PARTIALLY INTACT) FUEL ASSEMBLIES.

11/17/81

REACTOR EXAMINATION, DISASSEMBLY, AND DEFUELING
MAJOR STEPS

THE PRIMARY ACTIVITIES LEADING TO REMOVAL OF THE TMI-2 CORE ARE AS FOLLOWS:

- NUMEROUS PREREQUISITES TO CONDUCTING MAJOR WORK IN THE REACTOR AREA, SUCH AS:
  - --REMOVAL OF SUMP WATER
  - --GROSS CONTAINMENT DECONTAMINATION
  - --POLAR CRANE REFURBISHMENT
  - --PROVISION OF FUEL HANDLING AND STORAGE SYSTEMS AND FACILITIES
  - --ERECTION OF SUPPORT FACILITIES
  - --CONSTRUCTION OF MOCKUP
- PRE-HEAD LIFT EXAMINATION (VIA TV CAMERA INSERTED THROUGH CRDM NOZZLES)
- INITIAL REACTOR DISASSEMBLY
- REMOVAL, ENCAPSULATION, AND STORAGE OF FUEL MATERIAL
- FINAL REACTOR DISASSEMBLY
- FUEL DISPOSAL

11/17/81

REACTOR EXAMINATION, DISASSEMBLY, AND DEFUELING

CURRENT AND PROJECTED STATUS

MAJOR WORK TO DATE HAS BEEN IN AREAS OF:

--TECHNICAL PLANNING

--DEVELOPMENT OF PRE-HEAD LIFT EXAMINATION EQUIPMENT

--IN-CONTAINMENT PREPARATION (SUMPWATER REMOVAL, INITIAL DECON)

SCHEDULED MILESTONES:

--PRE-HEAD LIFT EXAMINATION--OCTOBER 1982

--FUEL REMOVAL--MARCH 1984

CONTINUED PROGRESS IS HEAVILY DEPENDENT ON FUNDING

11/19/81

WATER MANAGEMENT

STARTING POINT

FOLLOWING THE TMI-2 ACCIDENT, THE ACCUMULATION OF RADIOACTIVELY CONTAMINATED WATER POSED A MAJOR PROBLEM, AS FOLLOWS:

- 500,000 + GALLONS OF ACCIDENT GENERATED WATER WAS STAGED IN AUXILIARY BUILDING TANKS. RADIONUCLIDE CONCENTRATIONS (1-100 μCi/ml GROSS ACTIVITY) PRECLUDED PROCESSING BY INSTALLED SYSTEMS, AND THERE WAS MINIMAL FREE-BOARD FOR ADDITIONAL WATER COLLECTION.

- APPROXIMATELY 600,000 GALLONS OF HIGHLY CONTAMINATED (>100 μCi/ml) WATER HAD COLLECTED IN THE CONTAINMENT BUILDING BASEMENT. NO SAFE METHOD OF TRANSFERRING, STORING, OR PROCESSING WATER OF THIS ACTIVITY LEVEL EXISTED AT TMI.

- FACILITIES FOR ACCOMMODATING PROCESSING SYSTEM BYPRODUCTS (SOLID WASTES AND PROCESSED WATER) WERE INADEQUATE.

11/19/81

PROCESSING SYSTEMS

EPICOR II

THIS SYSTEM WAS INSTALLED IN SUMMER '79 FOR TREATMENT OF AUXILIARY BUILDING WATER. IT UTILIZES A SERIES OF REPLACEABLE ION EXCHANGERS CONTAINING ORGANIC AND INORGANIC MEDIA. AS OF EARLY 1981, EPICOR II HAD PROCESSED 565,000 GALLONS OF INTERMEDIATE LEVEL WATER.

IN SUMMER '81, EPICOR II WAS ADAPTED TO SERVE AS A POLISHING UNIT FOR SDS EFFLUENT.

SUBMERGED DEMINERALIZER SYSTEM (SDS)

SDS IS AN ION EXCHANGE SYSTEM CONCEPTUALLY SIMILAR TO EPICOR, BUT DESIGNED FOR THE HIGHER LEVELS OF RADIOACTIVITY IN THE REACTOR BASEMENT AND REACTOR COOLANT SYSTEM. IT IS INSTALLED IN THE TMI-2 SPENT FUEL POOL "B". AS OF NOVEMBER '81, OVER 200,000 GALLONS OF REACTOR BUILDING WATER HAD BEEN PROCESSED VIA SDS.

11/19/81

WATER STORAGE SYSTEMS

TANK FARM

THIS SIX-TANK SHIELDED SYSTEM WAS INSTALLED IN THE TMI-2 SPENT FUEL POOL "B", SHORTLY AFTER THE ACCIDENT, TO PROVIDE ADDITIONAL SURGE CAPACITY FOR ACCIDENT WATER AND TO SERVE AS A FEED TANK FOR EPICOR AND SDS.

PROCESSED WATER STORAGE SYSTEM

THIS OUTDOOR TWO-TANK, 1,000,000 GALLON SYSTEM WAS INSTALLED IN 1980 TO PROVIDE FOR STORAGE OF PROCESSED WATER (CONTAINS TRITIUM AND TRACE QUANTITIES OF OTHER FISSION PRODUCTS) AND FOR RECYCLE OF THIS WATER FOR OTHER RECOVERY USES.

SOLID WASTE MANAGEMENT

- TMI-2 RECOVERY SYSTEMS AND FACILITIES ARE REQUIRED TO ACCOMMODATE:

   1. SOLID WASTES RESULTING FROM CONTAMINATED WATER PROCESSING.

   2. CONTAMINATED EQUIPMENT AND MATERIAL AND OTHER RESIDUE FROM AUXILIARY, FUEL HANDLING, AND CONTAINMENT BUILDING DECONTAMINATION.

- EXISTING PLANT FACILITIES AT TMI-2 WERE NOT ADEQUATE FOR THE LARGE QUANTITIES OF WASTE MATERIAL INVOLVED. THE SITUATION WAS AGGRAVATED BY THE LIMITED AVAILABILITY (FOR TMI-2 WASTES) OF COMMERCIAL OFF-SITE DISPOSAL FACILITIES.

SYSTEMS AND FACILITIES FOR WATER PROCESSING SOLID WASTES

EPICOR II LINERS

- A TRANSFER CASK WAS DEVELOPED SPECIFICALLY FOR ON-SITE HANDLING OF EPICOR LINERS.
- DEWATERING CAPABILITY IS INCLUDED IN THE EPICOR SYSTEM. (SOLIDIFICATION CAPABILITY WAS CONSIDERED, BUT NOT PROVIDED).
- SHIELDED STORAGE MODULES HAVE BEEN CONSTRUCTED ON SITE FOR SAFE STAGING PRIOR TO DISPOSAL.
- EQUIPMENT IS BEING DEVELOPED FOR VENTING LINERS, PRIOR TO SHIPMENT.

SDS LINERS

- IN-POOL DEWATERING AND VENTING EQUIPMENT IS IN SERVICE.
- STORAGE RACKS ARE INSTALLED IN THE "B" FUEL POOL.

11/19/81

DECONTAMINATION--SOLID WASTES

- CONTAMINATED TRASH IS COMPACTED AND PACKAGED TO MINIMIZE VOLUME.
- TO DATE, LIQUID DECON AGENTS HAVE BEEN DIRECT-SOLIDIFIED FOR DISPOSAL.
- TEMPORARY STORAGE HAS BEEN PROVIDED IN EXISTING PLANT STRUCTURES. ONE NEW STORAGE FACILITY HAS RECENTLY BEEN COMPLETED AND ANOTHER IS IN THE PLANNING STAGES.

11/19/81

OFF-SITE DISPOSAL

- THE DOE-NRC MEMORANDUM OF UNDERSTANDING REGARDING REMOVAL AND DISPOSITION OF TMI-2 SOLID NUCLEAR WASTES IS A MAJOR STEP IN RESOLVING THE DISPOSAL PROBLEM.

- AS OF FALL '81, EFFECTIVELY ALL SOLID WASTE REMOVED FROM TMI-2 HAS BEEN DISPOSED AT THE RICHLAND, WASHINGTON SITE. THIS INCLUDES:

  23 EPICOR LINERS (THOSE CONTAINING RELATIVELY LOWER LOADINGS)

  2400 FILTER-FIVE GALLON DRUMS

  320 LSA BOXES

- MAJOR DOE PARTICIPATION TO DATE INCLUDES:

  --EXAMINATION OF ONE HIGHLY LOADED EPICOR II LINER AT BATTELLE-COLUMBUS NATIONAL LABORATORIES.

  --PLANS AND DEMONSTRATION FOR VITRIFICATION OF SDS LINERS BY BATTELLE NORTHWEST NATIONAL LABORATORY, AT HANFORD, WASHINGTON.

  --PLANS FOR REMOVAL OF REMAINING EPICOR LINERS.

11/19/81

TMI-2 RECOVERY PROGRAM

SUMMARY OF MAJOR ACCOMPLISHMENTS TO DATE

- SUBSTANTIAL AUGMENTATION OF REACTOR CONTROL AND INSTRUMENTATION.

- MAJOR, EFFECTIVE DECONTAMINATION OF AUXILIARY AND FUEL HANDLING BUILDINGS.

- CONTAINMENT BUILDING:
  - --ACCESS REGAINED
  - --EXTENSIVE EXAMINATION & CHARACTERIZATION PROGRAM UNDERWAY

- DESIGN, INSTALLATION, AND OPERATION OF LIQUID WASTE MANAGEMENT SYSTEMS, INCLUDING:
  - EPICOR II SYSTEM
  - SUBMERGED DEMINERALIZER SYSTEM
  - PROCESSED WATER STORAGE SYSTEM

- DESIGN, INSTALLATION, AND USE OF SOLID WASTE MANAGEMENT SYSTEMS, INCLUDING TRANSFER AND STORAGE.

- MAJOR PLANNING, DEVELOPMENT, AND ENGINEERING PROGRAM FOR REACTOR DEFUELING.

11/19/81

INSTRUMENTATION AND ELECTRICAL PROGRAM

R. Meininger

EG&G Idaho, Inc.

TMI-2
Domestic
Seminar

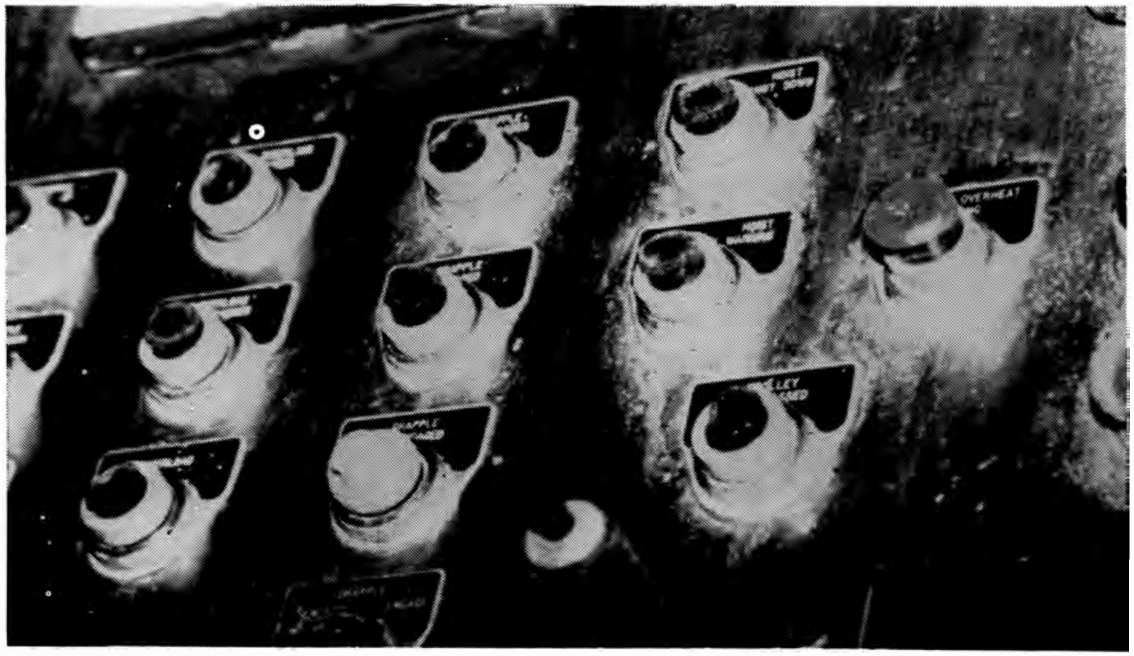
Instrumentation and Electrical Program

Presented by

Richard D. Meininger
EG&G Idaho, Inc.

December 1981

TMI I&E-1.



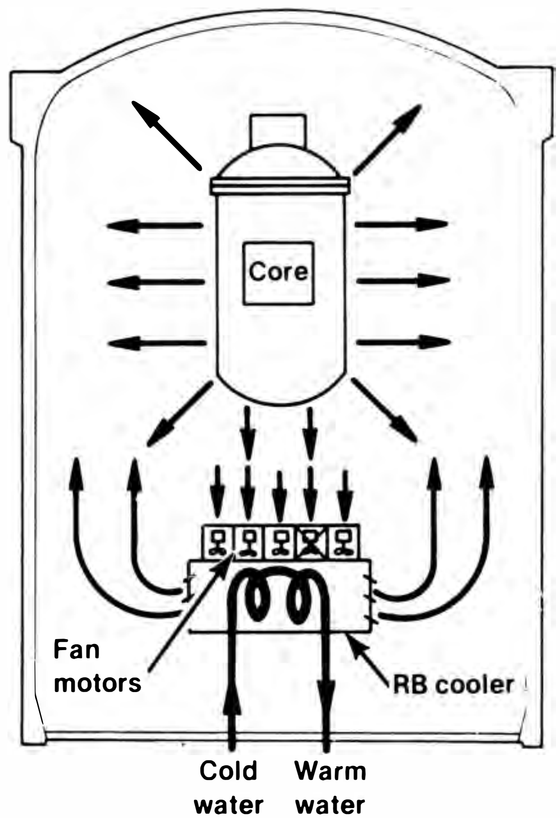
Instrumentation & Electrical Program

TMI I&E-2


Instrumentation and Electrical
Program Objectives
Survivability
Standards
Qualifications
Installation at TMI

Reactor Building Fan Motors

2 Years Continuous Operation With No Maintenance



Instrumentation & Electrical Program

GEND Established March 1980

General Public Utilities

Electric Power Research Institute

Nuclear Regulatory Commission

Department of Energy

TMI-2 Presents Opportunity to Obtain Information for Enhancement of Nuclear Power Industry Safety

GEND formed the

Technical

Working

Group

to direct the overall data acquisition program

GEND Formed Technical Planning Groups

- To acquire data in all research areas
- To benefit nuclear technology

Instrumentation and Electrical Program Planning Group

Nuclear Consultants * DOE * Architect Engineering Firms NRC * Utilities * National Labs

- Focused on industry I&E problems from accident
- Reviewed accident data
- Outlined data acquisition plans
- Established priorities for test and examination

Instrumentation and Electrical Planning Group May 1980

- Specify what to test
- Specify what to save
- Define methods and objectives
- Balance between need to restore plant and need to preserve data

Planning Report October 1980

- Recommended 228 items for testing
  - Important to plant safety
  - Accessible
  - Represent generic instrument categories

Planning Report
(cont'd)

- Recommended testing approach
  - Determine operational status
  - Compile data book
  - Conduct in situ tests
  - Remove and test off-site
  - Transfer information

Instrumentation and Electrical Program Initiated May 1980

- First In Situ test July 1980
- First device removed August 1980

Instrumentation and Electrical Technical Evaluation Group Established Aug 1981

- Review test and examination plans
- Review data
- Provide program guidance

Instrumentation and Electrical TEG Members

W.F. Schwarz, Coordinator	EG&G Idaho
J.D. Lawton	GPU (Met Ed)
D.W. Douds	BNC
R. Cheyne	UE&C
C.W. Mayo	SAI
R. Kubik	NSAC

Instrumentation and Electrical TEG Members

J.L. Voyles	INPO (Detroit Edison)
L.C. Oakes	ORNL
R. Feit	NRC
F.E. Tooper	DOE
A. Roble	Northeast Utilities

Instrumentation Categories

Resistance temperature devices

Radiation monitors

Pressure transducers

Vibration detectors

Self powered neutron detectors

Thermocouples

Electrical Component Categories

Cables

Polar crane

Motors

Motor control circuits

Relays

Solenoids

Switches

Heaters

Valve controllers

General Test Approach
for
Generic Categories

- Determine status
- Determine failure modes
- Analyze failure effects

General Test Approach

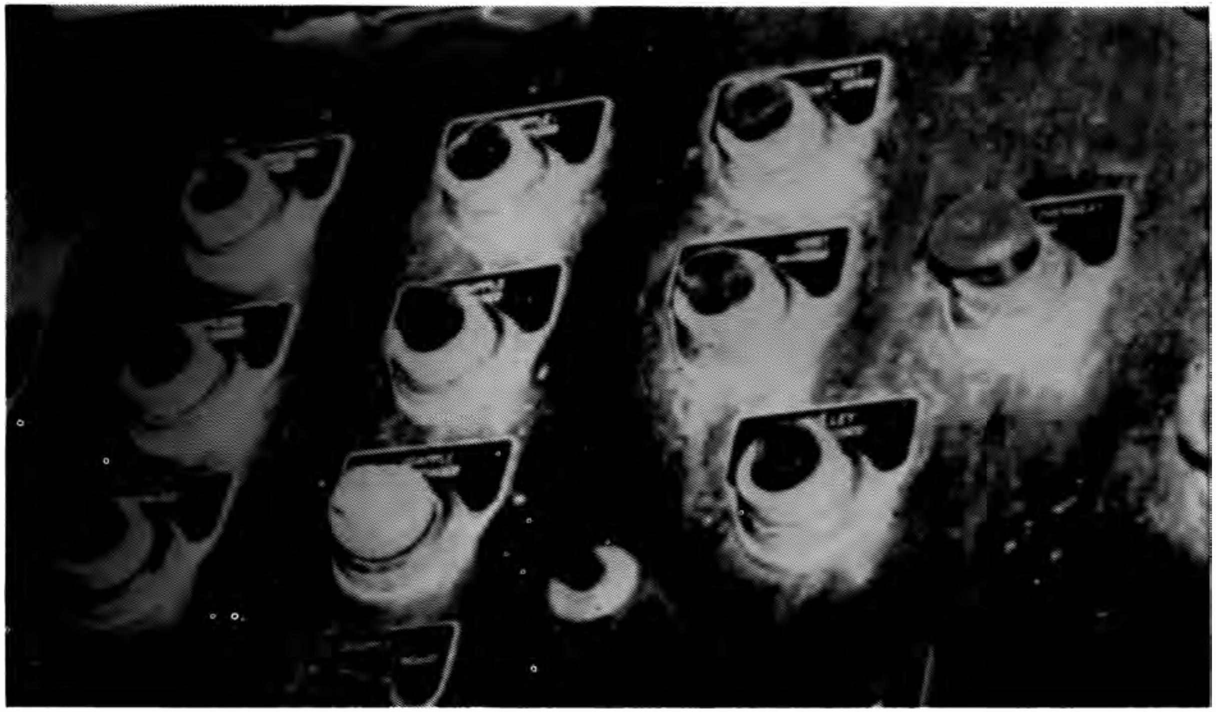
- Determine status
  - Accident data
  - Maintenance records
  - In situ tests

General Test Approach

- Determine failure modes or changes in operating characteristics
  - Selected removal
  - Examination
  - Vendor participation

- Analyze failure effects
  - Impact on system safety

Instrumentation & Electrical Program



Areas of Interest During FY-1982

TMI I&E-17

Instrumentation and Electrical Program Areas of Interest in FY-1982

- Area radiation monitor instrumentation
- Polar crane area electrical components
- Penetrations, cables, and cable terminations
- Resistance temperature devices
- Self powered neutron detectors and thermocouples

Area Radiation Monitor Instrumentation

- Three units removed to date
  - Failures due to radiation damage and moisture
- Dome monitor to be removed
  - Verify operating configuration
  - Determine cause of failure
  - Compare accident data to post accident radiation environment data

Polar Crane Electrical Components

- High concentration of electrical components
  - Low radiation
  - High temperature
  - Hydrogen burn
  - Probable moisture damage
- Initial in situ tests completed
  - Assess overall damage
- Remove and test motors, cables, and motor control components

Additional Electrical Components

Penetrations, Cables, and Cable Terminations

- Probable damage by heat, radiation, and moisture
- Remove samples and test to determine remaining life
- Perform in situ tests to determine if remaining items meet minimum life specifications
- Resolve decontamination problems

Resistance Temperature Devices (RTD's)

- Examine RTD's
  - Reactor coolant system
  - Air handling system
  - Secondary plant
- Determine survivability
  - Failures
  - Rise time degradation
- Comparison of survivability
  - LOCA qualified
  - Safety qualified
  - Other

SPND's and Thermocouples

- 52 bundles with 7 SPND's and 1 thermocouple in each
- Many SPND's failed
- Most thermocouples still operating

SPND's and Thermocouples

- Early analysis to determine accident core temperature
- Data on core uncovery history
- No reliable high temperature data

SPND's and Thermocouples

- Develop in situ test to locate failure area
- Ex-vessel cable or connector failure from LOCA
- In-vessel high temperature failure

Industry Involvement

- Technical evaluation group
- Subcontractors
  - GPU UE&C
  - TEC SAI
- Cooperative agreements with vendors
  - develop test plans
  - evaluate data
- Full time information coordinator
  - W. Schwarz (717) 948-1063

Accomplishments

- Radiation monitors & electronics
- Neutron detectors
- Electrical components
- Notices on notepad
  - Radiation monitors installation
  - Radiation sensitive electronics
- List of publications in handouts

Survivability, Standards, Qualifications = Safety

INSTRUMENTATION AND ELECTRICAL EQUIPMENT SURVIVABILITY RESULTS

M. B. Murphy

Sandia National Laboratories

TMI–2
INFORMATION AND EXAMINATION PROGRAM
DOMESTIC SEMINAR

TASK (1.0)
INSTRUMENTATION AND ELECTRICAL EQUIPMENT SURVIVABILITY RESULTS

PRESENTATION BY

M.B. MURPHY
SANDIA NATIONAL LABORATORIES
DECEMBER 4, 1981

INSTRUMENTATION EQUIPMENT ANALYZED AT SANDIA LABORATORIES

1. HP-R-211, AREA RADIATION MONITOR
2. HP-R-213, AREA RADIATION MONITOR
3. YM-AMP-7023, LPM CHARGE AMPLIFIER
4. YM-AMP-7025, LPM CHARGE AMPLIFIER
5. NI-AMP-2, SOURCE RANGE NEUTRON PREAMPLIFIER
6. MULTICONDUCTOR CABLE

TMI-2 AREA RADIATION MONITORS

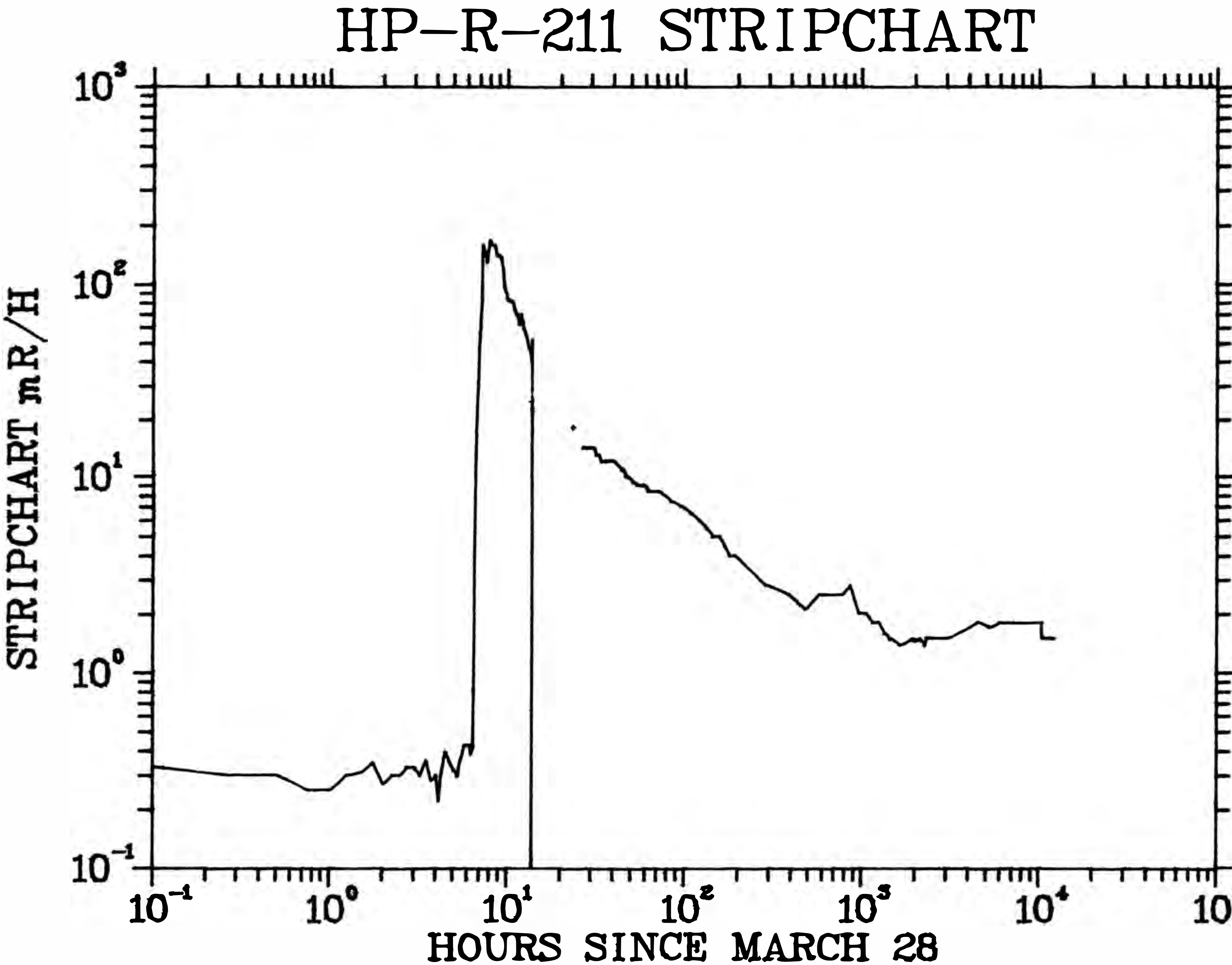
DESCRIPTION:

- 5 GM TUBE DETECTORS AND 1 ION CHAMBER DOME MONITOR. ALL MANUFACTURED BY VICTOREEN INC.
- 4 ARE KNOWN TO HAVE FAILED EITHER DURING OR SINCE THE ACCIDENT
- GM TUBE DETECTORS ARE NOT LOCA QUALIFIED BUT HAVE "O" RING SEAL AND DESIGNED FOR 10^5 RADS (3 FAILED)
- DOME MONITOR HERMETICALLY SEALED INSIDE 2" LEAD/SS CONTAINER AND LOCA QUALIFIED (FAILED)
- HP-R-211 (PERSONNEL HATCH) AND HP-R-213 (INCORE TUBE ACCESS AREA) REMOVED AND ANALYZED

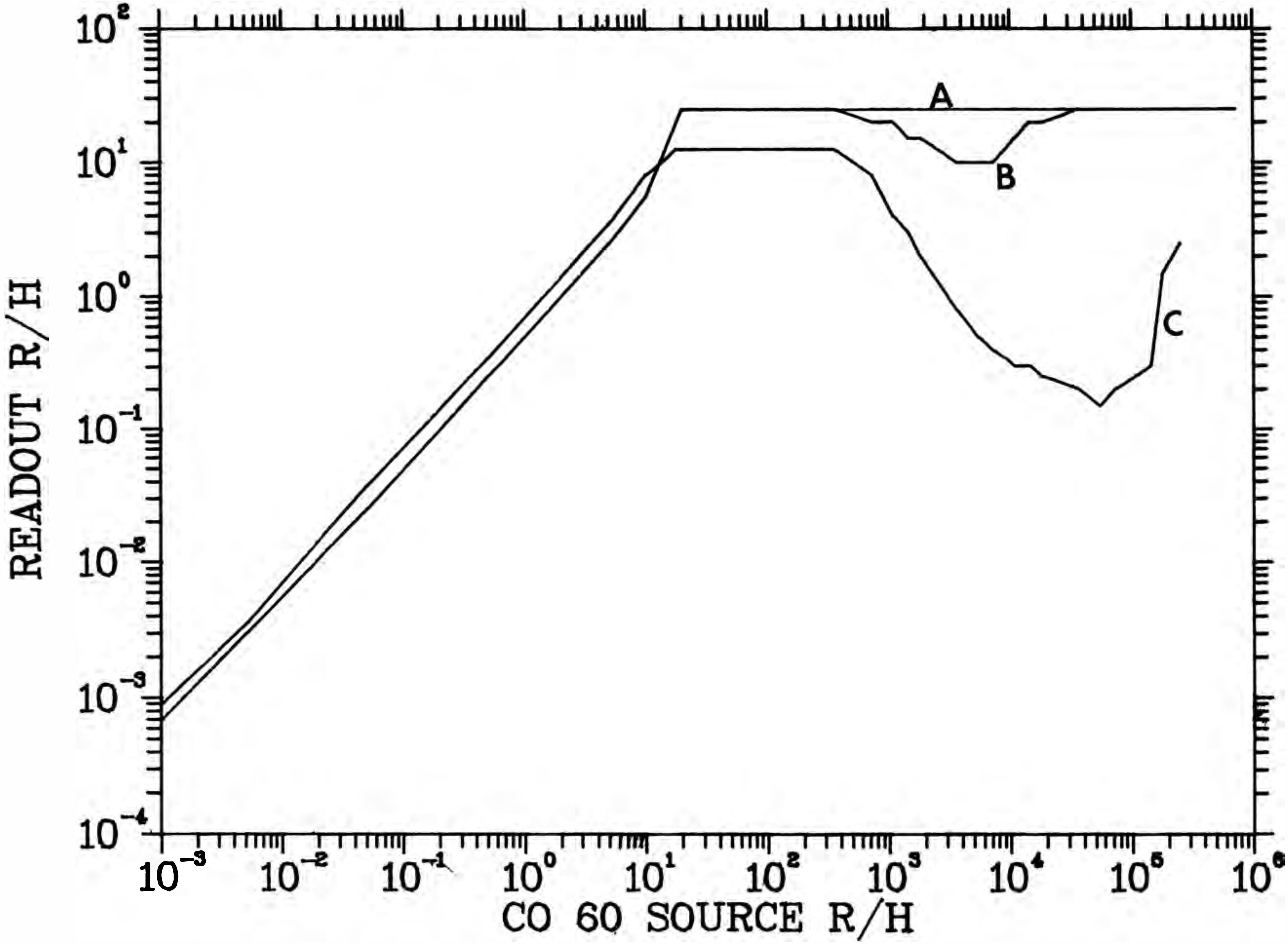
HP-R-211 RADIATION DETECTOR ANALYSIS

CONCLUSIONS:

1. TRANSISTOR PUNCH-THROUGH CAUSED DEGRADED OUTPUT
2. SPRAYS ENTERED IMPROPERLY MATED CONNECTOR BACKSHELL ALLOWING HV SHORTS
3. DETECTOR WAS MOUNTED UPSIDE DOWN
4. MULTIVALUED OUTPUT DISCOVERED
5. IMPROPER CABLE MATCHING CIRCUIT COMBINED WITH RADIATION DEGRADATION OF TRANSISTORS AND GM TUBE CAUSE MULTIVALUED OUTPUT
6. TOTAL GAMMA DOSE OF 2.5 X 10^5 RADS, FROM TRANSISTOR AND ELASTOMERIC DATA
7. MAJOR SURFACE CONTAMINANTS: CS-134, CS-137, SR-90
8. DECONTAMINATION TECHNIQUES WERE EVALUATED
9. RADIATION TIME HISTORY BEING INVESTIGATED


HP-R-211 STRIPCHART
STRIPCHART mR/H
HOURS SINCE MARCH 28
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}

MULTIVALUED READOUT



HP-R-213 RADIATION DETECTOR ANALYSIS

CONCLUSIONS:

1. FAILED AT TIME OF HYDROGEN BURN
2. NO INTERNAL CONTAMINATION
3. BROKEN GM TUBE
4. GAMMA RADIATION TOTAL DOSE OF 8×10^5 RADS

TMI-2 LOOSE PARTS MONITORING

DESCRIPTION:

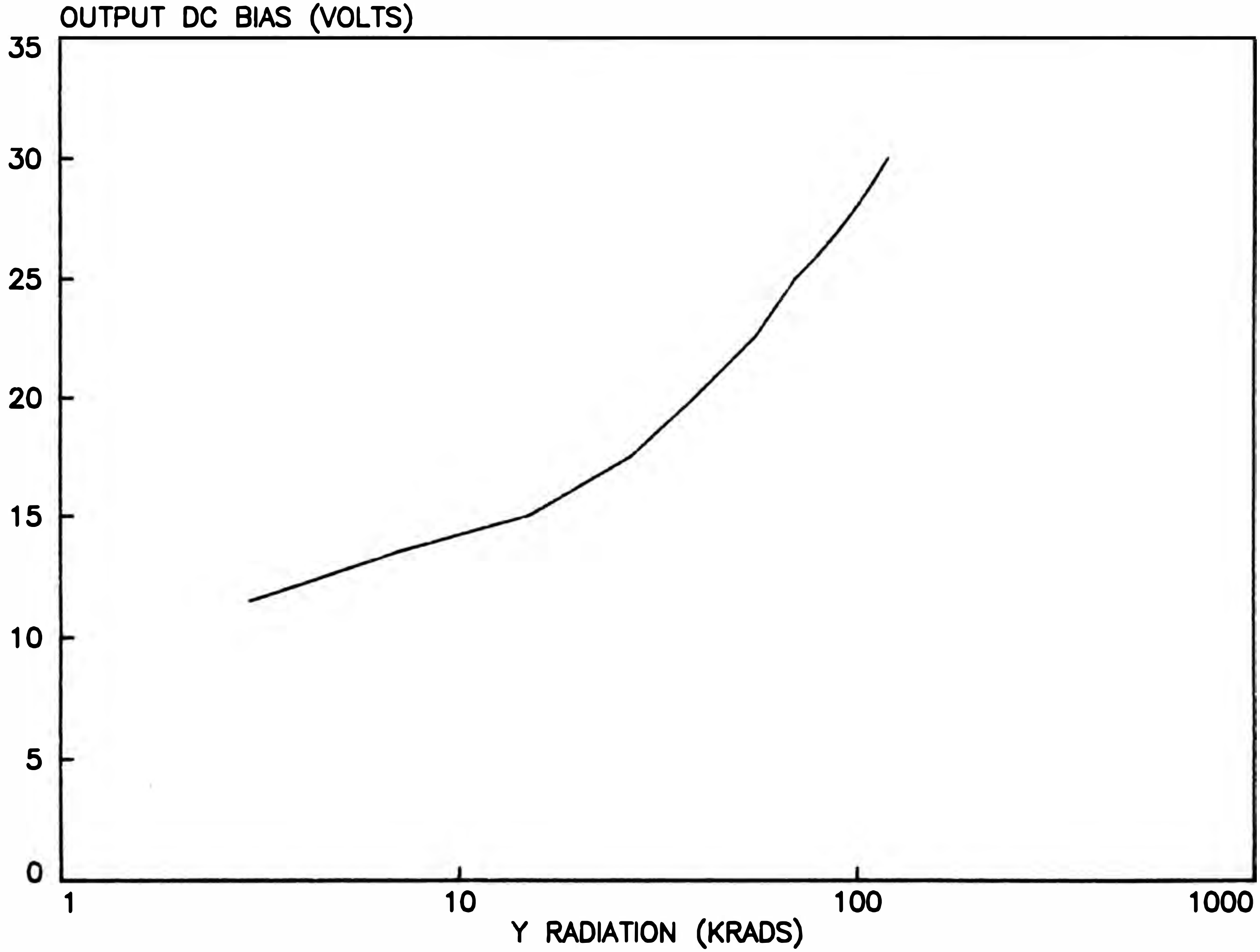
- ROCKWELL LPM SYSTEM USES PIEZOELECTRIC TRANSDUCERS AND CHARGE AMPLIFIERS INSIDE CONTAINMENT.
- 7 OF 8 STEAM GENERATOR MONITORING CHANNELS INOPERABLE TODAY. PROBABLY FAILED DURING FIRST TWO DAYS.
- ENDEVCO CHARGE CONVERTERS MOUNTED OUTSIDE D RING.
- 2 CHARGE CONVERTERS REMOVED AND ANALYZED. ONE MARGINAL, ONE BAD.
- CHARGE CONVERTER HAS RADIATION SUSCEPTABLE MOS TRANSISTOR
- USED FOR POST ACCIDENT MONITORING AND OUTPUTS WERE ASSUMED (INCORRECTLY) TO BE ACCURATE.

CHARGE CONVERTER
YM-AMP-7023/7025 ANALYSIS

CONCLUSIONS:

1. DISTORTED OR NO OUTPUT CAUSED BY MOS $V_{GS(th)}$ RADIATION DEGRADATION
2. ESTIMATE THIS DESIGN USABLE UP TO ONLY 1.2×10^5 RADS
3. TOTAL GAMMA DOSE OF 9×10^4 AND 2.2×10^5 RADS FROM MOS TRANSISTOR DATA
4. DO NOT USE MOS TRANSISTORS IN ANY APPLICATION IN A NUCLEAR REACTOR

MODEL 2652 — OUTPUT BIAS VS. GAMMA



TMI-2 NEUTRON DETECTORS

DESCRIPTION:

- TWO NON-CLASS 1E SOURCE RANGE CHANNELS MANUFACTURED BY BAILEY USING BF3 DETECTORS
- PREAMPLIFIERS HOUSED IN TRIPLE BOX AND MOUNTED OUTSIDE D RING
- ONE CHANNEL FAILED IN MID APRIL, 1979
- PREAMPLIFIER HAS 4 TRANSISTORS AND 5 IC's

TMI-2 NEUTRON DETECTOR ANALYSIS

CONCLUSIONS:

1. PREAMPLIFIER OPERATES WITHIN SPECIFICATIONS
2. SPARE PREAMPLIFIER ANALYZED AND OK
3. CHANNEL FAILURE IN THIS AND A POWER RANGE CHANNEL POSSIBLY DUE TO CABLE CONNECTIONS IN PENETRATIONS
4. RECOMMEND CONFORMAL COATING OF ASSEMBLED PRINTED WIRING BOARDS BECAUSE OF HUMID ENVIRONMENTS

HP-R-211 CABLE ANALYSIS

DESCRIPTION:

- CONNECTS TO AREA MONITOR HP-R-211
- RAYCHEM FLAMTROL (TM) CABLE, 10 INSULATED CONDUCTORS, 2 COAX

CONCLUSIONS:

1. NO MEASURABLE DEGRADATION IN STRENGTH, ELONGATION OR RESISTIVITY PROPERTIES
2. RADIATION LEVELS UNDER 10^6 RADS

TMI-2 LESSONS LEARNED

1. TMI-2 ALLOWS ASSESSMENT OF EQUIPMENT IN AN ACTUAL OPERATING PLANT
   - INSTALLATION AND MAINTENANCE PRACTICES (UNANTICIPATED)
   - BASIC EQUIPMENT EVALUATION
2. MORE CONSIDERATION SHOULD BE GIVEN TO DESIGN, TESTING AND INSTALLATION OF ANY INSTRUMENT (SAFETY-RELATED OR NOT)
   - POST ACCIDENT MONITORING IMPROVEMENT
3. TMI-2 ENVIRONMENT WAS A "MILD" LOCA BUT STILL EQUIPMENT FAILED
4. SEVERAL SIMPLE CIRCUIT DESIGN CHANGES HAVE BEEN IDENTIFIED
5. THREE NOTEPAD ALERTS HAVE BEEN ISSUED

HP-R-211 TOTAL GAMMA RADIATION DOSE

	TRANSISTOR GAIN[1] DEGRADATION	ELASTOMER[2]	
		TEFLON SLEEVE	BUNA NITRILE O-RING
NOMINAL RADS ($X10^5$)	2.5	2.0	[3] 10.0
ERROR BARS RADS ($X10^5$)	0.8 TO 5.1	0.7 TO 6.0 (EST)	–

1. AVERAGE OF 6 TRANSISTORS. INCLUDES BIAS & ANNEALING EFFECTS.
2. AVERAGE OF 2 TEFLON SLEEVES AND 1 O RING.
3. THE "O" RING APPEARS TO BE NEAR BUT UNDER ITS DAMAGE THRESHOLD OF 10^6 RADS.

HP-R-211 CONTAMINATION NUCLIDES

- RATIO Cs 137 TO Cs 134 = 6.3/1

- TOP HORIZONTAL SURFACE Cs 137 = 0.973 $\mu Ci/cm^2$

- BODY (MOSTLY VERTICAL) Cs 137 = 0.103 $\mu Ci/cm^2$

- OTHER RADIOISOTOPES (CONNECTOR THREADED RING)

Sr	0.11 µCi
Te	NOT DETECTED
Pu	<0.002 µCi
U	NOT DETECTED (<10 ppm)

HP-R-211 DECONTAMINATION

APPROACH NO SCRUBBING, MINIMIZE CHEMICALS

	DECONTAMINATION STEP				
	HANDLING	WATER SPRAY	DETERGENT SPRAY	LOW P STEAM	TURCO 4512[2] SPRAY/SOAK
PERCENT ACTIVITY DECREASE PER STEP (Cs 137)	44	14.5	10.5	37.3	46.2
mRAD/HR AFTER DECON STEP (HOTSPOT)[1]					
BETA	98.2	80.0	71.0	46.2	15.7
GAMMA	7.9	6.6	5.9	3.4	1.5

1. PEAK TO AVERAGE RATIO ~ 2 (GAMMA)
2. TWO APPLICATIONS OF TURCO 4512

MBM 8/24/81

TMI-2 AREA RADIATION MONITORS

DESCRIPTION:

- 4 MONITOR CHANNELS KNOWN TO BE INOPERABLE
- 2 GM TUBE DETECTORS ANALYZED, HP-R-211 AND HP-R-213
- DOME MONITOR (ION CHAMBER) NOT EXAMINED YET
- GM TUBE DESIGNS NOT LOCA QUALIFIED

RADIATION DETECTOR ANALYSIS

CONCLUSIONS:

1. TRANSISTOR PUNCH-THROUGH CAUSED HP-R-211 DEGRADED OUTPUT
2. SPRAYS ENTERED CONNECTOR BACKSHELL
3. DETECTORS WERE MOUNTED UPSIDE DOWN
4. MULTIVALUED OUTPUT CAUSED BY RADIATION DEGRADATION
5. BROKEN GM TUBE IN HP-R-213 CAUSED BY HYDROGEN BURN
6. TOTAL GAMMA DOSES OF 2.5 X 10^5 AND 8 X 10^5 RADS
7. MAJOR SURFACE CONTAMINANTS: CS-134, CS-137, SR-90
8. DECONTAMINATION TECHNIQUES EVALUATED
9. RADIATION TIME HISTORY BEING INVESTIGATED

OTHER TMI–2 EQUIPMENT ANALYZED

LPM CHARGE CONVERTERS (2) – ENDEVCO

- ONE MARGINAL, ONE BAD (OTHERS BAD ALSO)
- MOS TRANSISTOR DEGRADED PROBABLY IN FIRST 2 DAYS
- DESIGN PROBABLY USABLE UP TO 1.2 X 10^5 RADS
- TOTAL GAMMA DOSE 9 X 10^4 AND 2.2 X 10^5 RADS
- DO NOT USE MOS TRANSISTORS IN NUCLEAR REACTORS

SOURCE RANGE NEUTRON PREAMPLIFIER – BAILEY

- PREAMPLIFIER OPERATES WITHIN SPECIFICATIONS
- FAILURE PROBABLY IN CABLE CONNECTIONS
- OTHER POTENTIAL CABLE CONNECTION FAILURES INDICATED
- RECOMMEND CONFORMALLY CO AT PRINTED WIRING ASSEMBLIES

MULTICONDUCTOR CABLE – RAYCHEM

- NO MEASURABLE DEGRADATION

CRYSTAL RIVER #3 DOME MONITOR RESPONSE

DESCRIPTION:

- 40,000 GALLONS OF PRIMARY COOLANT DISCHARGED INTO CONTAINMENT IN 2 HOURS THROUGH PORV AND CODE SAFETY VALVES ON FEBRUARY 26, 1980
- DOME RADIATION MONITOR 60 R/hr. CALCULATED IS 4 R/hr.
- GENERAL EMERGENCY SHOULD BE DECLARED ON HIGH RANGE GAMMA HIGH ALARM (8 R/hr AT TMI-2) BUT WAS NOT
- PROBABLY A GENERAL ATOMICS ION CHAMBER INSIDE STAINLESS-STEAL SHROUD

COMMENTS:

- CRYSTAL RIVER PEOPLE BELIEVE MONITORS WERE OK
- CALCULATED LEVELS DO NOT CORRESPOND TO MEASURED LEVELS
- SIMILARITY EXISTS WITH TMI-2 DOME MONITOR
- TMI-2 CALCULATIONS TO COMPARE TO DOME MONITOR READINGS
- DOES A MEASUREMENT PROBLEM EXIST

TVA LOOSE PARTS MONITOR EXPERIENCE

DESCRIPTION:

- LPM CHARGE CONVERTERS (ENDEVCO MODEL 2652M4) AT SEQUOIA 1 FAILED DURING FIRST YEAR OPERATION
- PROBABLE GAMMA DEGRADATION OF MOS TRANSISTORS LIKE TMI-2
- TEC LPM DESIGN. CONVERTERS LOCATED WITHIN 10' OF TRANSDUCER IN HIGH GAMMA FIELDS
- DEGRADATION DIAGNOSED BY BIAS VOLTAGE MEASUREMENT

STATUS:

- CHARGE CONVERTERS AT SEQUOIA 1 & 2, WATTS BAR 1 & 2, AND BELLEFONT 1 & 2 BEING REPLACED
- SEQUOIA 1 CONVERTERS BEING SHIPPED TO SANDIA FOR ANALYSIS
- NOTEPAD NOTIFICATION TO BE MADE BY TVA AND TIO

MECHANICAL COMPONENTS PROGRAM PLANS

G. Sliter

Electric Power Research Institute

TMI-2
DOMESTIC SEMINAR

TMI-2 Mechanical Component Information and Examination Program Plans

Presented By:

George Sliter
Electric Power Research Institute

December 1981

PROGRAM OBJECTIVES

- Use Condition & Performance of Selected TMI-2 Mechanical Components to Identify Improvements in Safety & Cost-Effectiveness
  - Component and System Design
  - Codes and Standards
  - Specification of DBA Conditions
  - Fabrication, Installation, Maintenance, and Operating Procedures
  - Qualification Requirements

PROGRAM PLAN

Phase I — Program Development (1981)

- **Establish Site Facilities and Interfaces**
- **Compile Background Information (Recovery Schedule, Environment, Component Data, etc.)**
- **Establish QA and Decon Protection Plans**
- **Develop Detailed Program Plan for Major Examinations**
- **Perform Test Case Recovery and Examination of One or Two Lead Components**

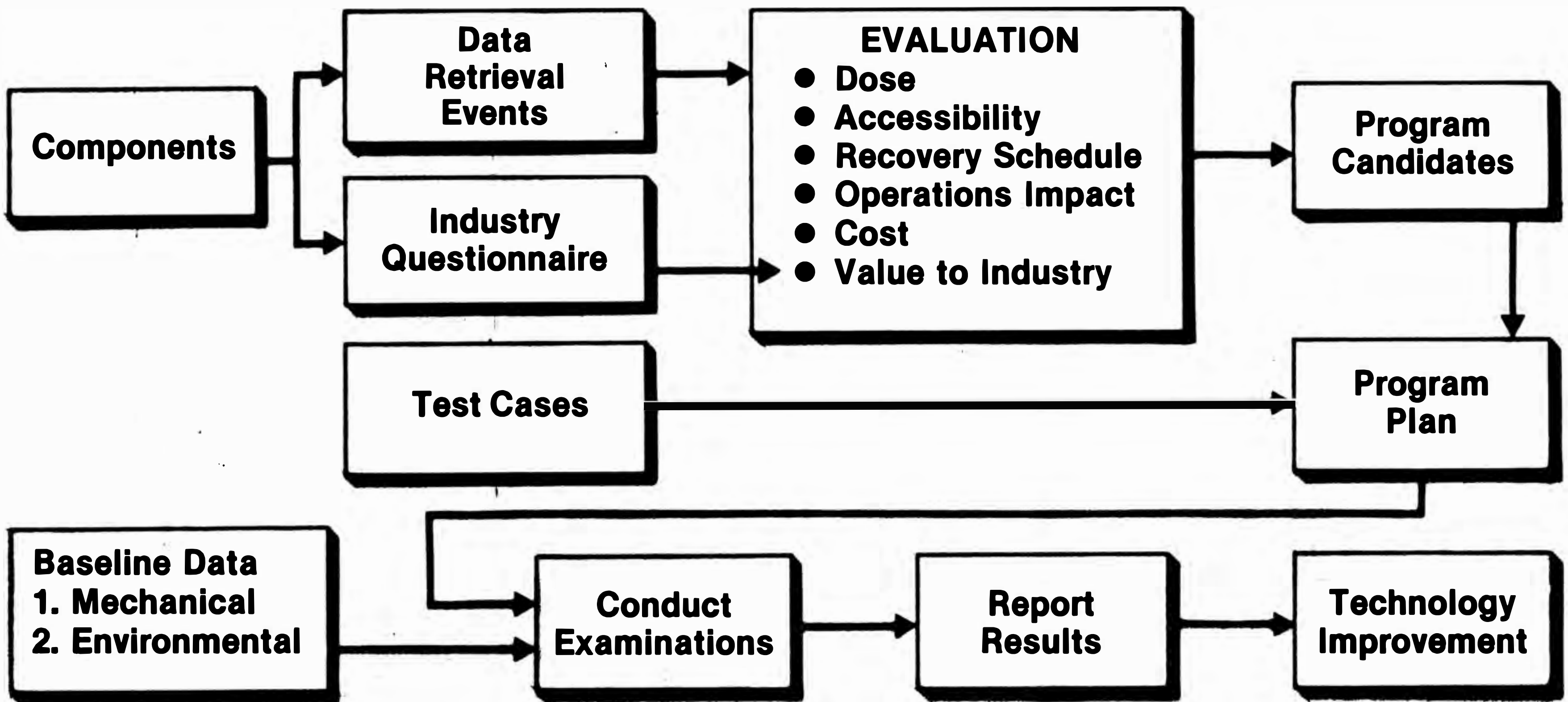
Phase II — Program Implementation (1982 and Beyond)

- **Implement Program Defined by Phase I**

PROGRAM APPROACH

- Industry Committee Coordinated by EPRI Produced List of 34 Candidate Components (1980)
  - Pumps, Valves, Snubbers, Supports, Coatings, etc.
- Prime Contractor (IEAL):
  - Examine "Lead" Components
  - Prioritize & Order Candidate Components for Exam in 1982 and Beyond (Utility, A/E, Vendor Input via Questionnaire)
- In-situ Tests, Recovery, and Lab Exam Performed by GPU and Other Contractors (Coordination with TIO)
- Data Analysis & Recommendation of Technology Improvements via Reports and Seminars

MECHANICAL COMPONENT INFORMATION AND EXAMINATION PROGRAM



CANDIDATE COMPONENTS

1. Reactor Coolant Pump
2. Reactor Coolant Pump Motor
3. Pilot-Operated Relief Valve
4. Pressurizer Block Valve
5. Pressurizer Relief Valve Piping & Supports
6. Major Component Supports
7. Miscellaneous Metallurgical Specimens
8. Steam Generator
9. Hydraulic Snubbers
10. Various Isolation Valves
11. Control Rod Drives & Position Indicators
12. Pressurizer Safety Valves
13. Coatings
14. Airlock Door Seals
15. Reactor Drain Tank Relief Valves
16. Mechanical Snubbers
17. Makeup System Filters
18. Cranes and Hoists

CANDIDATE COMPONENTS
(Continued)

19. Reactor Vessel Closure Seals & Bolting
20. Makeup Pumps
21. Pressurizer Heaters
22. Reflective Insulation
23. Reactor Building Air Cooling Unit
24. Reactor Building Quick-Opening Dampers
25. Reactor Building Quick-Opening Damper Pilot Valve
26. Reactor Building Ductwork
27. Miscellaneous Valves
28. CRD Service Structure Fans
29. Reactor Vessel Cavity Cooling Fans
30. Letdown Coolers
31. Pipe & Cable Tray Supports
32. Concrete Surfaces
33. Electrical Distribution Panels
34. Containment Spray Header
35. Refueling Canal Seal

NEAR-TERM CANDIDATE SELECTION

- Field of Candidates Dominated by Accessibility and Schedule
- Four Candidates in Finals for Near-Term

  1. Pilot Valves for Containment Isolation Valves
  2. Coatings
  3. Mechanical Shock Suppressors (Snubbers)
  4. Reflective Insulation

NEAR-TERM CANDIDATE SELECTION
(Continued)

- **Attributes Evaluated**
  1. Objectives of the MCI&EP
  2. Impact on TMI-2 Recovery Effort
  3. Occupational Exposure
  4. Cost
  5. Total Entry Hours Required
  6. Knowledge of Baseline and Accident Condition Data
  7. Probability of Successful Results
  8. Alleviates Data Preservation Requirements
- **Selected Snubbers as Lead and Insulation as Backup**

NEAR-TERM CANDIDATE #1
MECHANICAL SNUBBERS

Parameters Subject to Exam

- External Conditions; Corrosion, Distortion
- Freedom of Motion of Attachment to Pipe
- Breakaway Friction Force
- Damping Characteristics
- Structural Integrity

NEAR-TERM CANDIDATE #2
REFLECTIVE INSULATION

Parameters Subject to Exam

- External Conditions; Corrosion, Distortion
- Ease of Decontamination
- Insulating/Conductance Properties

ENVIRONMENTAL CONDITIONS

- Radiation
- Containment Spray
- Steam
- Temperature
- Humidity
- Pressure
- Submergence
- Hydrogen Burn

USE OF RESULTS

- Document Non-Failures and Failures
- Compare Conditions to Specification
- Non-Failures, Either:
  - Verify Design within Bounds of Conditions Experienced
  - Indicate Margin
- Failures
  - If Inside Design Envelope; Correction Needed
  - If Outside Design Envelope; Technical Interest

PROGRAM PLANS

1982 Likely Candidates

- Coatings
- Pressurizer Safety and Relief Valves
- Polar Crane
- Other Valves within Containment
- Some Supports
- Cooling Fans
- Visual Examinations of Accessible Components

Beyond 1982 — Depends Heavily on TMI-2 Schedule

PRIMARY SYSTEM PRESSURE BOUNDARY CHARACTERIZATION

Electric Power Research Institute

TMI-2
INFORMATION AND EXAMINATION
PROGRAM

PRIMARY SYSTEM PRESSURE BOUNDARY CHARACTERIZATION

- DEFINITION OF THERMAL TRANSIENTS ASSOCIATED WITH THE UPPER PLENUM REGION, BELTLINE REGION, NOZZLE BELT REGION, AND THE VESSEL INLET PIPING DURING THE ACCIDENT, RESEARCH PROJECT (DECEMBER 1981)

- CODIFICATION OF A GENERIC REQUALIFICATION STANDARD (FRAMEWORK DEVELOPED UNDER EPRI RESEARCH PROJECT)

- DEFINITION OF MATERIAL PROPERTIES REQUIREMENTS FOR REQUALIFICATION

- DEFINITION OF THERMAL, STRESS, AND FRACTURE ANALYSIS REQUIREMENTS FOR REQUALIFICATION

- DEFINITION OF NON-DESTRUCTIVE EXAMINATION REQUIREMENTS FOR REQUALIFICATION

TMI-2

INFORMATION AND EXAMINATION PROGRAM

PRIMARY SYSTEM PRESSURE BOUNDARY CHARACTERIZATION

- RESEARCH PROJECT "THERMAL ANALYSIS OF TMI-2 PRESSURE BOUNDARY"

  CONTRACTOR: GENERAL ELECTRIC COMPANY - VALLECITOS NUCLEAR CENTER

  THE THERMAL MODEL OF THE BELTLINE REGION IS UNDER CONSTRUCTION. MATERIAL PROPERTIES HAVE BEEN COLLECTED, AND NODAL STRUCTURE AND DIMENSIONING HAVE BEEN COMPLETED. GAMMA HEATING DISTRIBUTION ESTIMATES HAVE BEEN COMPUTED. BOUNDARY CONDITIONS FOR THE ANALYSIS ARE BEING ESTABLISHED.

- RESEARCH PROJECT "PRIMARY PRESSURE BOUNDARY REQUALIFICATION"

  CONTRACTOR: NEGOTIATIONS UNDERWAY WITH THE BABCOCK AND WILCOX COMPANY - LYNCHBURG

TMI-2
INFORMATION AND EXAMINATION
PROGRAM

PRIMARY SYSTEM PRESSURE BOUNDARY CHARACTERIZATION

EMPHASIS ON REACTOR PRESSURE VESSEL AND HEAD BECAUSE:

- THEY ARE PRIMARY SYSTEM COMPONENTS MOST LIKELY TO HAVE BEEN SUBJECTED TO SIGNIFICANTLY ADVERSE CONDITIONS

- WHETHER OR NOT THEY ARE QUALIFIED FOR FURTHER SERVICE HAS MAJOR IMPACT ON PLANT RECOVERY STRATEGIES AND PLANS

TMI-2
INFORMATION AND EXAMINATION
PROGRAM

PRIMARY SYSTEM PRESSURE BOUNDARY CHARACTERIZATION

PRINCIPAL PURPOSES:

- TO ACCELERATE RESEARCH AND DEVELOPMENT EFFORTS IN AREAS WHICH CAN PROVIDE INPUT INFORMATION AND ADVANCED METHODS AND TECHNIQUES OF VALUE IN TMI-2 PRIMARY SYSTEM COMPONENT QUALIFICATION ASSESSMENT AND CONFIRMATION.

- TO UTILIZE TMI-2 PRESSURE VESSEL AND HEAD AS KEY APPLICATIONS OF METHODS AND PROCEDURES CONSIDERED FOR CODIFICATION AND ACCEPTANCE FOR GENERIC USE IN QUALIFYING PRESSURE BOUNDARY COMPONENTS FOR FURTHER SERVICE IN NUCLEAR SYSTEMS.

TMI-2
INFORMATION AND EXAMINATION
PROGRAM

PRIMARY SYSTEM PRESSURE BOUNDARY CHARACTERIZATION

CATEGORIES OF EFFORT INCLUDE:

- TECHNICAL INPUT TO AND INTEGRATION WITH GPU'S BASE PROGRAM
- ADVANCED METHODS DEVELOPMENT AND DEMONSTRATION
- DATA ACQUISITION AND ANALYSIS
- COMPILATION AND DISSEMINATION OF RESULTS

TMI-2
INFORMATION AND EXAMINATION
PROGRAM

PRIMARY SYSTEM PRESSURE BOUNDARY CHARACTERIZATION

INTEGRATION WITH GPU'S BASE PROGRAM AND OTHER I&E TASKS

- INDEPENDENT CALCULATIONS OF TEMPERATURE TRANSIENTS AT CRITICAL LOCATIONS
- ADDITIONAL BENCHMARKS FROM CAPSULE SAMPLES, CORE COMPONENTS, UPPER PLENUM INTERNALS, ETC.
- ANALYTICAL SUPPORT TO ASSESSMENT OF IMPOSED STRESSES, MATERIAL PROPERTIES, ETC.

TMI-2
INFORMATION AND EXAMINATION
PROGRAM

PRIMARY SYSTEM PRESSURE BOUNDARY CHARACTERIZATION

REQUALIFICATION OF COMPONENTS FOR CONTINUED USE AFTER EXPERIENCING C (EMERGENCY) OR D (FAULTED) TRANSIENTS

FROM NCA-2142.2 (ASME SECTION III)

C - "THE OCCURRENCE OF STRESS TO LEVEL C LIMITS MAY NECESSITATE REMOVAL OF THE COMPONENT FOR INSPECTION OR REPAIR OF DAMAGE TO COMPONENT OR SUPPORT"

D - "THE SETS OF LIMITS PERMIT GROSS GENERAL DEFORMATIONS WITH SOME CONSEQUENT LOSS OF DIMENSIONAL STABILITY AND DAMAGE REQUIRING REPAIR, WHICH MAY REQUIRE REMOVAL OF COMPONENT FROM SERVICE"

TMI-2
INFORMATION AND EXAMINATION
PROGRAM

PRIMARY SYSTEM PRESSURE BOUNDARY CHARACTERIZATION

UNRESOLVED TECHNICAL/PROCEDURAL ISSUES:

- HOW MUST DETERMINATION BE MADE AS TO WHAT LOADING CONDITIONS WERE IMPOSED ON THE COMPONENTS

- HOW CAN REQUIREMENTS FOR ACCEPTABILITY OF CONTINUED OPERATION BE CLEARLY DEFINED?

ALTERNATIVE APPROACHES:

- ANSI-TYPE STANDARD DEFINING STEPS REQUIRED FOR COMPONENT REQUALIFICATION

- DIRECT TECHNICAL EVALUATION OF SPECIFIC COMPONENT(S) WITHOUT NECESSARILY LEADING TO A CODE STANDARD AS THE END PRODUCT

TMI-2
INFORMATION AND EXAMINATION
PROGRAM

PRIMARY SYSTEM PRESSURE BOUNDARY CHARACTERIZATION

ADVANCED TECHNIQUES FOR:

- REMOTE INSPECTION AND EXAMINATION OF RADIOACTIVE COMPONENTS
- "REPAIRABLE" ACQUISITION OF MATERIAL SAMPLES
- DETERMINATION OF COMPONENT MATERIAL PROPERTIES BY SAMPLE TESTING

TMI-2
INFORMATION AND EXAMINATION PROGRAM

PRIMARY SYSTEM PRESSURE BOUNDARY CHARACTERIZATION

DEVELOPMENT OF NON-DESTRUCTIVE EVALUATION AND REPAIR TECHNIQUES FOR MAJOR TMI-2 PLANT COMPONENTS

- INCENTIVE TO AVOID REPLACING PRESSURE VESSEL AND STEAM GENERATORS
- SHOULD ATTEMPT TO AVOID INDISCRIMINATE USE OF ADVANCED NDE TECHNIQUES THAT FIND INDICATIONS NOT CAUSED BY TRANSIENT, WHICH WERE DEEMED ACCEPTABLE OR WERE DETECTED AT PRESSURE INSPECTION
- STRESS ANALYSIS OF THE TRANSIENT HISTORY SHOWS REGION JUST BELOW SOME NOZZLES EXPERIENCED THE GREATEST THERMAL SHOCK
- INNER SURFACE VOLUME (1 TO 1.5 INCHES OF METAL) MOST CRITICAL BECAUSE OF THERMAL STRESS GRADIENTS
- SOME NOZZLES WERE DIRECTLY USED IN VESSEL REFLOOD, AND OTHERS WERE NOT USED

TMI-2

INFORMATION AND EXAMINATION PROGRAM

PRIMARY SYSTEM PRESSURE BOUNDARY CHARACTERIZATION

DEVELOPMENT OF NON-DESTRUCTIVE EVALUATION AND REPAIR TECHNIQUES FOR MAJOR TMI-2 PLANT COMPONENTS

- REQUALIFICATION OF TMI-2 PRESSURE BOUNDARY REQUIRES THE APPLICATION OF BEST AVAILABLE NDE TECHNOLOGY

- PRINCIPAL TECHNICAL PROBLEM IS THE EXAMINATION OF THE NEAR SURFACE REGION AT THE PRESSURE VESSEL INNER DIAMETER BELOW THE INLET NOZZLES

- REGION WITH HIGHEST THERMAL SHOCK DUE TO HIGH DRY OUT TEMPERATURES AND SUDDEN COOLING DURING REFLOOD

- LESS SEVERELY DAMAGED MATERIAL IN NOZZLES, NOZZLE-TO-SHELL WELDS, AND VOLUME BELOW NOZZLES CAN BE USED FOR COMPARISON

- DIFFERENCES BETWEEN GROUPS OF INSPECTION REGIONS CAN BE ATTRIBUTED TO TRANSIENT INDUCED DAMAGE

TMI-2

INFORMATION AND EXAMINATION PROGRAM

PRIMARY SYSTEM PRESSURE BOUNDARY CHARACTERIZATION

DEVELOPMENT OF NON-DESTRUCTIVE EVALUATION AND REPAIR TECHNIQUES FOR MAJOR TMI-2 COMPONENTS

STARTING FROM THE EXISTING WESTINGHOUSE AND FRAMATOME TECHNOLOGY THE CRITICAL ASSESSMENT OF NEAR SURFACE CRACK-LIKE FLAW DETECTION AND SIZING CAPABILITY OF VARIOUS TECHNOLOGIES WILL BE MADE.

- SEVERAL CANDIDATE PROCEDURES AND TECHNIQUES WILL BE IDENTIFIED AND LABORATORY INSTRUMENTS BUILT
- DEVELOPMENT OF TEST MATRIX AND NECESSARY ACCEPTANCE CRITERIA
- KNOWN, WELL CHARACTERIZED, CLAD TEST SPECIMENS WILL BE FABRICATED USING TECHNIQUES DEVELOPED AT WESTINGHOUSE UNDER EPRI CONTRACT
- CANDIDATE PROCEDURES AND TECHNIQUES WILL BE EVALUATED BY EXAMINATION OF THE TEST SPECIMENS AND IN VIEW OF THE ACCEPTANCE CRITERIA

TMI-2
INFORMATION AND EXAMINATION PROGRAM

PRIMARY SYSTEM PRESSURE BOUNDARY CHARACTERIZATION

DEVELOPMENT OF NON-DESTRUCTIVE EVALUATION AND REPAIR TECHNIQUES FOR MAJOR TMI-2 COMPONENTS

THE INTEGRATION OF THE SUCCESSFUL, ACCEPTED TECHNIQUE INTO THE EPRI PRESSURE VESSEL INSPECTION SYSTEM NON UNDER DEVELOPMENT WILL PROVIDE FOR THE TIMELY FIELD READINESS OF THE BEST NEAR SURFACE EXAMINATION CAPABILITY.

- REDESIGN OF THE ACCEPTED TECHNIQUE TO FACILITATE FIELD USE MUST INCLUDE INTEGRATION INTO THE EPRI PRESSURE VESSEL INSPECTION SYSTEM. THE SYSTEM WILL BE IN FIELD EVALUATION IN OCTOBER 1982 AND WILL THEREFORE BE THOROUGHLY DEBUGGED BEFORE ITS USE AT TMI-2.

- FIELD DEMONSTRATION AND CHECK OUT ON TEST SPECIMENS AT THE REACTOR SIMULATION FACILITY OF THE INTEGRATED SYSTEM BEFORE SHIPMENT TO TMI-2. FACILITIES CURRENTLY EXIST AT SWRI IN SAN ANTONIO AND MAY BE FINISHED IN TIME AT THE NDE CENTER IN CHARLOTTE.

RADIATION AND ENVIRONMENT PROGRAM

P. Yarrington

Sandia National Laboratories

TMI-2 SEMINAR

RADIATION AND ENVIRONMENT

PRESENTATION BY

P. YARRINGTON

DECEMBER 1981

RADIATION AND ENVIRONMENT

PROGRAM OBJECTIVES

- DETERMINE FISSION PRODUCT DISPERSAL PATTERNS AND TRANSPORT MECHANISMS
- DETERMINE ACCIDENT ENVIRONMENTS FOR SELECTED INSTRUMENTS AND COMPONENTS
- COMPARE FISSION PRODUCT DATA WITH EXISTING LWR ACCIDENT ASSUMPTIONS
- IDENTIFY GENERIC DISPERSAL AND ATTENUATION MECHANISMS

RADIATION AND ENVIRONMENT

POTENTIAL PROGRAM BENEFITS

- IMPROVED BASIS FOR EQUIPMENT DESIGN REQUIREMENTS
- IMPROVED METHODS AND ASSUMPTIONS FOR ACCIDENT ANALYSES

RADIATION AND ENVIRONMENT

PLANNING GROUP OBJECTIVES

- IDENTIFY MAJOR LOCATIONS OF FISSION PRODUCT DEPOSITION
- SPECIFY TYPES OF SAMPLES TO BE ACQUIRED
- RECOMMEND PROCEDURES FOR SAMPLE ACQUISITION
- SPECIFY ANALYSES TO BE PERFORMED
- DEFINE SAMPLES FOR ARCHIVE STORAGE

RADIATION AND ENVIRONMENT PLANNING GROUP

H. M. BURTON	EG&G, TMI/TIO
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A. S. BENJAMIN	SANDIA LABORATORIES
C. E. CROUTHAMMEL	EXXON NUCLEAR
R. S. DENNING	BATTELLE COLUMBUS LABORATORIES
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W. F. PASEDAG	NRC/DOR
L. D. PERRIGO	BATTELLE PACIFIC NORTHWEST LABORATORIES
A. K. POSTMA	CONTRACTOR, NRC/DOR
R. L. RITZMAN	SCIENCE APPLICATIONS, INC.
R. R. SHERRY	NRC/RES
P. YARRINGTON	SANDIA LABORATORIES

RADIATION AND ENVIRONMENT

TASK SELECTION CRITERIA

- COMPARE LICENSING ASSUMPTIONS
- ASSESS SAFETY SYSTEM PERFORMANCE
- VALIDATE/DEVELOP ACCIDENT ANALYSIS MODELS
- DEFINE EQUIPMENT ENVIRONMENTS
- DIAGNOSE THE ACCIDENT

RADIATION AND ENVIRONMENT

Technical Evaluation Group (TEG)

TEG Objective

TECHNICAL REVIEW OF PROGRAM IMPLEMENTATION ACTIVITIES

TEG Review Process (Regular Basis)

REVIEW PROGRAM PLAN FOR DATA ACQUISITION AND ANALYSIS

REVIEW RESULTS OF TASKS AND ANALYSES TO DATE

RECOMMEND PROGRAM PLAN MODIFICATIONS AS WARRANTED

RADIATION AND ENVIRONMENT

Technical Evaluation Group

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D. Walker	Westinghouse/OPS
P. Yarrington*	Sandia National Laboratories

*Planning Group Participants

RADIATION AND ENVIRONMENT

G. R. Eidam

EG&G Idaho, Inc.

TMI-2
Domestic
Seminar

Radiation and Environment

G.R. Eidam
EG&G
Technical Integration Office

December 1981

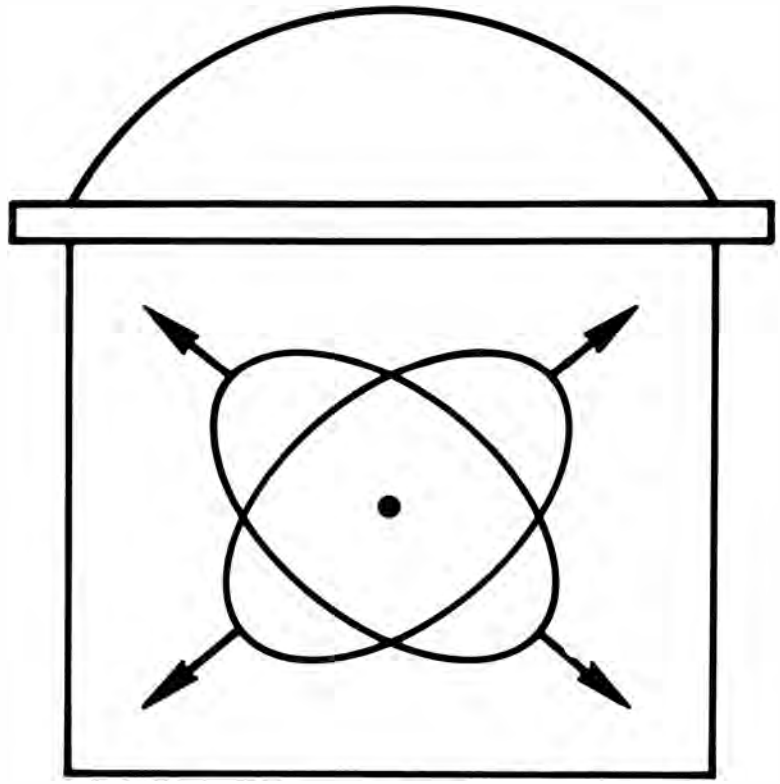
TMI R&E-1

Results to Date & Future Plans

- Fission product transport and deposition
- Decontamination and personnel exposure control
- Reactor building damage assessment
- Radionuclide mass balance

Radiation & Environment

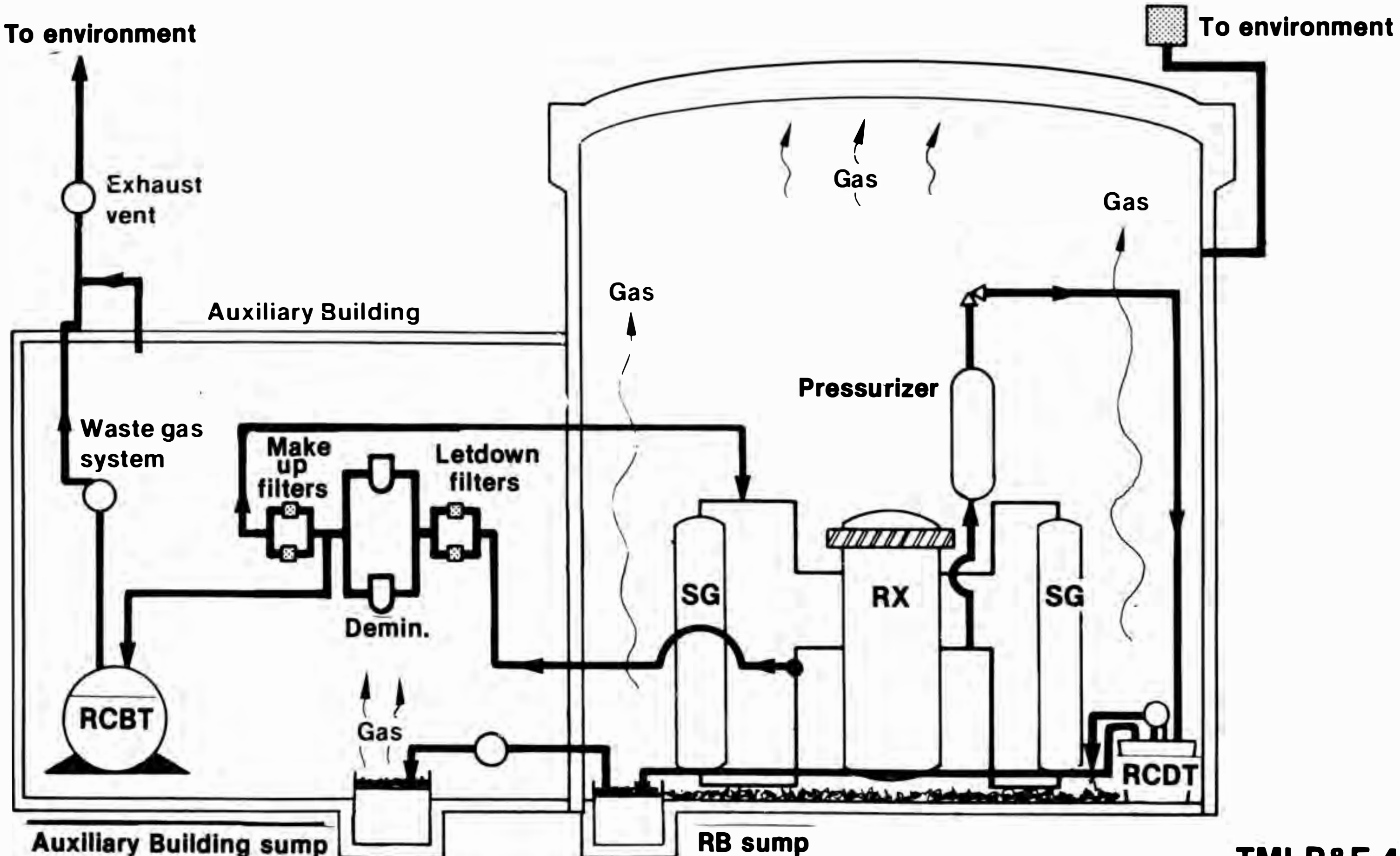
Fission Product



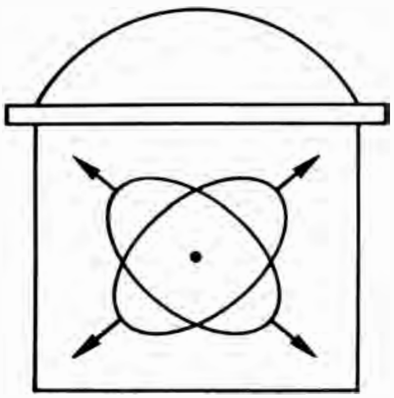
Transport and Deposition

TMI R&E-3

Fission Product Flow Paths

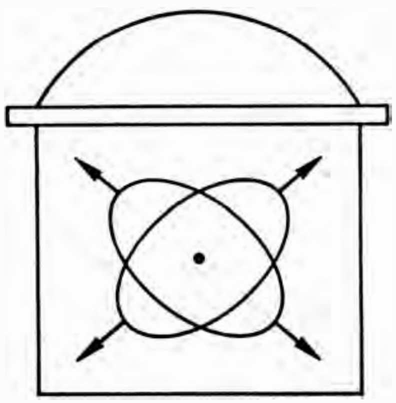


Fission Product Samples Taken



- Reactor coolant system liquid
- Reactor building basement
- Reactor building atmosphere
- Makeup and letdown demineralizer system
- Reactor coolant bleed tank
- Auxiliary building sump
- Reactor building surface deposition

Fission Product Transport Samples to be Taken



- Reactor coolant system liquid
- Reactor coolant system sludge
- Reactor coolant drain tank
- Reactor building basement
- Reactor building sump
- Air coolers
- Makeup and letdown demineralizer system
- Reactor coolant bleed tank
- Reactor building surface deposition

RCS Sample

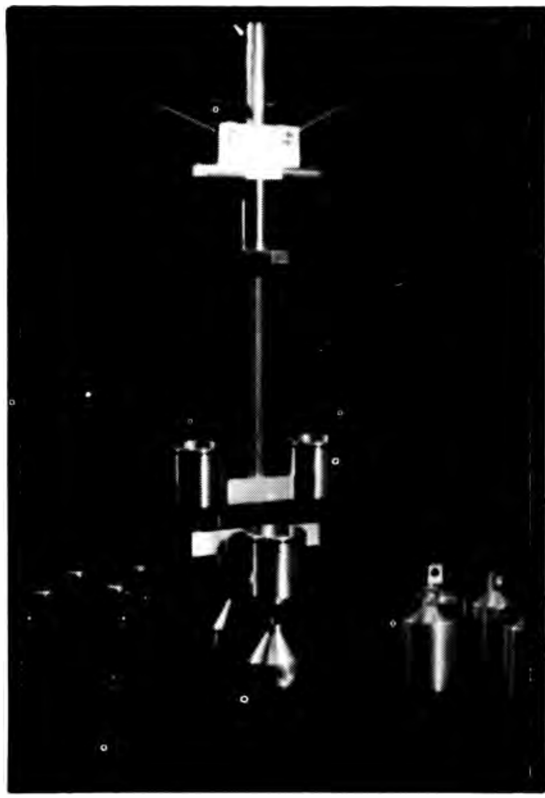
	μCi/ml of Filtered Solution	
	March 29, 1979	August 14, 1980
^{134}Cs	3.32 E-1	1.35 E-2
^{137}Cs	1.21 E+0	5.02 E-2
^{144}Ce	1.83 E-1	1.03 E-1
$^{239,240}Pu$	3.25 E-5	9.0 E-8
^{238}U	4 E-7	4 E-8

Reactor Building Basement

Samples taken

- 401 Penetration
- 3 - one liter samples
- 8 - approximately 100 milliliter samples
- 1 - 100 milliliter sludge

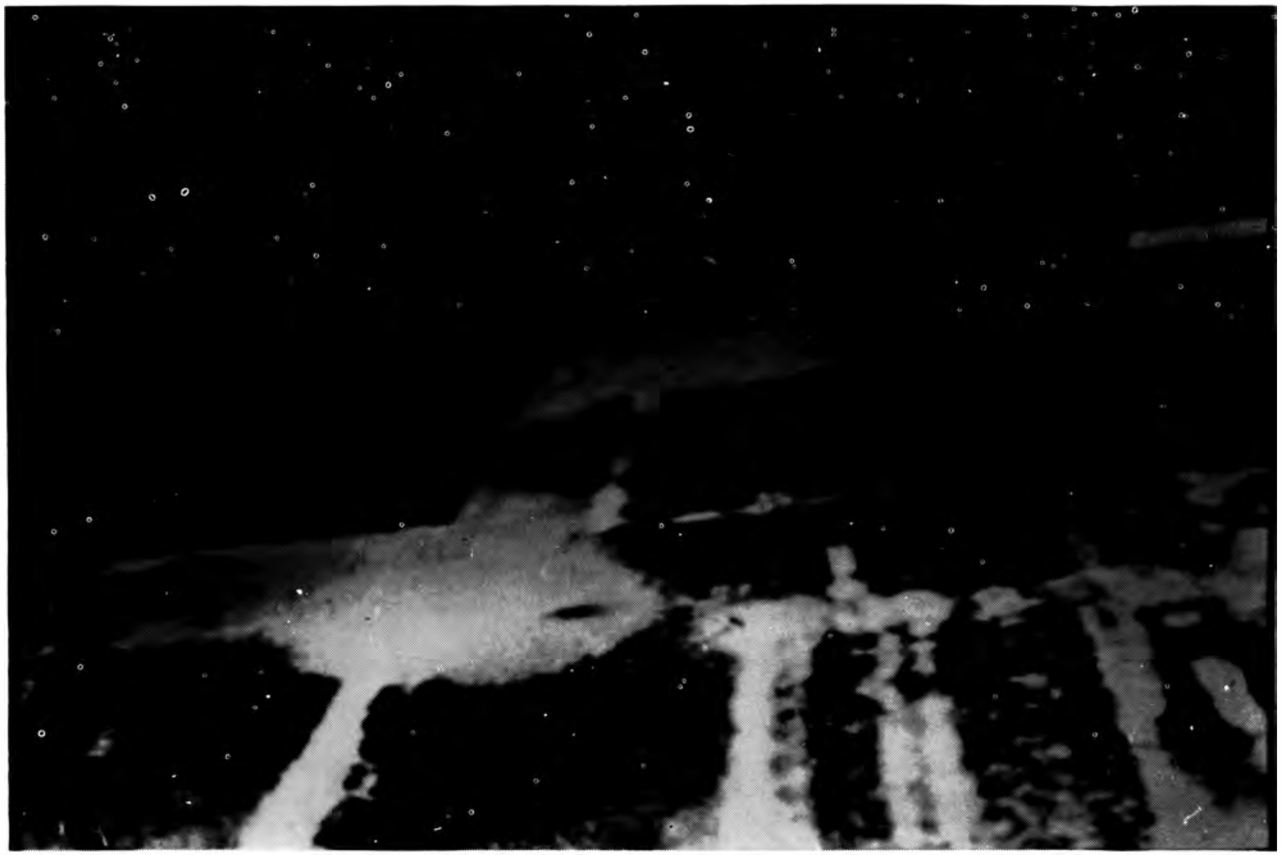
Reactor Building Basement



5-3/8"

0 - Basement floor
282 elevation

Entry I



Entry VIII

Reactor Building Basement

	Top Sample μci/ml	Middle Sample μci/ml	Particulate μci/g
^{134}Cs	1.85 E+1	1.84 E+1	1.79 E+2
^{137}Cs	1.43 E+2	1.42 E+2	1.29 E+3
^{129}I	5.5 E-6	5.4 E-6	0.24 E+0
^{238}Pu	4.0 E-8	NA	5.0 E-7
^{144}Ce	ND	ND	7.6 E+1

Samples taken May 14, 1981

TMI-2 REACTOR BUILDING BASEMENT WATER SAMPLE ANALYSES RESULTS[a]

Sample :	1	3	6	8		
Nuclide	(μCi/ml)	(μCi/ml)	(μCi/ml)	Slurry (μCi/ml)	Supernate (μCi/ml)	Particulate (μCi/g solids)
^{54}Mn	ND*	ND	ND	>2E-04	NA**	ND
^{60}Co	>6E-04	>3E-03	>2E-03	>8E-04	NA	1.7 ± 0.2E+01
^{90}Sr	5.0 ± 0.2E+00	5.4 ± 0.2E+00	5.2 ± 0.2E+00	NA	NA	8 ± 2E+02
^{90}Sr	5.4 ± 0.5E+00	5.2 ± 0.5E+00	5.1 ± 0.5E+00	NA	5.3 ± 0.5E+00	7.8 ± 0.8E+02
^{106}Ru	ND	ND	ND	>4E-04	NA	ND
^{125}Sb	>3E-02	>3E-02	>3E-02	>5E-02	NA	4.5 ± 0.2E+02
^{129}I	5.5 ± 0.7E-06	5.4 ± 0.7E-05	3.8 ± 0.5E-06	NA	2.5 ± 0.5E-06	NA
^{134}Cs	1.85 ± 0.01E+01	1.84 ± 0.01E+01	1.86 ± 0.01E+01	1.87 ± 0.01E+01	NA	1.79 ± 0.04E+02
^{137}Cs	1.43 ± 0.01E+02	1.42 ± 0.01E+02	1.43 ± 0.01E+02	1.44 ± 0.01E+02	NA	1.29 ± 0.01E+03
^{144}Ce	ND	ND	ND	>8E-03	NA	7.6 ± 0.6E+01
	(μg/ml	(μg/ml)	(μg/ml)	(μg/ml)	(μg/ml)	(mg/g solids)
^{235}U	<1E-02	<1E-02	<1E-02	NA	NA	8.8 ± 0.9E-02
^{239}Pu						
^{238}Pu	4 ± 1E-08	NA	NA	5 ± 1E-07	NA	5 ± 1E-07
^{239}Pu	2.2 ± 0.7E-04	NA	NA	2.6 ± 0.5E-03	NA	2.9 ± 0.6E-03

a. Concentrations as of 6-1-81.
*ND = not detected
**NA = not analyzed

Reactor Building Atmosphere

	μCi/cm^3 of Building Volume	Estimated Reactor Building Inventory (μCi)
^{134}Cs	1.1 E-10	6.1 E+0
^{137}Cs	7.2 E-10	4.0 E+1
^{144}Ce	<8 E-11	<5 E+0
^{238}U	<6 E-13	<4 E-2
^{238}Pu	<6 E-12	<4 E-1
^{129}I	5.7 E-11	3.2 E+0

TMI R&E-13

Sample taken April 29 , 1980 to May 2, 1980

RADIONUCLIDE CONTENT IN THE TMI UNIT-2 REACTOR BUILDING ATMOSPHERE APRIL 29 - MAY 2, 1980

Isotope	µCi/cm³ at STP	µCi/cm³ Building Volume	Estimated[c] Reactor Building Inventory (µCi)
^{3}H	4.7 ± 0.8(-5)	4.0 ± 0.7(-5)	2.2 ± 0.4(6)
^{14}C	3.5 ± 0.9(-7)	3.0 ± 0.8(-7)	1.7 ± 0.5(4)
^{54}Mn	2 ± 2(-11)	2 ± 2(-11)	1 ± 1(0)
^{58}Co	1.0 ± 0.3(-11)[a]	9 ± 3(-12)	5 ± 2(-1)
^{60}Co	3 ± 2(-12)[a]	3 ± 2(-12)	2 ± 1(-1)
^{85}Kr	1.02 ± 0.05(0)	8.8 ± 0.4(-1)	4.9 ± 0.2(10)
^{89}Sr	7 ± 3(-11)[a]	6 ± 3(-11)	3 ± 1(0)
^{90}Sr	1.9 ± 0.3(-10)	1.6 ± 0.3(-10)	9 ± 2(0)
^{91}Y	<3 E-11	<3 E-11	<2 E+0
^{95}Zr	<2 E-11	<2 E-11	<1 E+0
^{106}Rh	<1 E-10	<9 E-11	<5 E+0
^{110m}Ag	1.6 ± 0.6(-11)[b]	1.4 ± 0.5(-11)	8 ± 3(-1)
^{125}Sb	<2 E-10	<2 E-10	<1 E+1
^{129m}Te	4 ± 2(-10)[a]	3 ± 2(-10)	2 ± 1(+1)
^{129}I	6.6 ± 0.5(-11)	5.7 ± 0.4(-11)	3.2 ± 0.2(0)
^{134}Cs	1.3 ± 0.1(-10)	1.1 ± 0.1(-10)	6.1 ± 0.6(0)
^{137}Cs	8.4 ± 0.9(-10)	7.2 ± 0.8(-10)	4.0 ± 0.4(+1)
^{144}Ce	<9 E-11	<8 E-11	<5 E+0
^{235}U	<7 E-13	<6 E-13	<4 E-2
^{238}U	<7 E-13	<6 E-13	<4 E-2
^{238}Pu	<7 E-12	<6 E-12	<4 E-1
$^{239/240}Pu$	<2 E-12	<2 E-12	<1 E-1

a. Calculated from a mixture of positive results and less-than values.
b. The only positive value found for ^{110m}Ag was on the "hot" filter test Iodine Species 2.
c. Building inventory was estimated by multiplying the measured concentration times a building free volume of 5.58 x 10^{10} cm³.

Makeup and Letdown System

MU-F-5B Debris Sample

MU-F-5B filter: Letdown filter
MU-F-2A filter: Makeup filter
MU-F-2B filter: Makeup filter
MU-F-4A filter: Seal injection filters
MU-F-4B filter: Seal injection filters

Makeup and Letdown System

Sample Results

Nuclide	μCi/gm
^{95}Zr	6.3
^{134}Cs	285.1
^{137}Cs	2606.8
^{144}Ce	760.2

Sample taken February 27, 1981

MU-F-5B DEBRIS SAMPLE
(TAKEN FEBRUARY 27, 1981)

Nuclide	μCi/gm
^{54}Mg	14.4
^{60}Co	165.9
^{95}Zr	6.3
^{106}Ru	388.8
^{134}Cs	285.1
^{137}Cs	2606.8
^{144}Ce	760.2
^{125}Sb	1606.0

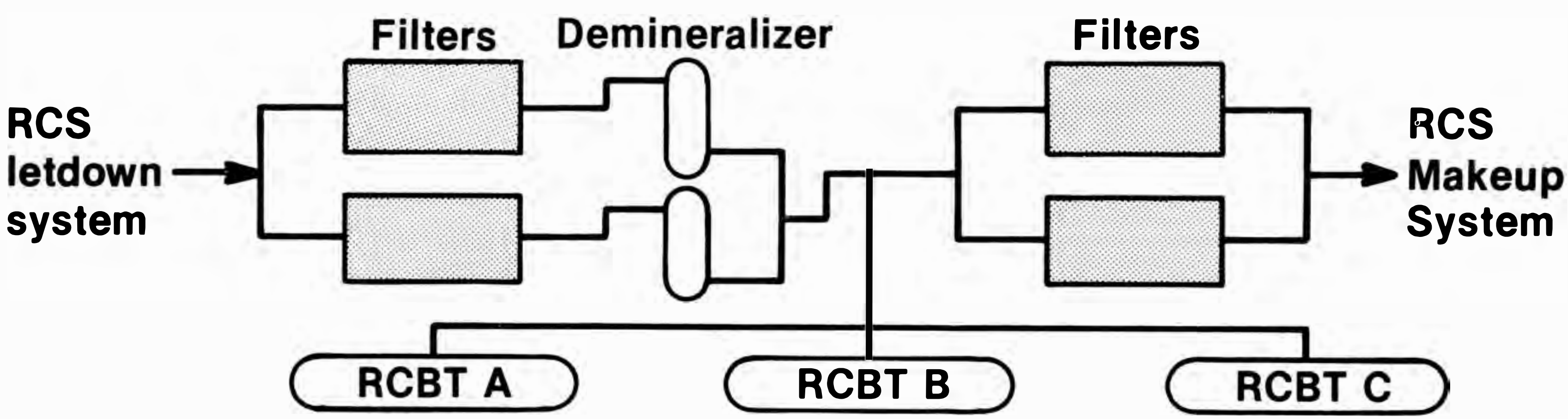
Reactor Coolant Bleed Tank Samples:

"A" Reactor Coolant Bleed Tank Liquid & Sludge

"B" Reactor Coolant Bleed Tank Liquid

"C" Reactor Coolant Bleed Tank Liquid

"A" Reactor Coolant Bleed Tank Gamma Scan



Reactor Coolant Bleed Tank

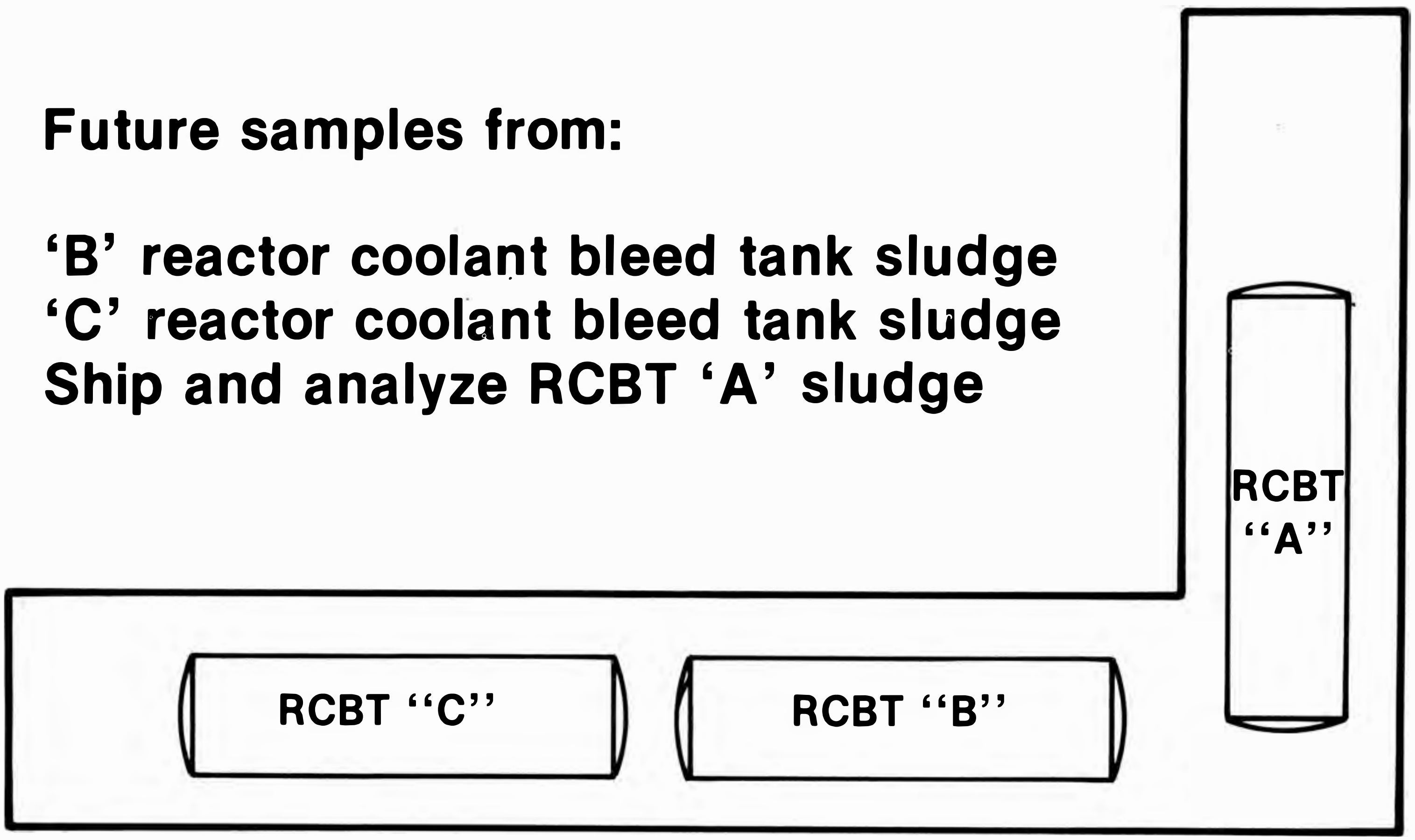
Tank	^{144}Ce	^{129}I	$^{239,240}Pu$	^{238}U
A	<2 E-4	4.4 E-6	<4 E-8	1.8 E-8
B	<4 E-6	4.4 E-6	3 E-8	7.0 E-8
C	7.9 E-6	5.3 E-1	3 E-7	3.0 E-8

All samples taken before February 4, 1980

Reactor Coolant Bleed Tanks

Future samples from:

'B' reactor coolant bleed tank sludge
'C' reactor coolant bleed tank sludge
Ship and analyze RCBT 'A' sludge



Radioactive Debris on Tank Manway

TMI-2 RCS, AND RCBT SOLID SAMPLE ANALYSIS - GAMMA RAY SPECTROMETRY MEASUREMENTS (μCi/ml of filtered solution at T_o)

Sample	Gamma-Ray Spectrometry Analysis		
	^{134}Cs	^{137}Cs	^{144}Ce
RCS-1	3.32 ± 0.03E-1	1.212 ± 0.005	1.834 ± 0.005E-1
RCS-2	1.35 ± 0.03E-2	5.02 ± 0.04E-2	1.030 ± 0.005E-1
RCBT-A	8.79 ± 0.08E-2	4.98 ± 0.01E-1	8.3 ± 0.2E-3
RCBT-B	9.05 ± 0.07E-2	4.52 ± 0.02E-1	5.6 ± 0.8E-4
RCBT-C	1.64 ± 0.03E-2	7.56 ± 0.05E-2	1.47 ± 0.03E-3

NOTES: Additional radionuclides were detected in the following samples:

Sample	^{60}Co	^{125}Sb	^{106}Ru	^{54}Mn
RCS-1	2.0 ± 0.2E-3	2.4 ± 0.5E-2	7 + 1	--
RCS-2	8 ± 1E-1	--	--	6 ± 1E-4
RCBT-C	4.6 ± 0.8E-5	--	--	--

-- = not detected

All samples taken prior to August 24, 1980

TMI-2 RCS AND RCBT SOLID SAMPLE ANALYSIS - ALPHA ISOTOPIC MEASUREMENTS
(μCi/ml OF FILTERED SOLUTION AT T_0)

	Alpha Isotopic Analysis							
Sample	^{238}Pu	^{239,240}Pu	^{241}Am	^{242}Cm	^{244}Cm	^{235}U	^{234}U	^{238}U
RCS-1	3.7 ± 0.2E-6	3.25 ± 0.09E-5	5.7 ± 0.3E-7	7 + 2E-7	<6E-9	5 ± 2E-7	2.2 ± 0.2E-5	4 ± 1E-7
RCS-2	2.4 ± 0.8E-7	9 ± 5E-8	4.5 ± 0.6E-7	<3E-7	<4E-8	<2E-8	<5E-8	4 ± 1E-8
RCBT-A	1.3 ± 0.2E-6	1.04 ± 0.05E-5	2.1 ± 0.1E-7	3 ± 2E-8	<5E-9	<2E-8	<5E-8	6 ± 3E-8
RCBT-B	<5E-8	1.4 ± 0.5E-7	<6E-8	<1E-7	<4E-8	<2E-8	<8E-8	<2E-8
RCBT-C	<6E-8	3.9 ± 0.5E-7	1.3 ± 0.6E-8	<1E-8	5 ± 3E-9	<9E-8	4 ± 2E-7	5 ± 1E-7

All samples taken prior to August 24, 1980

TMI-2 RCS AND RCBT LIQUID SAMPLE GAMMA SPECTROMETRY ANALYSIS BEFORE AND AFTER FILTRATION

		μCi/ml at Time of Measurements, 15 Dec 1980				μCi/ml at T_o	
		^{134}Cs		^{137}Cs		^{134}Css	^{137}Cs
Sample	T_o	BF	AF	BF	AF	AF	AF
RCS-1	29 Mar 79	5.32 ± 0.04E+1	5.11 ± 0.04E+1	3.35 ± 0.02E+2	3.42 ± 0.02E+2	8.77 ± 0.07E+1	3.56 ± 0.02E+2
RCS-2	14 Aug 80	4.41 ± 0.03	4.45 ± 0.06	2.92 ± 0.01E+1	2.81 ± 0.02E+1	6.14 ± 0.08	2.87 ± 0.02E+1
RCBT-A	20 Dec 79	5.58 ± 0.05	5.43 ± 0.007	3.50 ± 0.01E+1	3.31 ± 0.02E+1	6.06 ± 0.07	3.33 ± 0.02E+1
RCBT-B	28 Jan 80	5.58 ± 0.04	5.71 ± 0.06	3.65 ± 0.01E+1	3.55 ± 0.02E+1	7.79 ± 0.08	3.71 ± 0.02E+1
RCBT-C	4 Feb 80	8.57 ± 0.05	7.74 ± 0.04	5.26 ± 0.02E+1	4.83 ± 0.01E+1	1.050 ± 0.005E+1	5.05 ± 0.01E+1

NOTES: BF = Before Filtration

AF = After Filtration

Additional nuclides detected

		μCi/ml at T_o
		^{60}Co
Sample	T_o	BF
RCS-1	29 Mar 79	2.1 ± 03E-1

TMI-2 RCS AND RCBT SOLID SAMPLE ANALYSIS - BETA ISOTOPIC MEASUREMENTS
(μCi/ml OF FILTERED SOLUTION AT T_o)

	Beta Isotopic Analysis				
Sample	^{90}Sr	^{89}Sr	^{91}Y	^{55}Fe	^{64}Ni
RCS-1	9.4 $\pm$ 0.9E-3	<10	<2E-3	1.0 $\pm$ 0.1E-2	3.1 $\pm$ 0.3E-6
RCS-2	3.9 $\pm$ 0.3E-1	<9	<7E-5	1.4 $\pm$ 0.1E-3	8.2 $\pm$ 0.8E-7
RCBT-A	2.0 $\pm$ 0.1E-1	<2E-1	<9E-6	1.8 $\pm$ 0.2E-4	1.0 $\pm$ 0.1E-6
RCBT-B	4.4 $\pm$ 0.6E-2	<5E-1	<1E-5	6.3 $\pm$ 0.6E-5	2.6 $\pm$ 0.4E-7
RCBT-C	1.4 $\pm$ 0.1E-2	<2E-5	<2E-5	3.1 $\pm$ 0.4E-5	4.3 $\pm$ 0.4E-7

All samples taken prior to August 24, 1980

TMI-2 RCS AND RCBT FILTRATE ANALYSIS ^{3}H, ^{14}C, ^{144}Ce, AND ^{129}I (μCi/ml at T_o)

Sample	T_o	^{3}H	^{14}C	^{144}Ce	^{129}I
RCS-1	29 Mar 79	1.71 ± 0.08	7.21 ± 0.07E-4	1.80 ± 0.09E-2	5.3 ± 0.3E-6
RCS-2	14 Aug 80	8.8 ± 0.4E-2	7.0 ± 0.7E-5	<9E-5	3.4 ± 0.2E-6
RCBT-A	20 Dec 79	2.0 ± 0.1E-1	1.04 ± 0.01E-4	<2E-4	4.4 ± 0.2E-6
RCBT-B	28 Jan 80	2.6 ± 0.1E-1	3.34 ± 0.03E-4	<4E-6	4.4 ± 0.2E-6
RCBT-C	4 Feb 80	1.57 ± 0.08E-1	1.63 ± 0.02E-4	7.9 ± 0.7E-6	5.3 ± 0.3E-1

TMI-2 RCS AND RCBT FILTRATE SAMPLE ANALYSIS - pH, CONDUCTIVITY, SPECIFIC GRAVITY, ANIONS AND ELEMENTAL

				Elemental Analysis by Alternative Current Spark Emission Spectrometry (μg/ml) (Cation)							
Sample[3]	pH	Conductivity (μmho/cm)	Specific Gravity	Al	B	Ca	Fe	K	Mg	Na	Si
RCS-1	8.43	2.98	1.0054	3	2300	1	<1	<0.1	0.2	1050	3
RCS-2	7.94	2.72	1.0080	4	3500	3	13	<0.1	0.9	795	3
RCBT-A	8.00	1.18	1.0021	1	1400	8	<0.6	<0.1	2	360	2
RCBT-B	8.63	1.33	1.0014	0.8	760	8	<0.6	<0.1	2	423	2
RCBT-C	8.64	1.36	1.0012	1	860	5	<0.6	0.3	0.9	383	3

	Anions Analysis by Ion Chromatography[1,2] (μg/ml)					
Sample	F^-	Cl^-	Br^-	SO_4^{-2}	PO_4^{-3}	NO_3^-
RCS-1	<1.0	2.1	<10	28	<10	10.3
RCS-2	<0.5	<0.1	<1.0	23	<1.0	3.1
RCBT-A	<1.0	5.0	<10	147	<10	3.2
RCBT-B	2.0	11.7	<10	92	<10	3.2
RCBT-C	<1.0	10.3	<10	205	<10	2.0

NOTES:
(1) High levels of boron interfered with the NO_2^- analyses.
(2) An unidentified peak in RCBT-A was tentatively identified as the oxalate ion ($C_2O_4^{-2}$) at a level of 15.6 μg/ml.
(3) All samples taken prior to August 24, 1980.

TMI-2 RCS AND RCBT FILTRATE ANALYSIS - ALPHA ISOTOPIC (μCi/ml at T_0)

Sample	T_0	Alpha Isotopic							
		^{238}Pu	^{239,240}Pu	^{235}U	^{234}U	^{238}U	^{241}Am	^{242}Cm	^{244}Cm
RCS-1	29 Mar 79	2.7 ± 0.2 E-6	3.8 ± 0.1 E-5	2.7 ± 0.3 E-7	4.2 ± 0.2 E-6	1.0 ± 0.8 E-6	2.4 ± 0.2 E-7	6 ± 2 E-7	1.1 ± 0.2 E-7
RCS-2	14 Aug 80	<9E-8	3.2 ± 0.4 E-7	<2E-8	<8E-8	<2E-8	8 ± 3E-7	<6E-8	8 ±E-8
RCBT-A	20 Dec 79	<1E-8	<4E-8	<2E-8	<6E-8	1.8 ± 0.4 E-8	7 ± 5E-9	<7E-9	2.3 ± 0.5 E-8
RCBT-B	28 Jan 80	4.7 ± 0.6 E-8	3 ± 1E-8	<3E-8	<8E-8	7 + 3E-8	<4E-8	7 ± 2E-7	2.0 ± 0.5 E-7
RCBT-C	4 Feb 80	<1E-7	3.0 ± 0.6 E-7	<2E-8	<6E-83	3 + 1E-8	1.4 ± 0.6 E-8	9 ± 3E-8	5 ± 4E-9

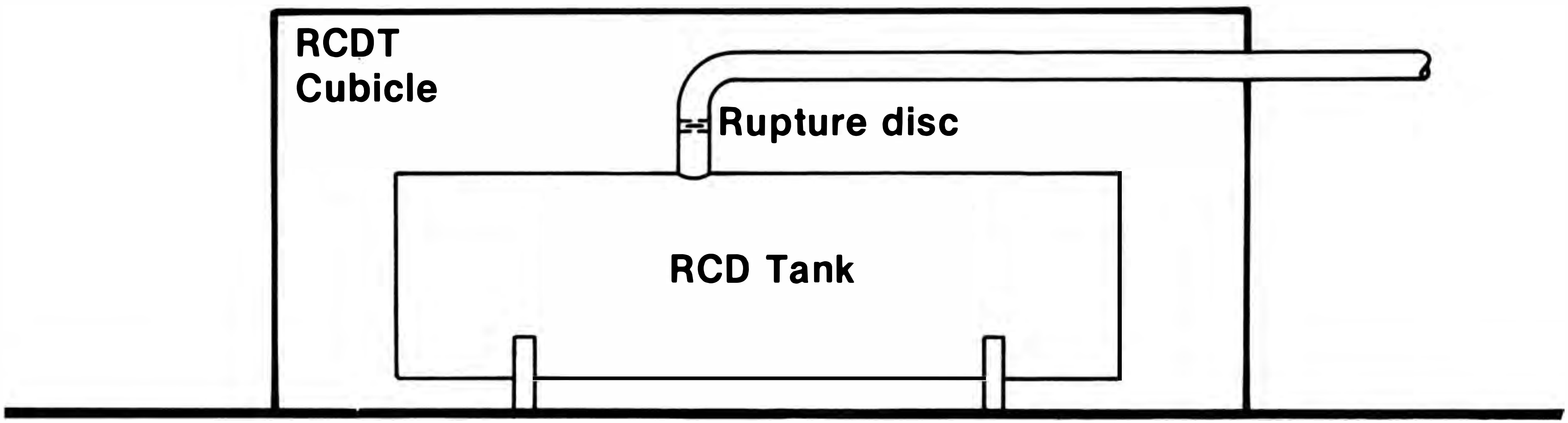
TMI-2 RCS AND RCBT FILTRATE ANALYSIS - BETA ISOTOPIC (μCi/ml at T_o)

Sample	T_o	^{90}Sr	^{89}Sr	^{91}Y	^{55}Fe	^{63}Ni
RCS-1	29 Mar 79	5.7 ± 0.3E-4	<4E-1	5.9 ± 0.5E-2	<5E-5	1.4 ± 0.1E-4
RCS-2	14 Aug 80	2.3 ± 0.1E+1	<400	3.8 ± 0.2E-3	2.1 ± 0.2E-3	<3E-5
RCBT-A	20 Dec 79	1.2 ± 0.1	<8E-1	<5E-6	4.5 ± 0.5E-6	1.7 ± 0.1E-5
RCBT-B	28 Jan 80	3.2 ± 0.2E-1	<4	<9E-5	<2E-5	<3E-5
RCBT-C	4 Feb 80	5.3 ± 0.3E-1	<6	8 ± 6E-5	<2E-5	<3E-5

Reactor Coolant Drain Tank (RCDT)

Future plans

- Liquid sample from RCDT
- Sludge sample from RCDT
- Sample from RCDT cubicle



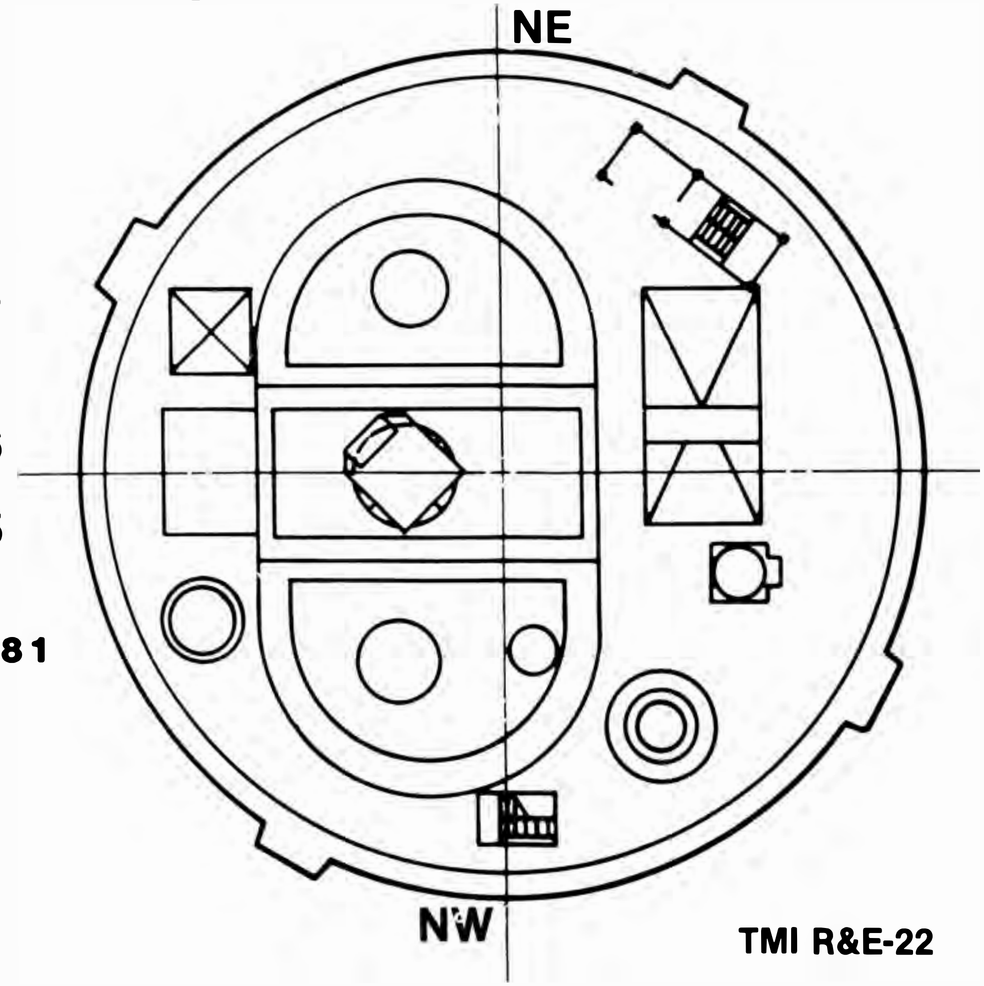
Surface Deposition

- Bootie residue
- Entry smears
- Gamma scans 305-foot el.
- Radiation surveys
- Reactor service structure smears
- Paint chips from the dome
- Concrete samples
- Water samples

Surface Deposition

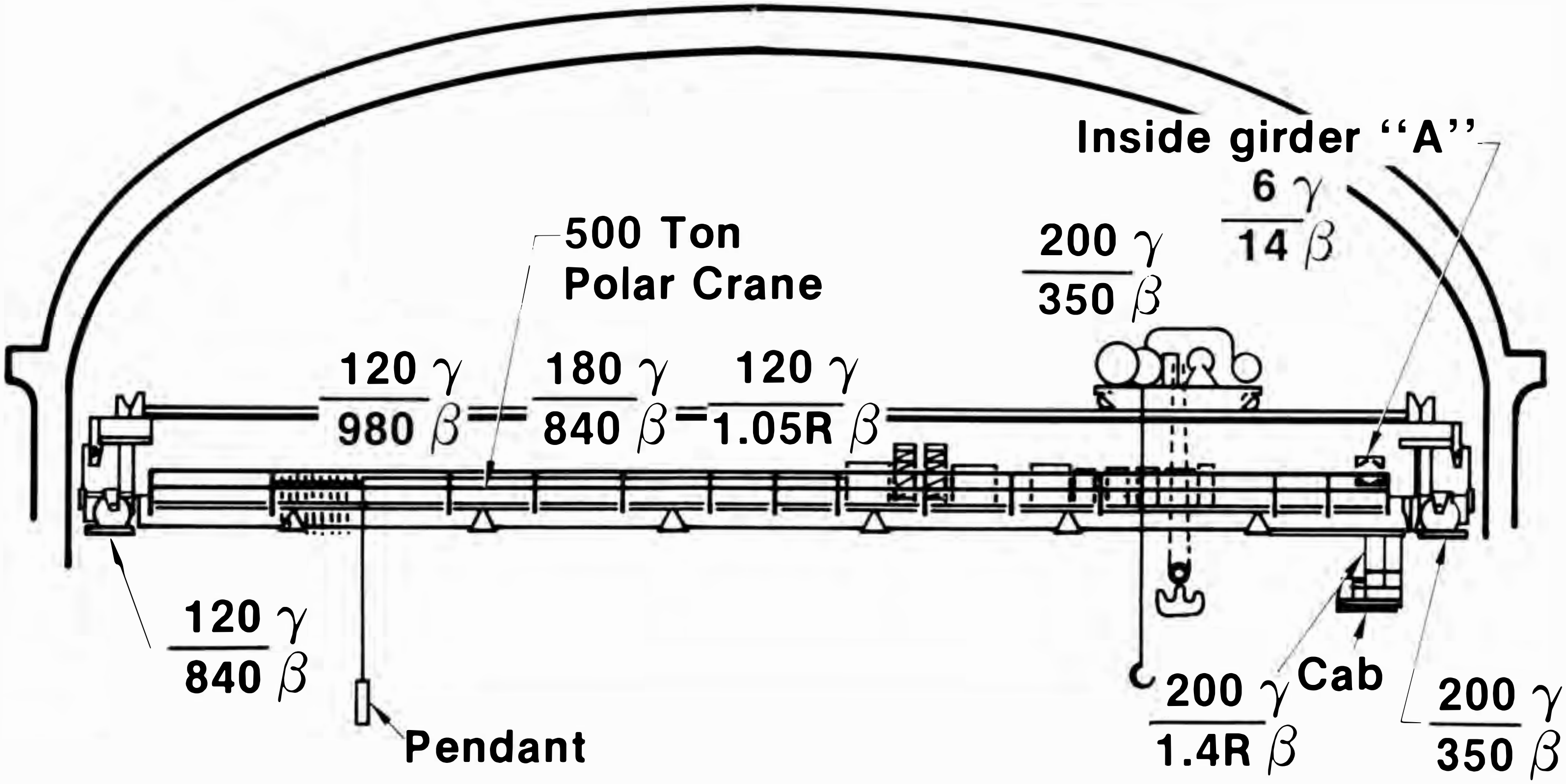
	NW Dome	NE Dome
^{134}Cs	4.73 E-4	4.39 E-2
^{137}Cs	3.41 E-3	3.22 E-1
^{129}I	2.53 E-7	4.74 E-6
^{144}Ce	<3.99 E-5	<2.78 E-5

Samples taken February 3 and 5, 1981



TMI R&E-22

Polar Crane Radiation Map
Surface Deposition

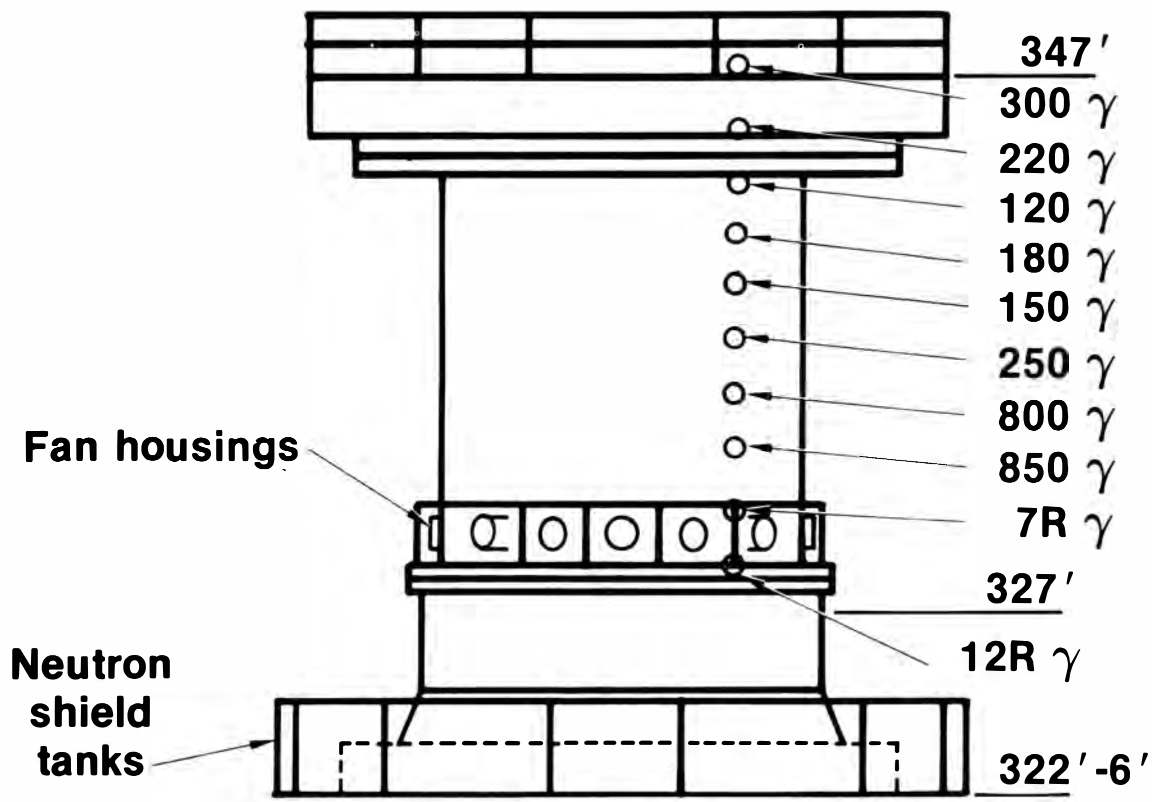


TMI R&E-27

All readings in mR/hr or mrad/hr unless otherwise noted

Data taken July 1, 1981

Control Rod Drive Mechanism Radiation Map

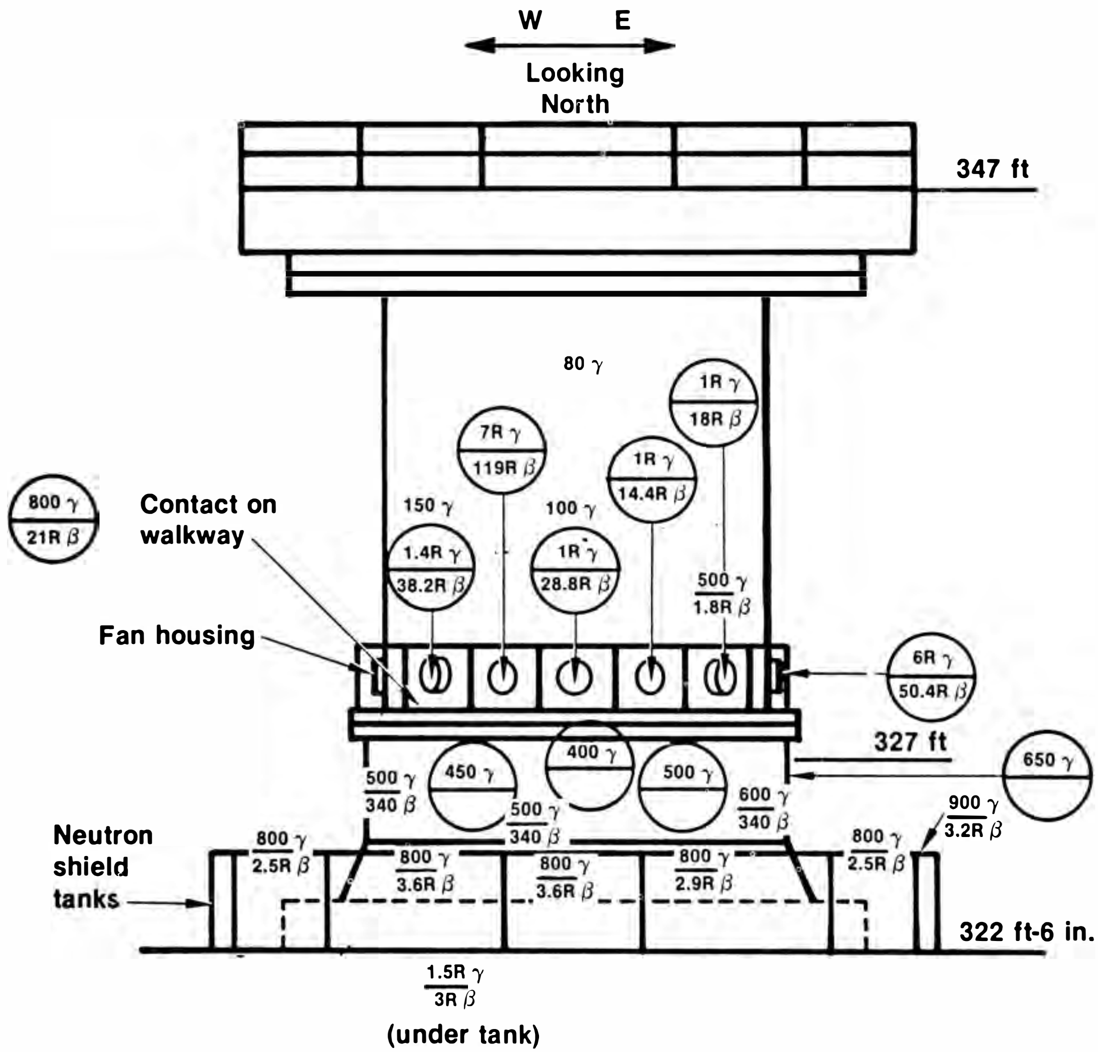


All readings in mR/hr unless otherwise noted

Data taken March 19, 1981

TMI R&E-26

Service Structure Survey



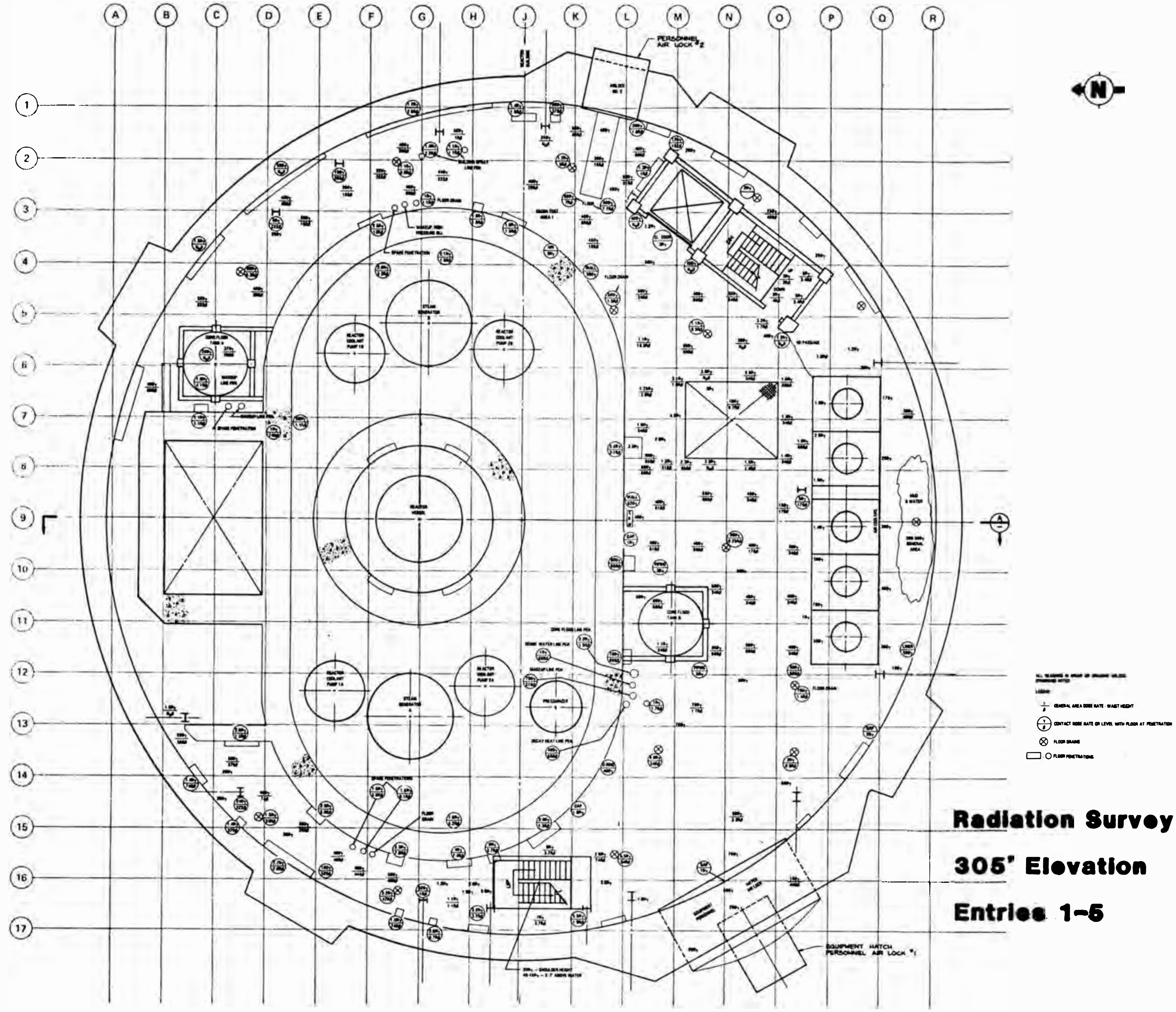
NOTE:

Data Taken

December 11, 1980

and July 23, 1981

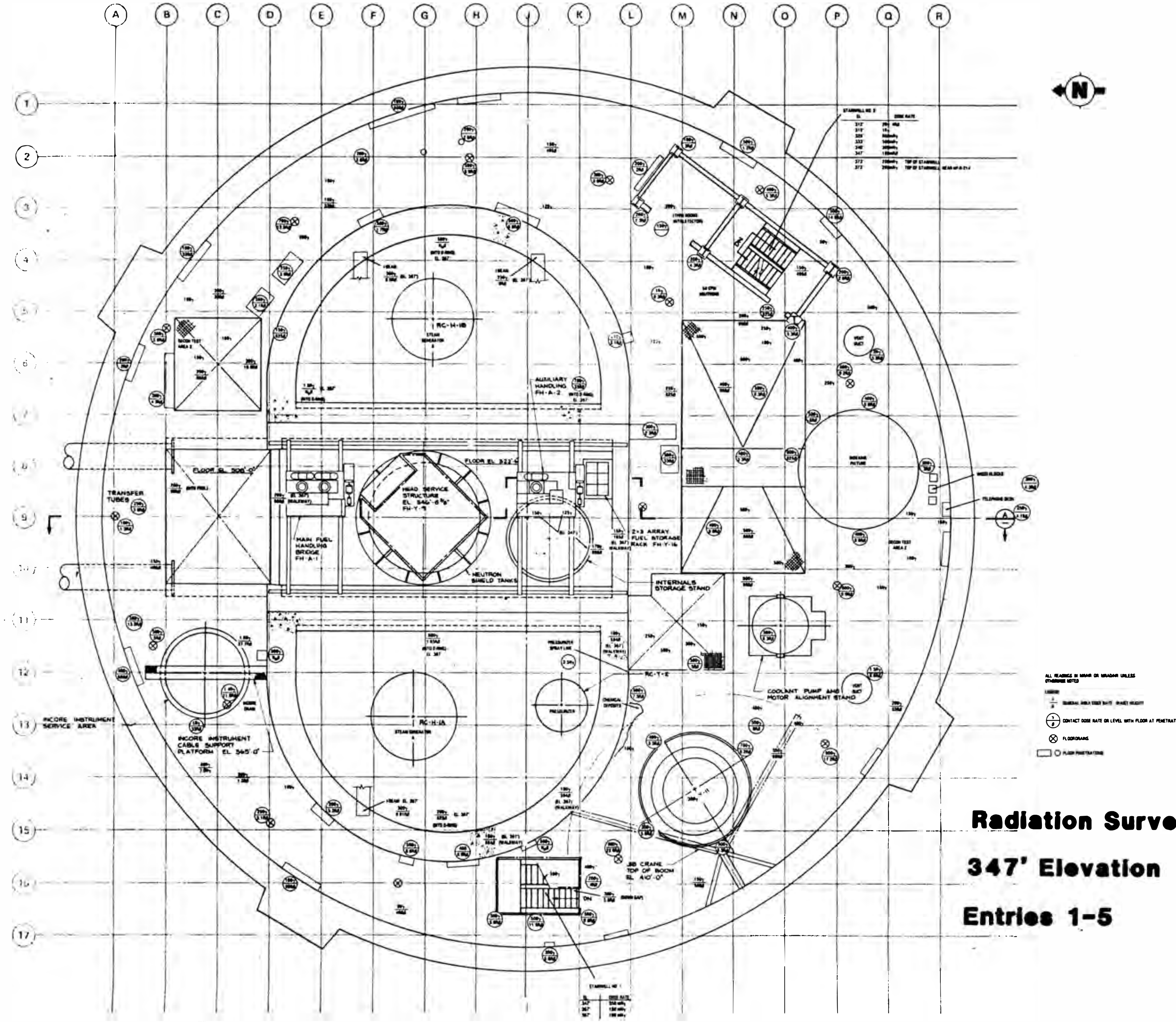
All readings in mR/hr or mrad/hr unless otherwise noted



Radiation Survey

305' Elevation

Entries 1-5



Radiation Survey

347' Elevation

Entries 1-5

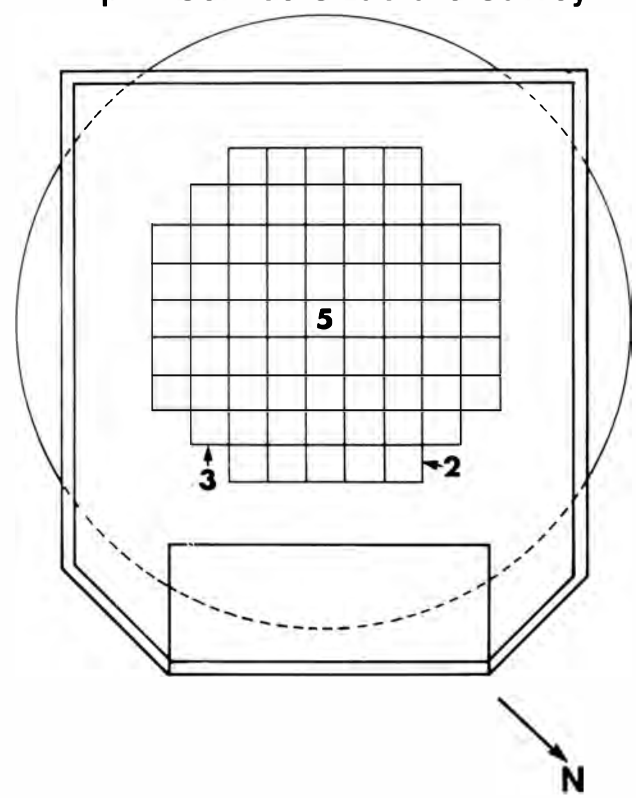
Surface Deposition

CRDM Smear Results

Nuclide	μCi/smear #2	μCi/smear #3	μCi/smear #5
^{134}Cs	7.7 E+0	2.6 E+1	1.5 E+0
^{137}Cs	5.6 E+0	2.6 E+1	1.2 E+2
$^{144}Ce/Pr$	4.4 E-3	5.5 E-2	1.2 E-2
^{238}Pu	3.8 E-6	1.1 E-2	7.3 E-6

Sample taken May 14, 1981

Top of Service Structure Survey



Surface Deposition

Activities Prior to Gross Decontamination Experiments

- 46 concrete and carbon steel samples
- 2 liquid samples
- 4 air cooler gamma scans
- 10 floor and wall gamma scans
- 100 TLD measurements
- 3 air samples

Results to Date & Future Plans

- Fission product transport and deposition
- Decontamination and personnel exposure control
- Reactor building damage assessment
- Radionuclide mass balance

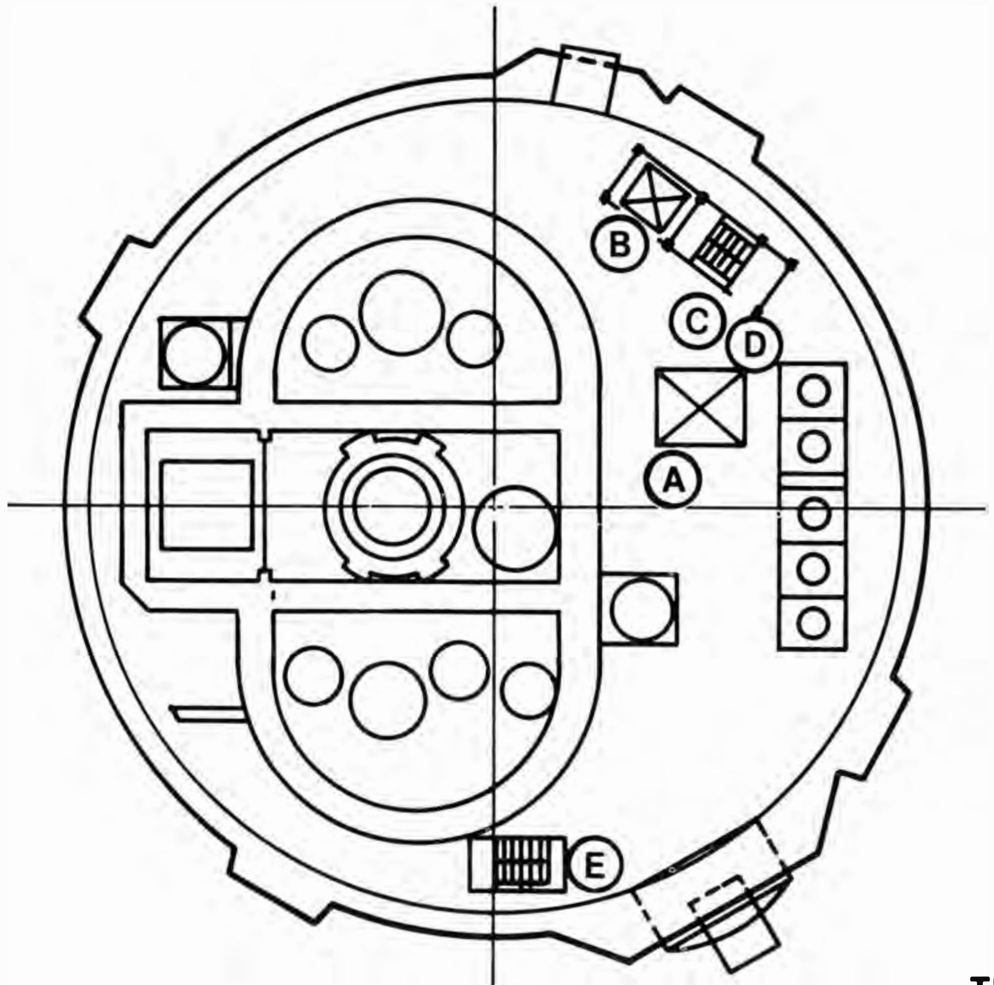
Results to Date & Future Plans

- Fission product transport and deposition
- Decontamination and personnel exposure control
- Reactor building damage assessment
- Radionuclide mass balance

Reactor Building Damage Assessment

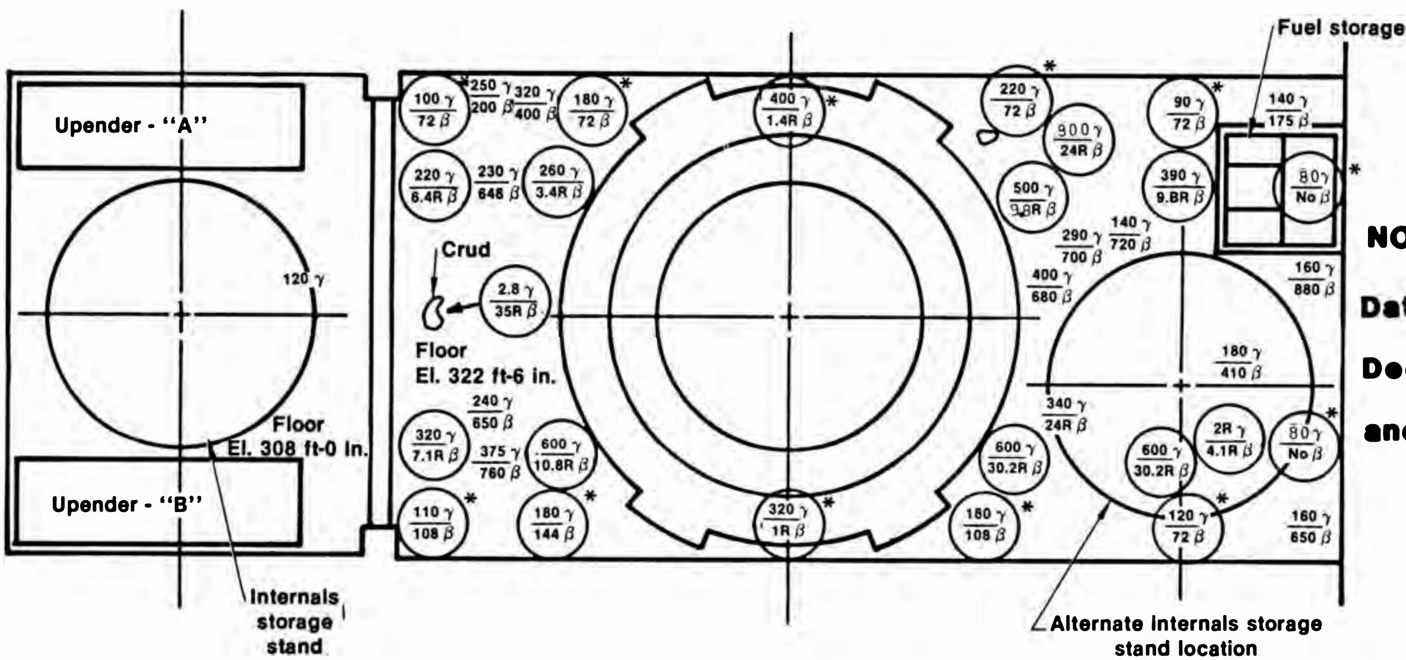
- Photos of every entry
- Samples removed
- Damage map
- Temperature estimates

Reactor Building Damage Assessment, 305-ft Elevation



TMI R&E-32

Refueling Canal Survey



*Contact with wall approximately 4.5' high

All readings in mR/hr or mrad/hr unless otherwise noted

NOTE:

Data Taken December 11, 1980 and July 23, 1981

CONTROL ROD DRIVE MECHANISM SMEAR RESULTS (μCi/SMEAR--TAKEN MAY 14, 1981)

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
^{134}Cs	3.97±0.20(0)	7.73±0.38(0)	2.62±0.13(1)	8.05±0.41(0)	1.59±0.08(0)
^{137}Cs	2.87±0.02(1)	6.58±0.02(1)	1.87±0.01(2)	5.74±0.02(1)	1.15±0.02(3)
$^{144}Ce/Pr$	4.85±0.19(-3)	4.90±0.01(-3)	2.47±0.07(-2)	5.59±1.06(-3)	1.20±0.02(-2)
^{106}Ru	3.76±0.61(-3)	3.38±0.09(-3)	1.19±0.11(-2)	1.88±0.41(-3)	4.42±0.33(-3)
$^{239/240}Pu$	2.33±0.12(-5)	2.16±0.5(-5)	1.56±0.08(-4)	1.62±0.09(-3)	3.92±0.29(-5)
^{238}Pu	2.41±0.19(-6)	3.84±0.63(-6)	1.10±0.08(-5)	2.24±0.35(-6)	7.26±1.23(-6)
^{241}Am	3.06±0.35(-6)	3.23±0.28(-6)	1.83±0.09(-5)	3.01±0.43(-6)	3.05±0.30(-6)
$^{242/243}Cm$	3.16±1.58(-7)	2.88±1.17(-7)	1.69±0.32(-6)	4.05±2.25(-7)	3.09±1.26(-7)
^{244}Cm	<1.02(-7)	1.22±0.54(-7)	1.41±0.65(-7)	9.35±7.64(-8)	5.86±3.91(-8)

ACTIVITIES ON PAINT CHIP FOUND ON THE FLOOR SOUTH OF SEAL TABLE (TAKEN ON FEBRUARY 3 AND 5, 1981)

Nuclides	Test 1	Test 2	Test 3
^{134}Cs	4.73±.36(-4)	1.21±.06(-4)	7.03±.32(-4)
^{137}Cs	3.41±.08(-3)	9.23±.17(-4)	5.15±.05(-3)
^{51}Cr	<1.35(-4)	<2.43(-5	<6.60(-5)
^{54}Mn	<1.84(-5)	<3.69(-6)	<6.40(-6)
^{59}Fe	<2.87(-5)	<5.94(-6)	<9.95(-6)
^{58}Co	<1.19(-5)	<2.42(-6)	<4.04(-6)
^{60}Co	<7.12(-5)	<1.49(-6)	<2.52(-5)
^{65}Zn	<4.53(-5)	<9.34(-6)	<1.59(-5)
^{95}Nb	<1.22(-5)	<2.53(-6)	<4.33(-6)
^{110m}Ag	<2.49(-5)	<4.97(-6)	<8.68(-6)
^{106}Ru	<1.55(-4)	<2.97(-5)	<5.71(-5)
^{124}Sb	<5.28(-5)	<1.13(-5)	<1.80(-5)
^{125}Sb	<1.71(-4)	<3.22(-5)	<6.90(-5)
^{141}Ce	<1.46(-5)	<2.05(-6)	<5.37(-6)
^{144}Ce	<3.99(-5)	<5.93(-6)	<1.45(-5)
^{90}Sr	4.17±.24(-3)	--	--
^{89}Sr	<1.31(-5)	--	--
^{129}I	2.53±.25(-7)	--	--

1 Leach portion of paint chip (used NaOH)
2 Paint chip counted after leach with NaOH
3 Original paint chip

ACTIVITIES ON PAINT CHIP TAKEN FROM NEAR STAIRWELL (TAKEN ON FEBRUARY 3 AND 5, 1981)

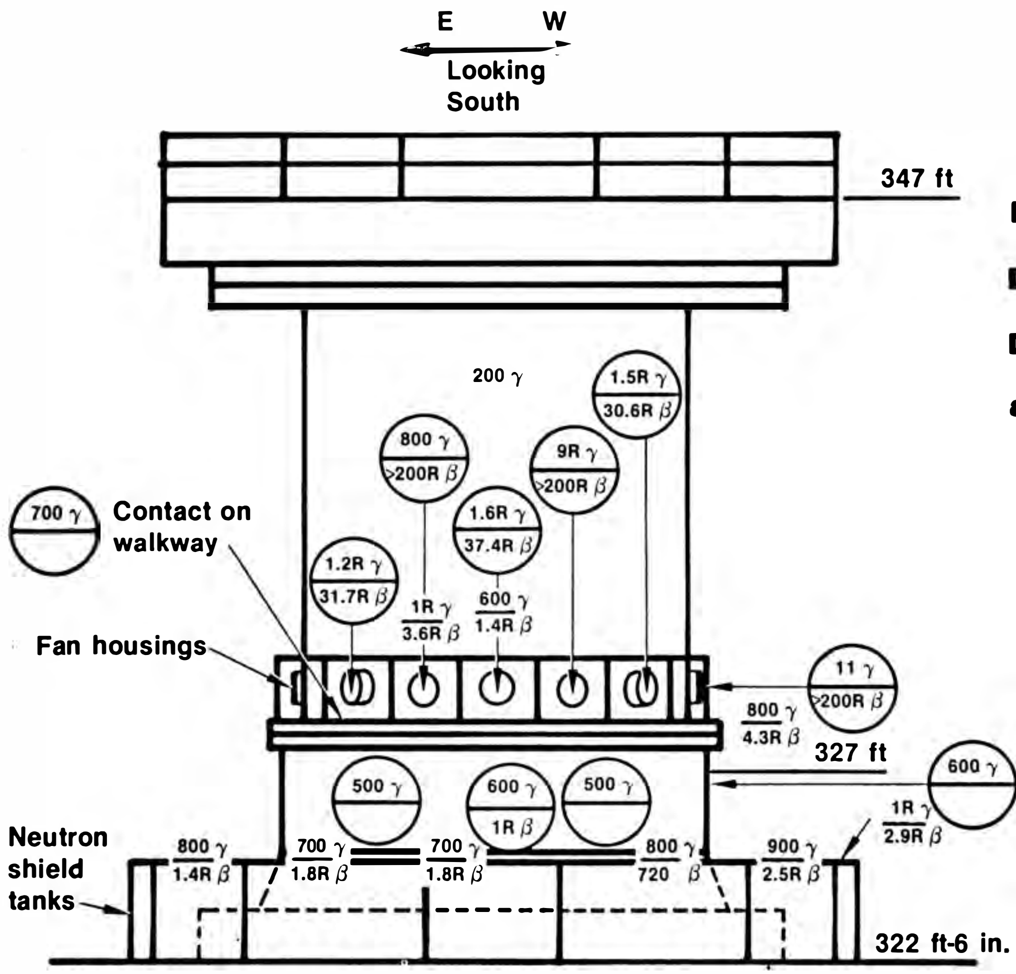
Nuclides	Test 1	Test 2	Test 3
^{134}Cs	4.39±.21(-2)	3.56±.18(-3)	5.01±.24(-2)
^{137}Cs	3.22±.10(-1)	2.90±.10(-2)	3.64±.67(-1)
^{51}Cr	<7.19(-4)	<1.63(-4)	<7.69(-4)
^{54}Mn	<2.00(-5)	<7.12(-6)	<2.44(-5)
^{59}Fe	<4.50(-5)	<1.44(-5)	<5.18(-5)
^{58}Co	<2.40(-5)	<6.89(-6)	<3.07(-5)
^{60}Co	<4.60(-5)	<2.48(-5)	<5.10(-5)
^{65}Zn	<4.09(-5)	<1.69(-5)	<4.63(-5)
^{95}Nb	<4.00(-5)	<8.70(-6)	<4.45(-5)
^{110m}Ag	<2.66(-5)	<9.64(-6)	<3.26(-5)
^{106}Ru	<3.34(-4)	<8.48(-5)	<3.94(-4)
^{124}Sb	<3.10(-5)	<1.93(-5)	<3.65(-5)
^{125}Sb	<5.80(-5)	<1.15(-4)	<6.31(-5)
^{141}Ce	<1.00(-4)	<1.34(-5)	<1.44(-4)
^{144}Ce	--	<2.78(-5)	--
^{90}Sr	9.67±.30(03)	--	--
^{89}Sr	<5.89(-5)	--	--
^{129}I	4.74±.47(-6)	--	--

1 Leach portion of paint chip (used NaOH)

2 Paint chip counted after leach with NaOH

3 Original paint chip

Service Structure Survey



NOTE:

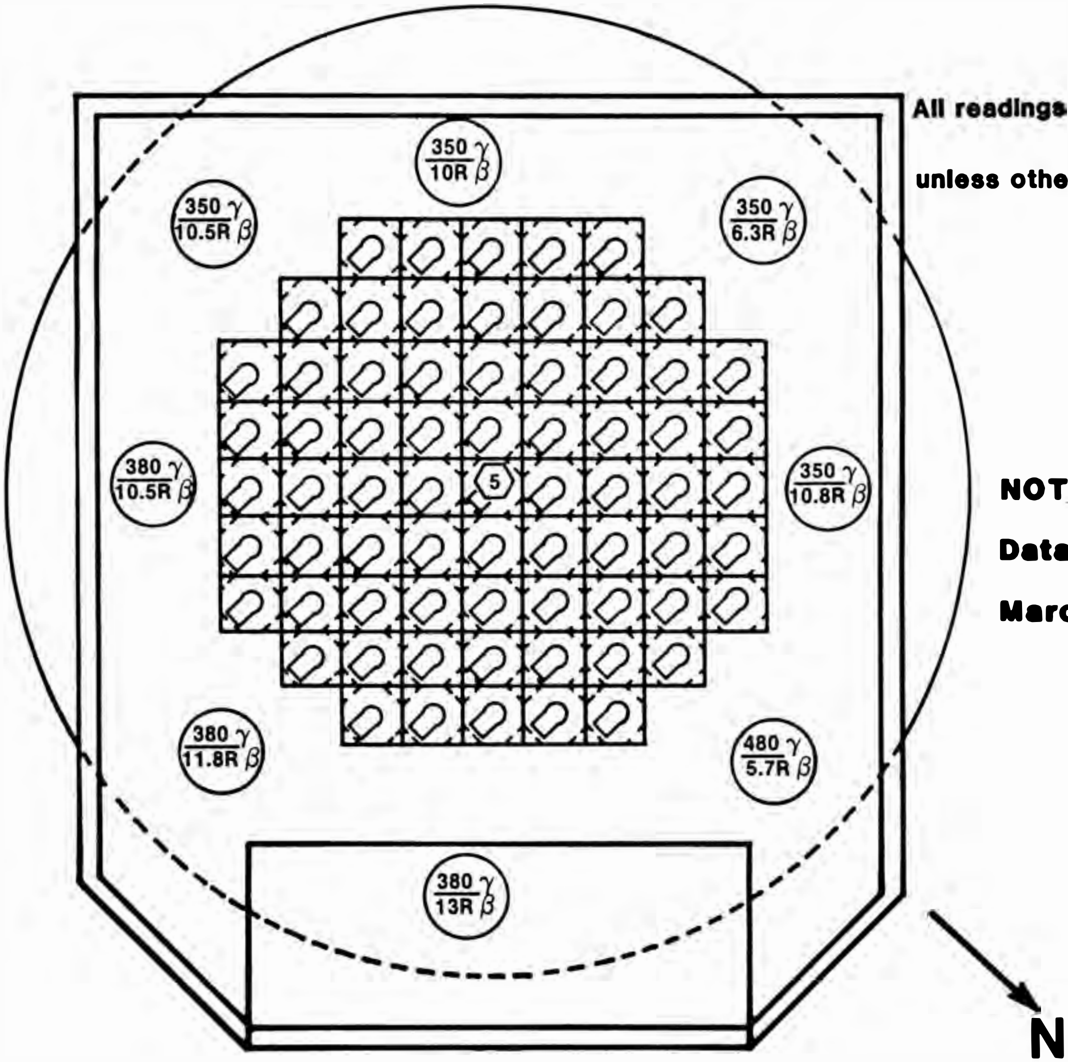
Data Taken

December 11, 1980

and July 23, 1981

All readings in mR/hr or mrad/hr unless otherwise noted

Top of Service Structure Survey



All readings in mR/hr or mrad/hr

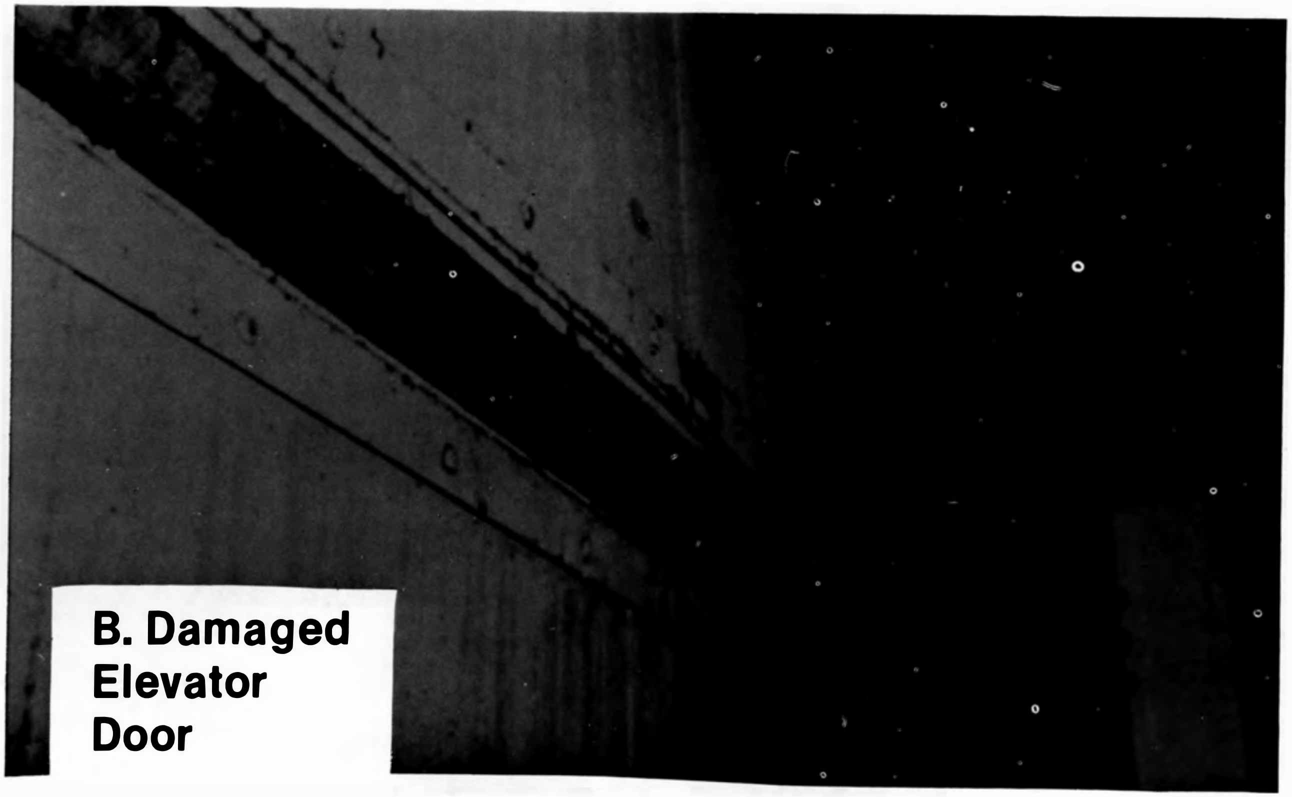
unless otherwise noted

NOTE:

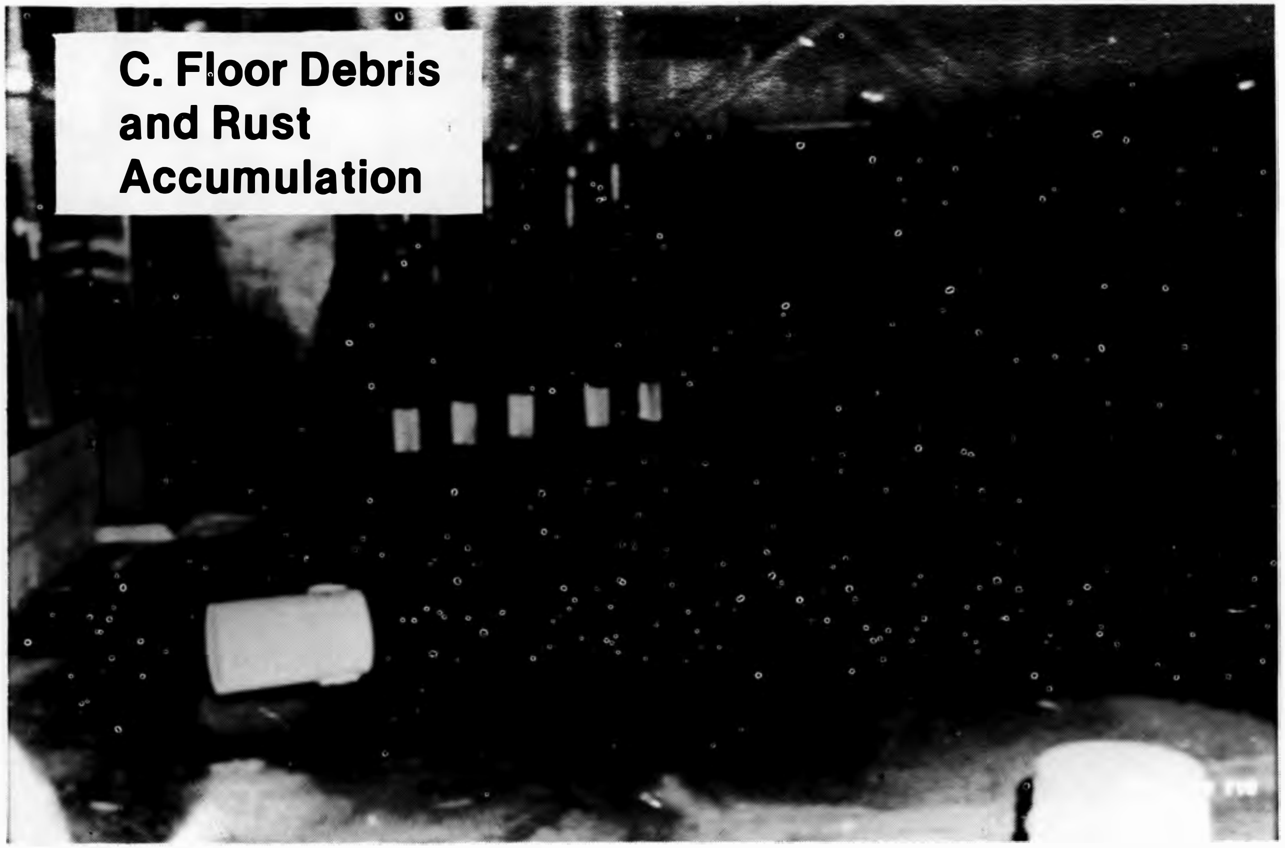
Data Taken

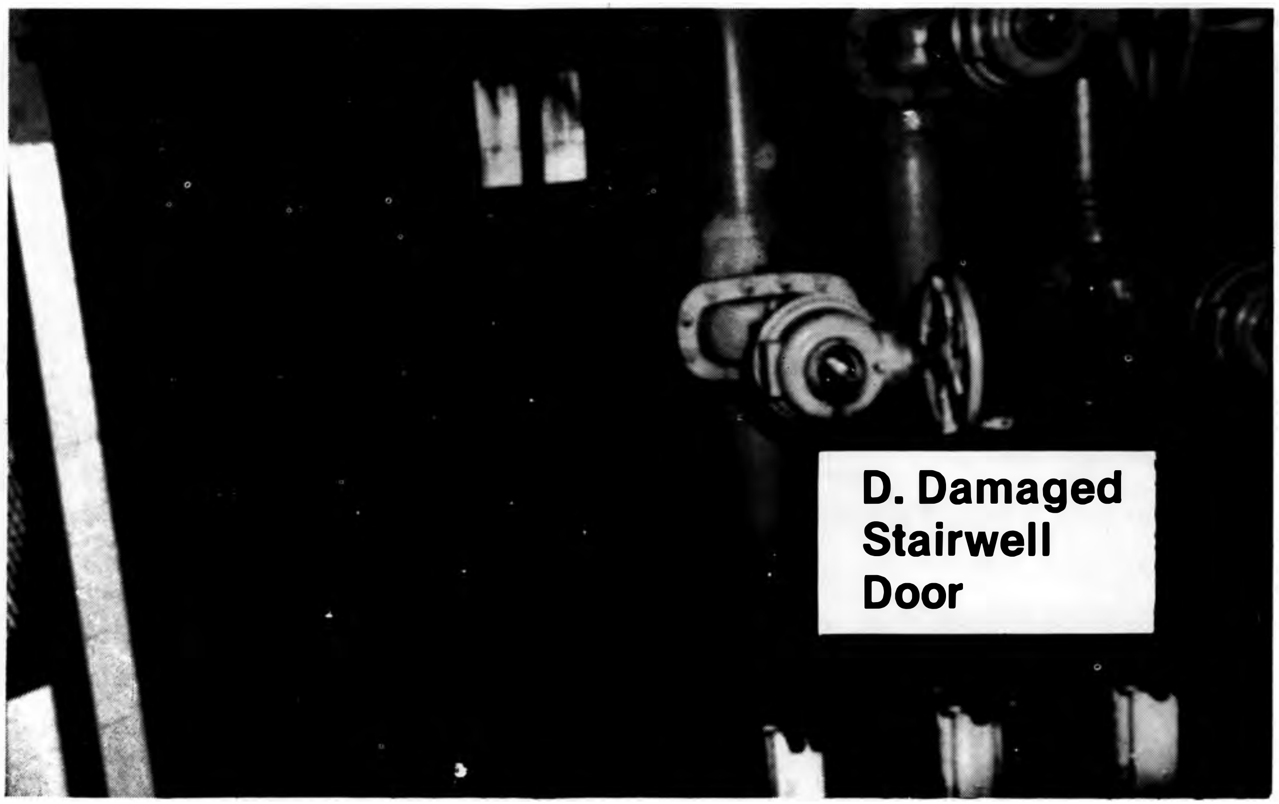
March 19, 1981

A. Moved Deck Plates



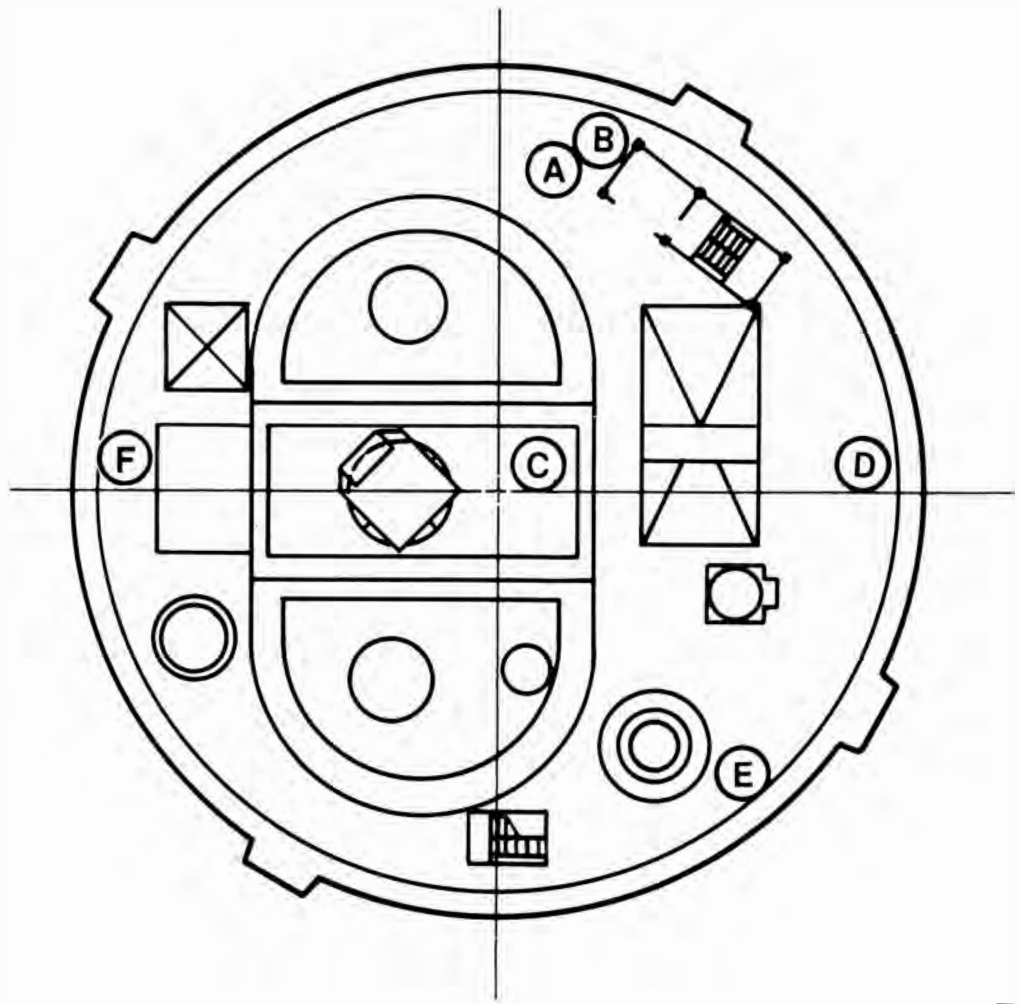
B. Damaged Elevator Door


C. Floor Debris
and Rust
Accumulation

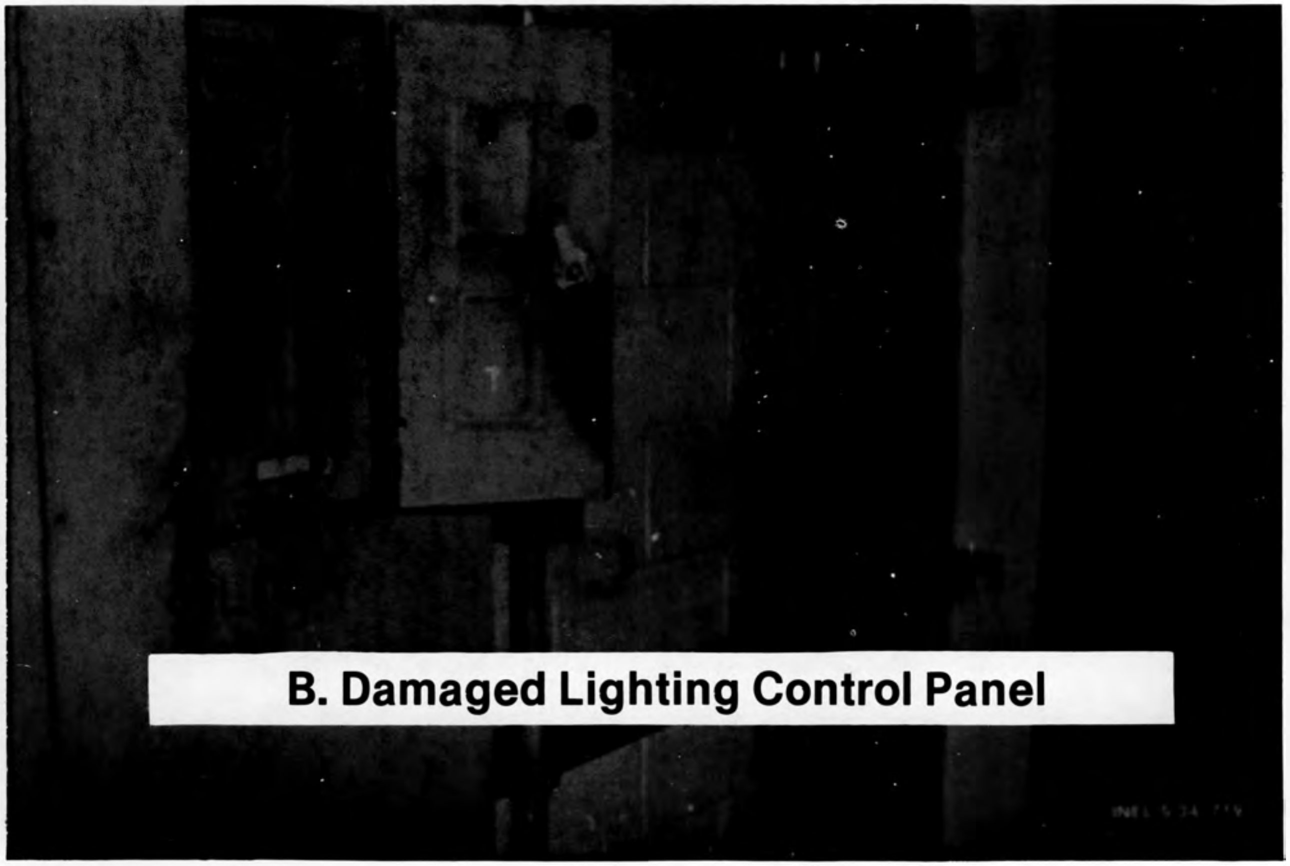

D. Damaged
Stairwell
Door


E. Stairwell leading to Flooded Basement

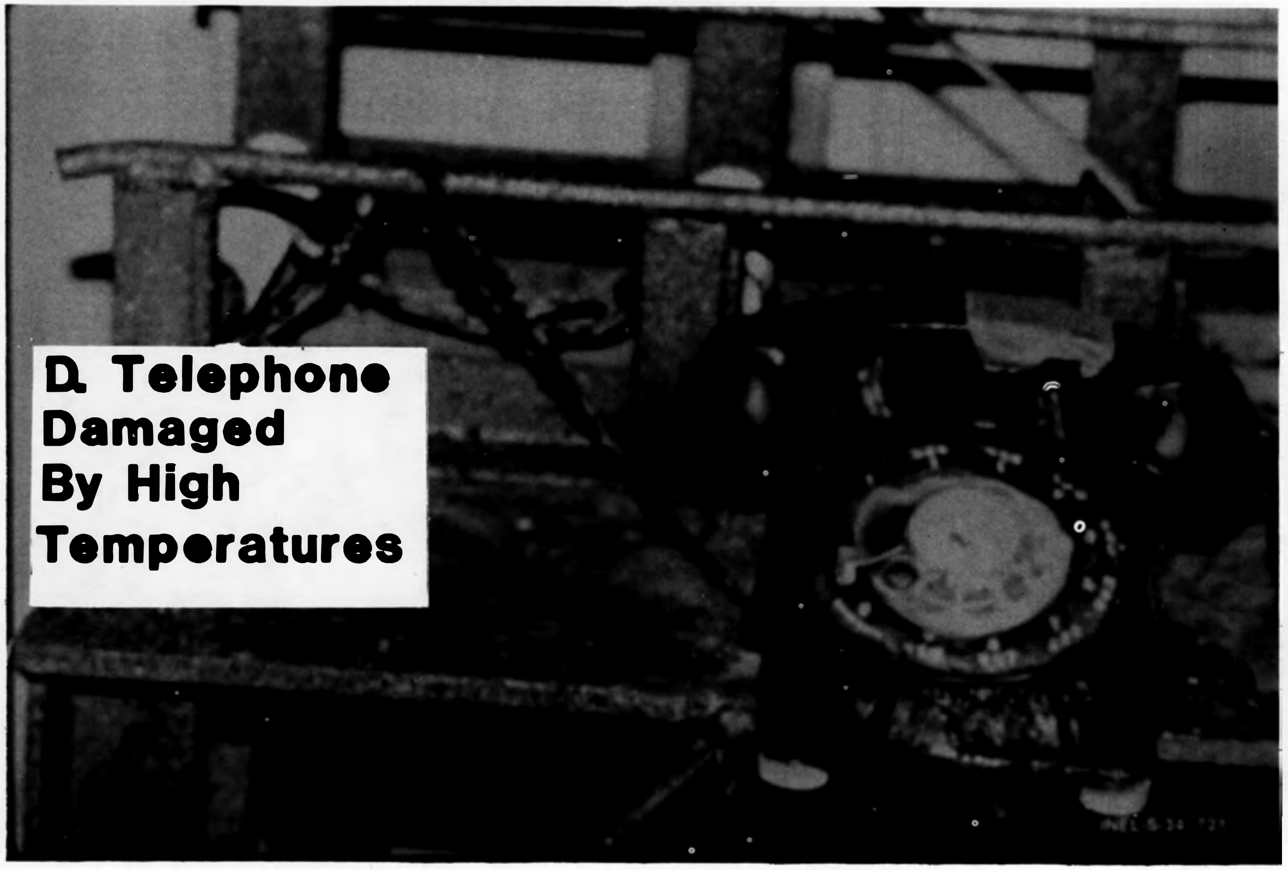
Reactor Building Damage Assessment, 347-ft Elevation



A. Imploded Storage Drum



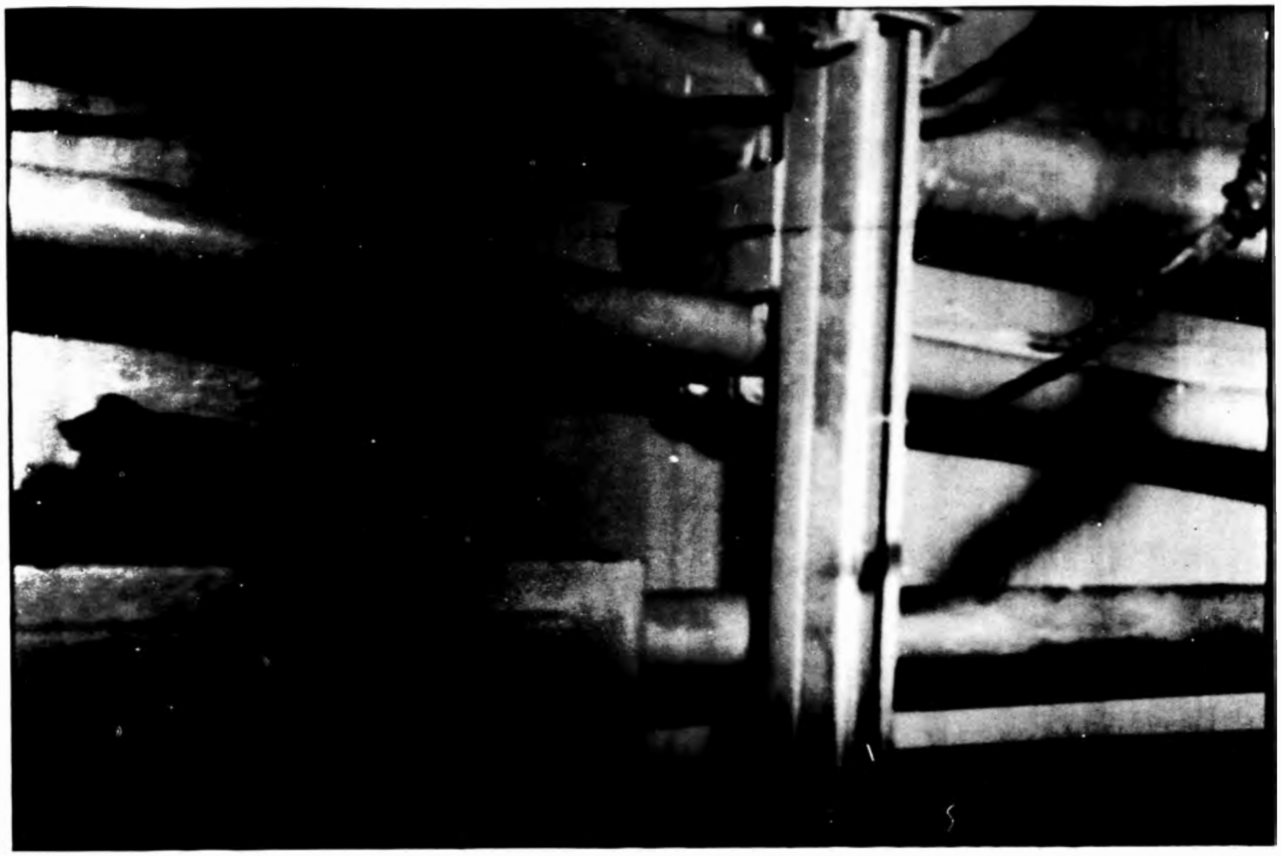
B. Damaged Lighting Control Panel



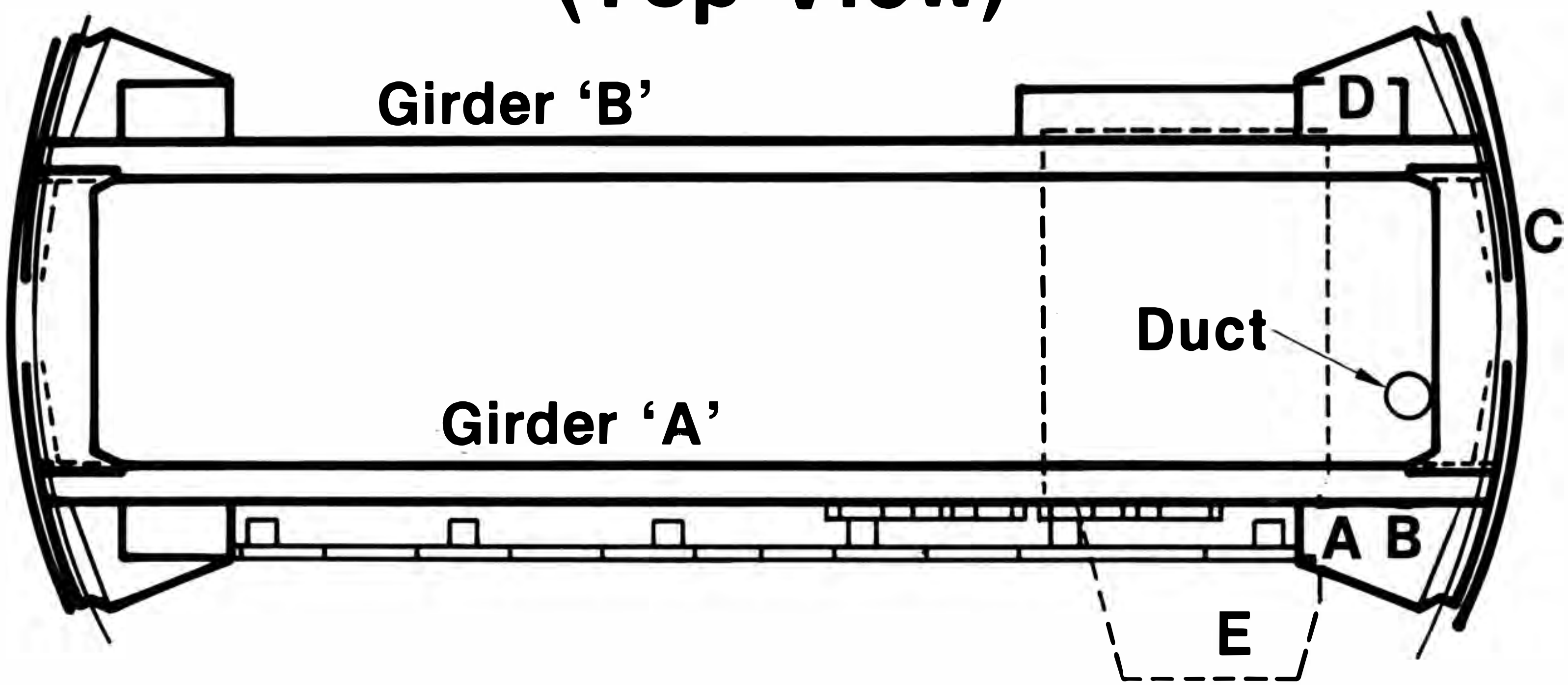
D. Telephone Damaged By High Temperatures

E. Rusted Guide Studs on Storage Rack

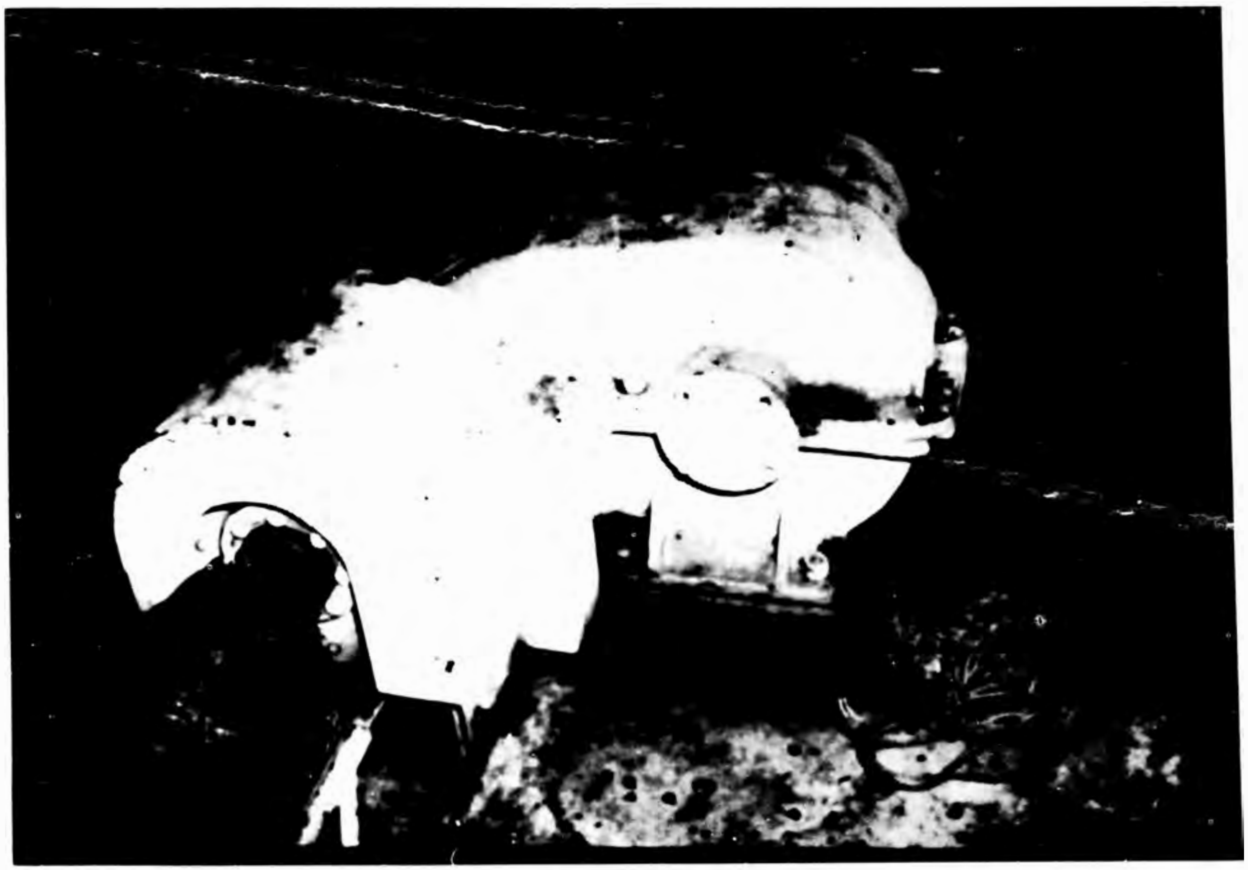
F. Burned Maintenance Manual



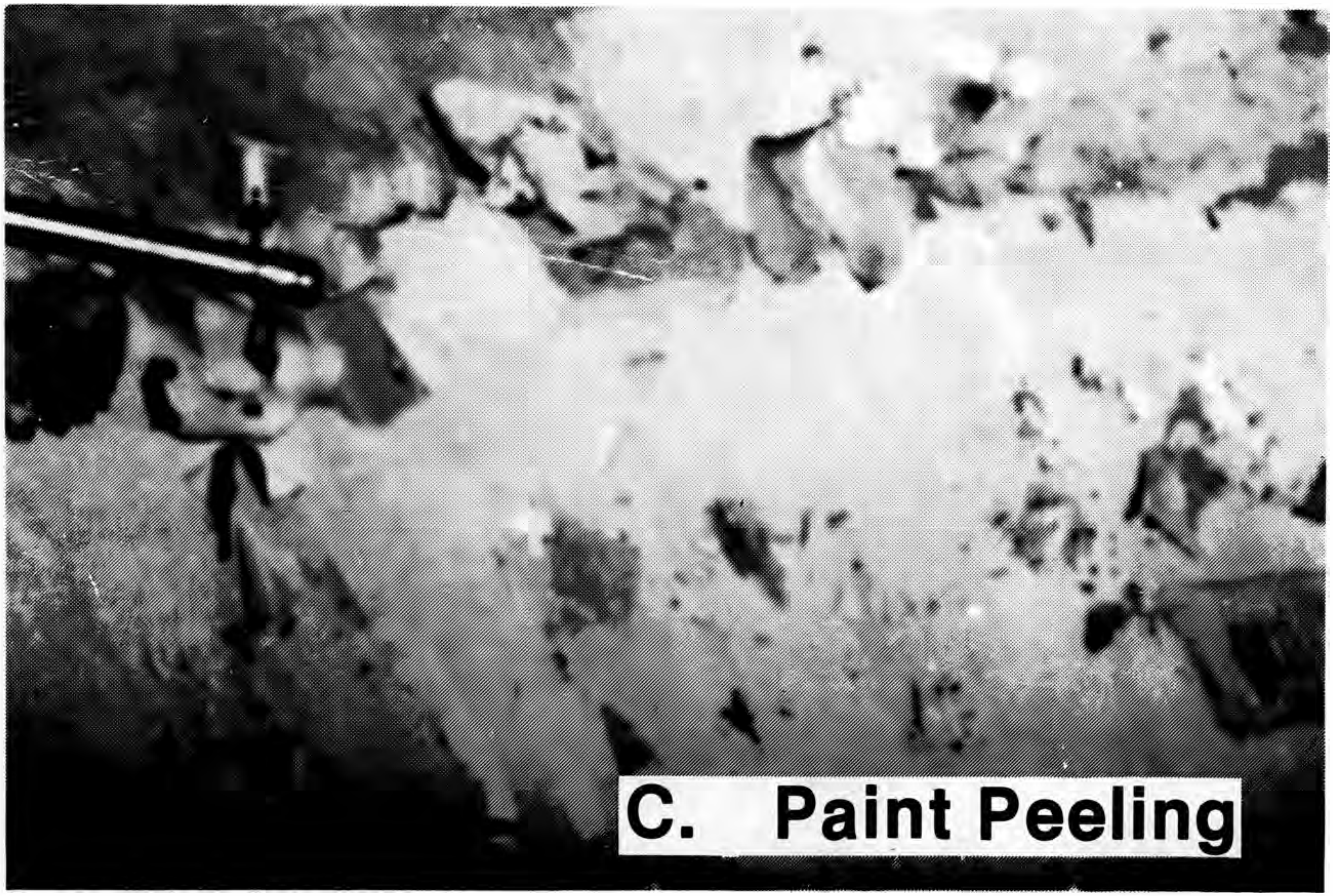
Polar Crane Damage Map (Top View)



A. Melted Rope



B. Burned Polar Crane Operator's Chair


C. Paint Peeling

D. Extensive Rust on Bridge Drive Motor

E. Paper and Blistered Paint

Radiation & Environment

Reactor Building Damage Assessment Future

H_2 burn investigation
Total damage assessment report
Entry photo reports

Results to Date & Future Plans

- Fission product transport and deposition
- Decontamination and personnel exposure control
- Reactor building damage assessment
- Radionuclide mass balance

Radionuclide Mass Balance

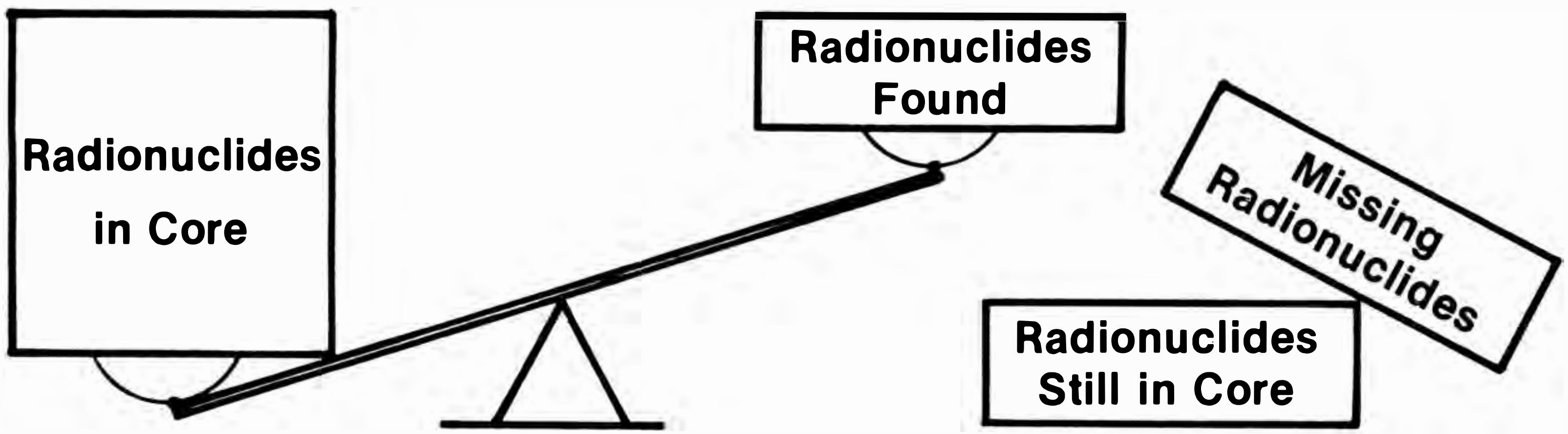
Purpose

- Know where the radionuclides are
- Account for total inventory of radionuclides
- Understand radionuclide flow paths
- Better the industry's understanding of fission product transport and deposition
- Update transport and deposition models

Radionuclide Mass Balance

Current effort

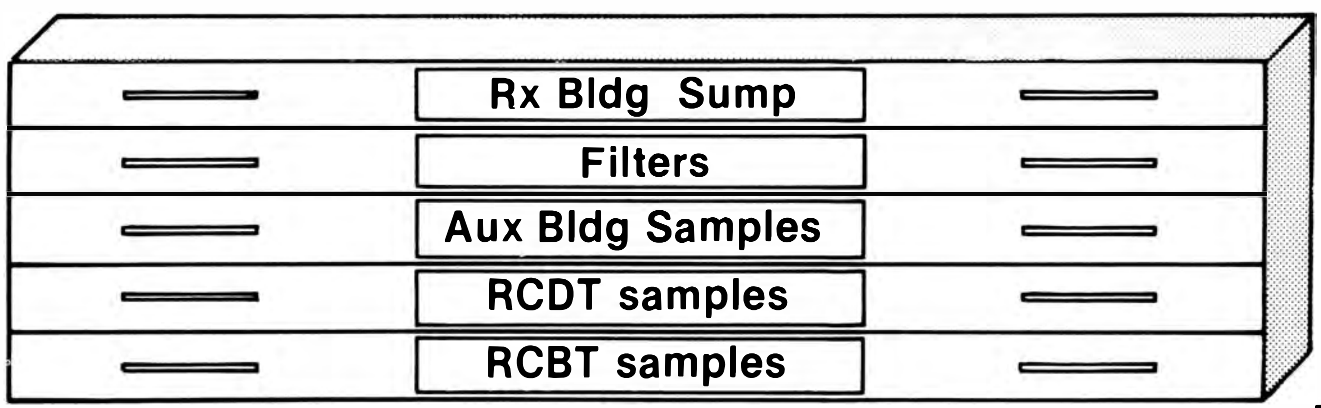
- Identify, organize, and compile existing data
- Recommend further sampling
- Outline analytical procedures to calculate missing information



Radionuclide Mass Balance

Future activities

- Assemble and sort all current data
- Use calculational models for unreported nuclides
- Prepare first draft of a ^{129}I mass balance



TMI R&E-56

Results to Date & Future Plans

- Fission product transport and deposition
- Decontamination and personnel exposure control
- Reactor building damage assessment
- Radionuclide mass balance

DECONTAMINATION AND DOSE REDUCTION

D. W. Leigh

Bechtel Corporation

TMI-2

DOMESTIC SEMINAR

DECONTAMINATION AND DOSE REDUCTION

- PROGRAM PLAN AND RESULTS TO DATE
- FUTURE PLANS

PRESENTED BY

D. W. LEIGH

BECHTEL CORPORATION

DECEMBER 1981

MAJOR RECOVERY PLANS
TECHNICAL PLANNING

CONTAINMENT CHARACTERIZATION

DECONTAMINATION

- GROSS
- HANDS-ON
- SUPPORT

REACTOR DISASSEMBLY AND DEFUELING

WASTE MANAGEMENT

RCS DECONTAMINATION

REQUALIFICATION/DECOMMISSIONING

7/31/81

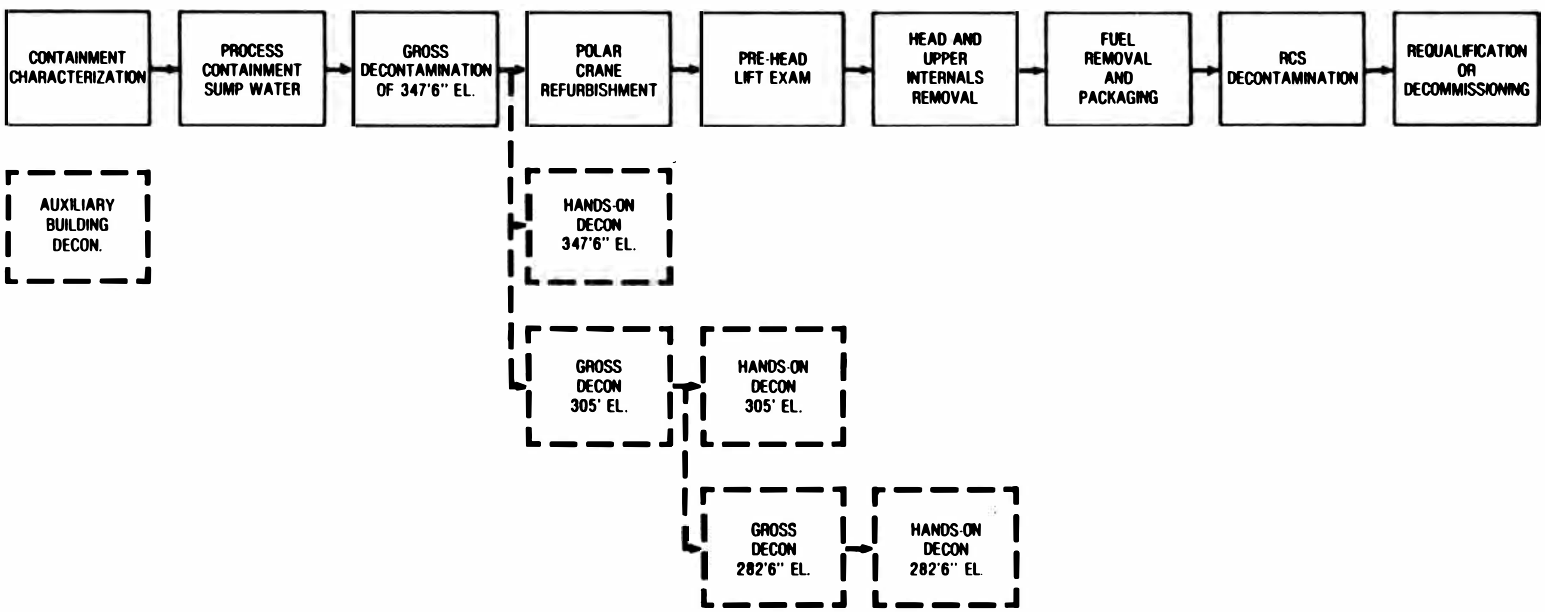
FUEL REMOVAL AND DECONTAMINATION SEQUENCE

CONTROLLING RECOVERY SEQUENCE

7/31/81

FUEL REMOVAL AND DECONTAMINATION SEQUENCE

COMPLETION OF BUILDING DECONTAMINATION



7/31/81

TECHNICAL PLANNING
CONTAINMENT CHARACTERIZATION

PLANNING DOCUMENTS

• DATA ACQUISITION ENTRIES	AUG 1980
• REACTOR BUILDING CHARACTERIZATION	SEP 1980

SUPPORTING DOCUMENTS

- ENTRY REPORTS
- TECHNICAL DATA BOOK - REACTOR BUILDING CHARACTERIZATION
- NUMEROUS ANALYTICAL REPORT

7/31/81

TECHNICAL PLANNING
REACTOR BUILDING DECONTAMINATION

PLANNING DOCUMENTS

• PLANNING STUDY FOR CONTAINMENT ENTRY AND DECONTAMINATION (PHASE I)	JUL 1979
• TECHNICAL PLAN FOR REACTOR BUILDING GROSS DECONTAMINATION (DRAFT)	MAY 1981
• TECHNICAL PLAN FOR REACTOR BUILDING HANDS-ON DECONTAMINATION	JAN 1982
• TECHNICAL PLANT FOR SUPPORT DECONTAMINATION	(?)

SUPPORTING DOCUMENTS

• PRELIMINARY ASSESSMENT OF CONTAINMENT DECON TECHNIQUES	SEP 1980
• EARLY DECONTAMINATION OF TMI-II REACTOR BUILDING	FEB 1981
• DECONTAMINATION TECHNIQUES TEST PROGRAM	MAY 1981
• REACTOR BUILDING LARGE-SCALE DECON TEST	JUN 1981
• DOCUMENTATION OF FUEL HANDLING AND AUXILIARY BUILDING DECON	AUG 1981

7/31/81

TECHNICAL PLANNING
RCS DECONTAMINATION

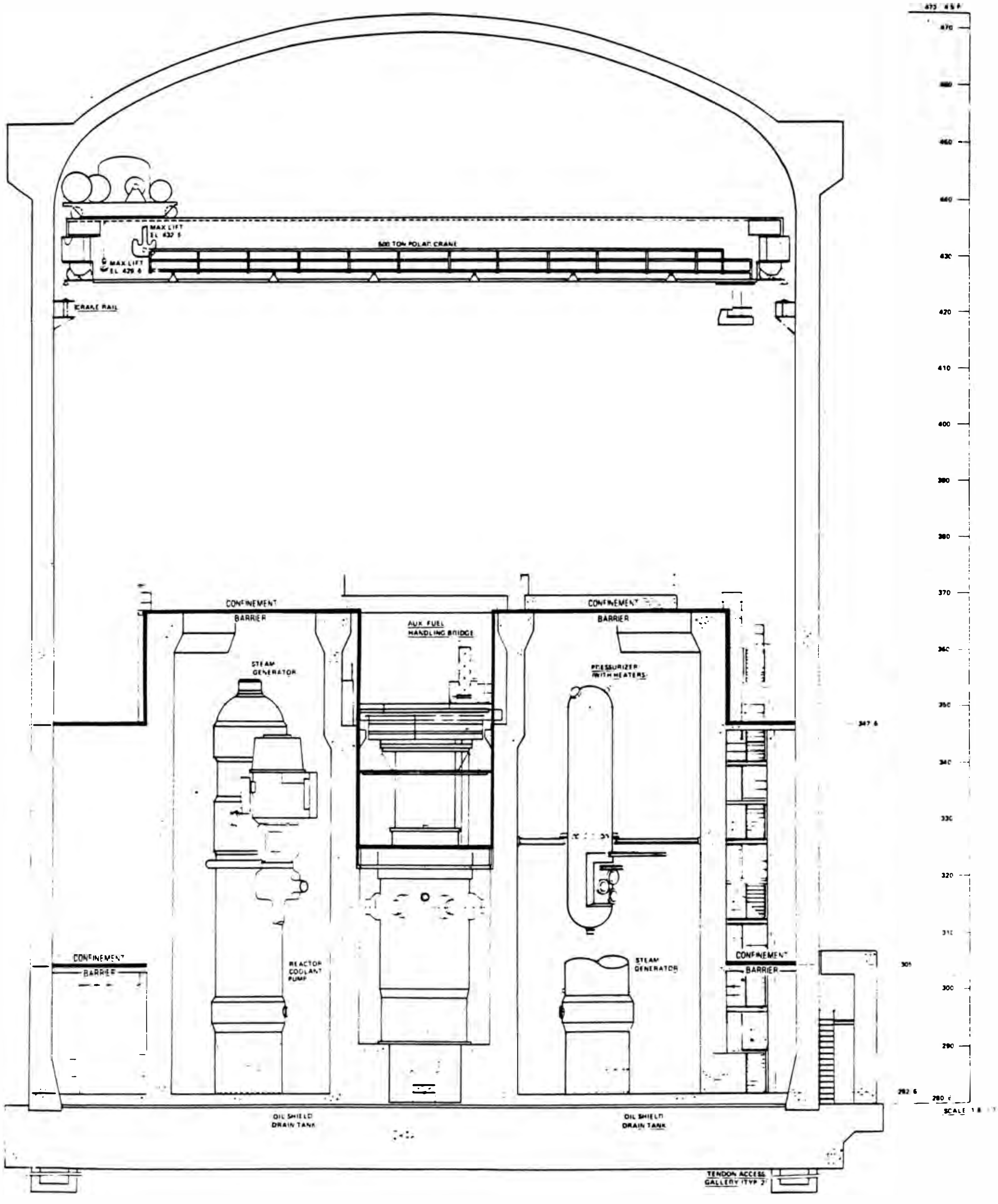
TECHNICAL PLANS

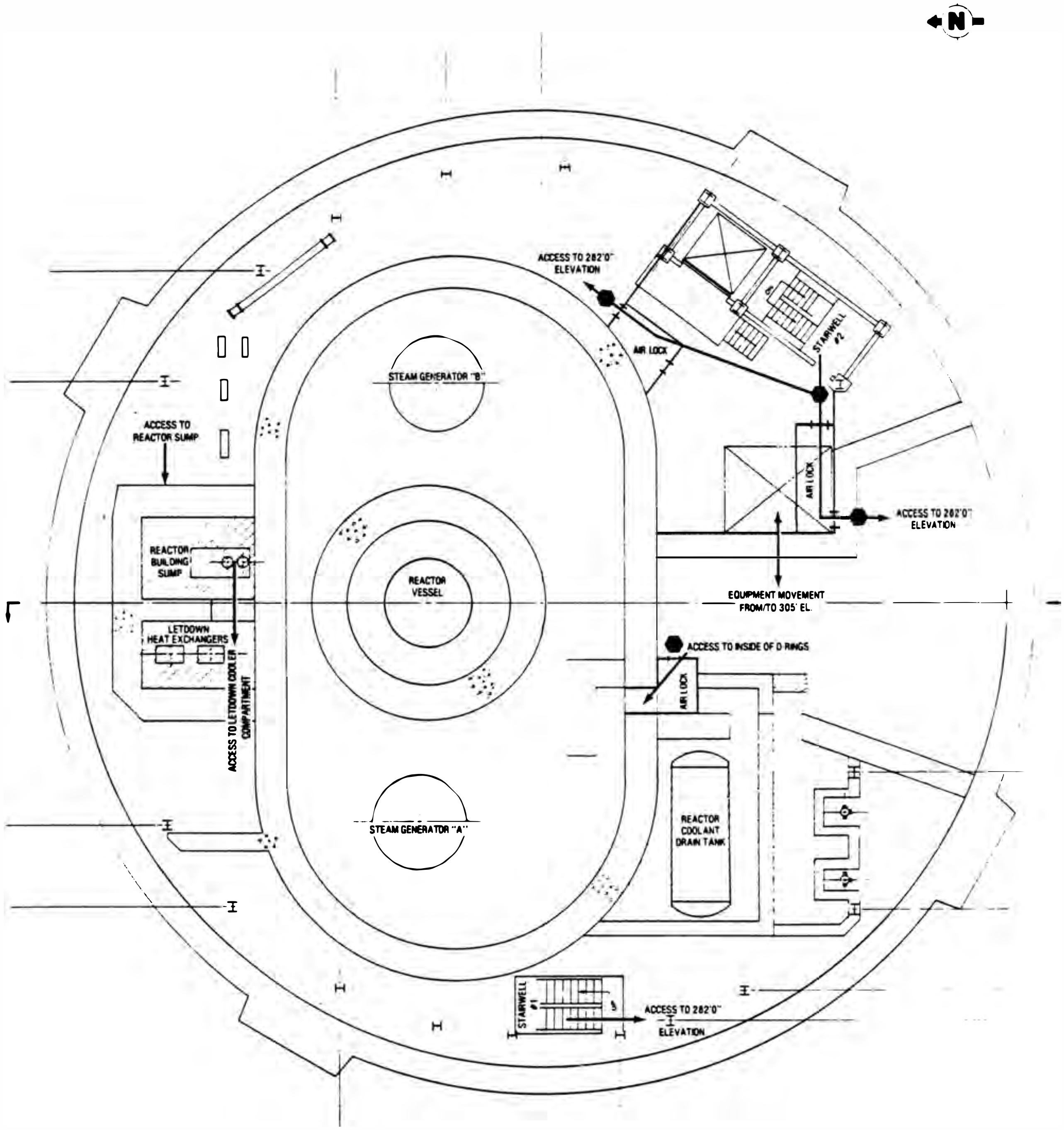
- RCS DECONTAMINATION PLAN

SUPPORT STUDIES

• RCS CHEMICAL DECONTAMINATION STUDIES (B&W)	ONGOING
• REACTOR COOLANT SYSTEM DECONTAMINATION & DOSE REDUCTION (EPRI)	ONGOING

7/31/81


MAX LIFT
EL 432 5
MAX LIFT
EL 429 6
500 TON POLAR CRANE
CRANE RAIL
CONFINEMENT
BARRIER
AUX FUEL
HANDLING BRIDGE
CONFINEMENT
BARRIER
STEAM
GENERATOR
PRESSURIZER
WITH HEATERS
REACTOR
COOLANT
PUMP
CONFINEMENT
BARRIER
STEAM
GENERATOR
CONFINEMENT
BARRIER
OIL SHIELD
DRAIN TANK
OIL SHIELD
DRAIN TANK
TENDON ACCESS
GALLERY (TYP 2)
470
460
450
440
430
420
410
400
390
380
370
360
350
340
330
320
310
300
290
280



N
ACCESS TO 282'0" ELEVATION
AIR LOCK
STAIRWELL #2
STEAM GENERATOR "B"
ACCESS TO REACTOR SUMP
AIR LOCK
ACCESS TO 282'0" ELEVATION
REACTOR BUILDING SUMP
REACTOR VESSEL
EQUIPMENT MOVEMENT FROM/TO 305' EL.
LETDOWN HEAT EXCHANGERS
ACCESS TO INSIDE OF D RINGS
AIR LOCK
ACCESS TO LETDOWN COOLER COMPARTMENT
STEAM GENERATOR "A"
REACTOR COOLANT DRAIN TANK
STAIRWELL #1
ACCESS TO 282'0" ELEVATION

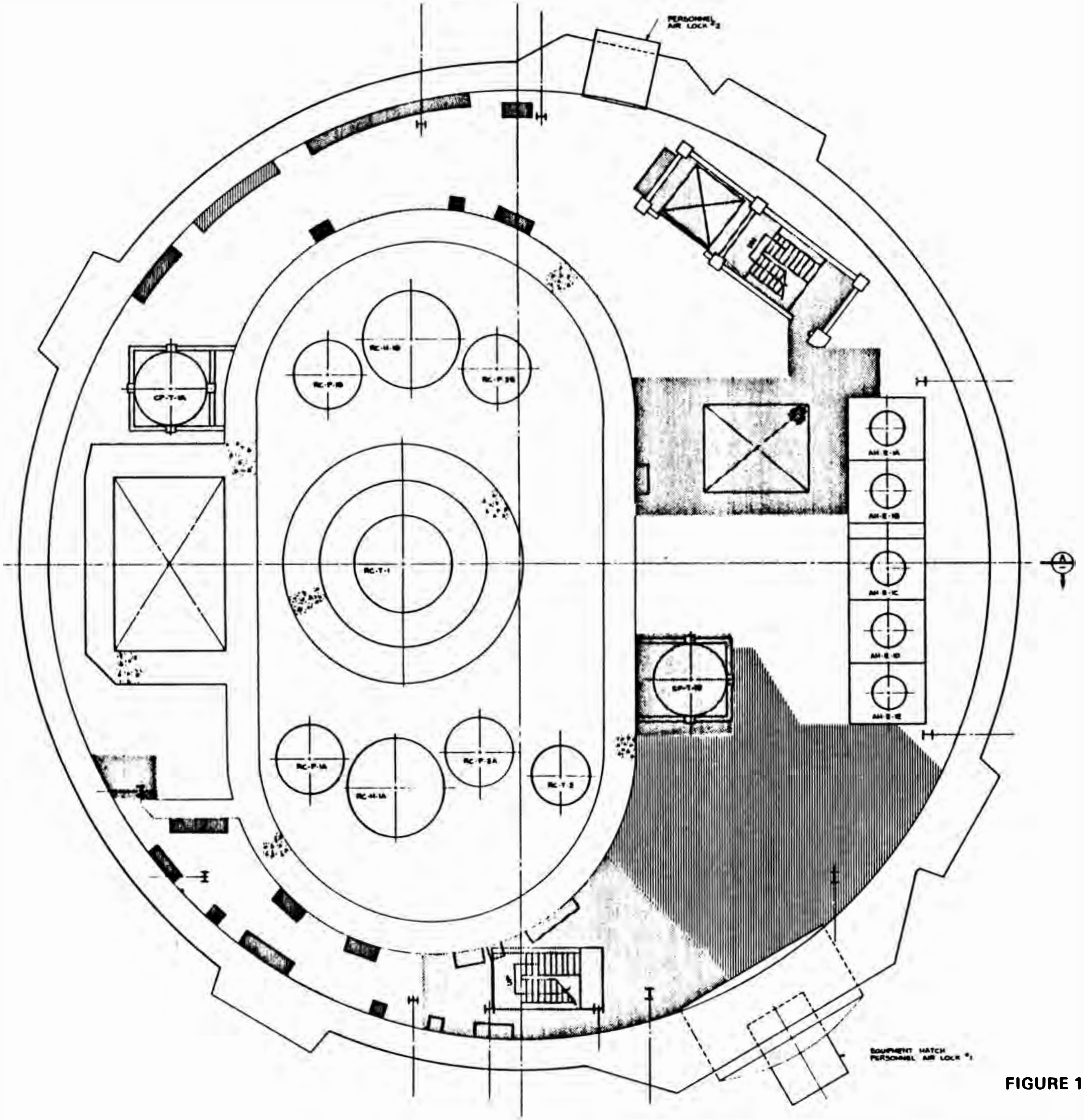


FIGURE 1 - GENERAL RADIATION LEVELS AT 305' ELEVATION

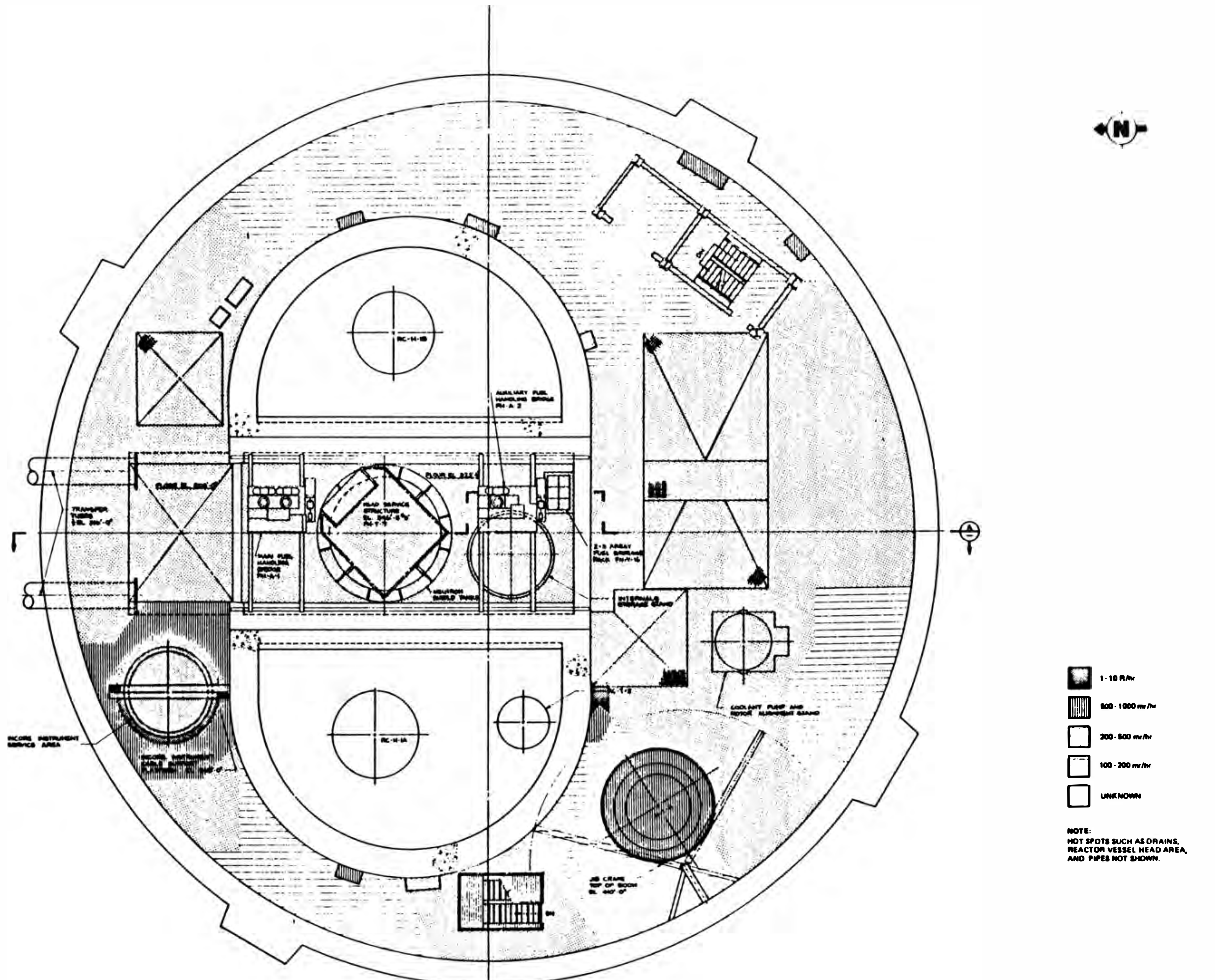
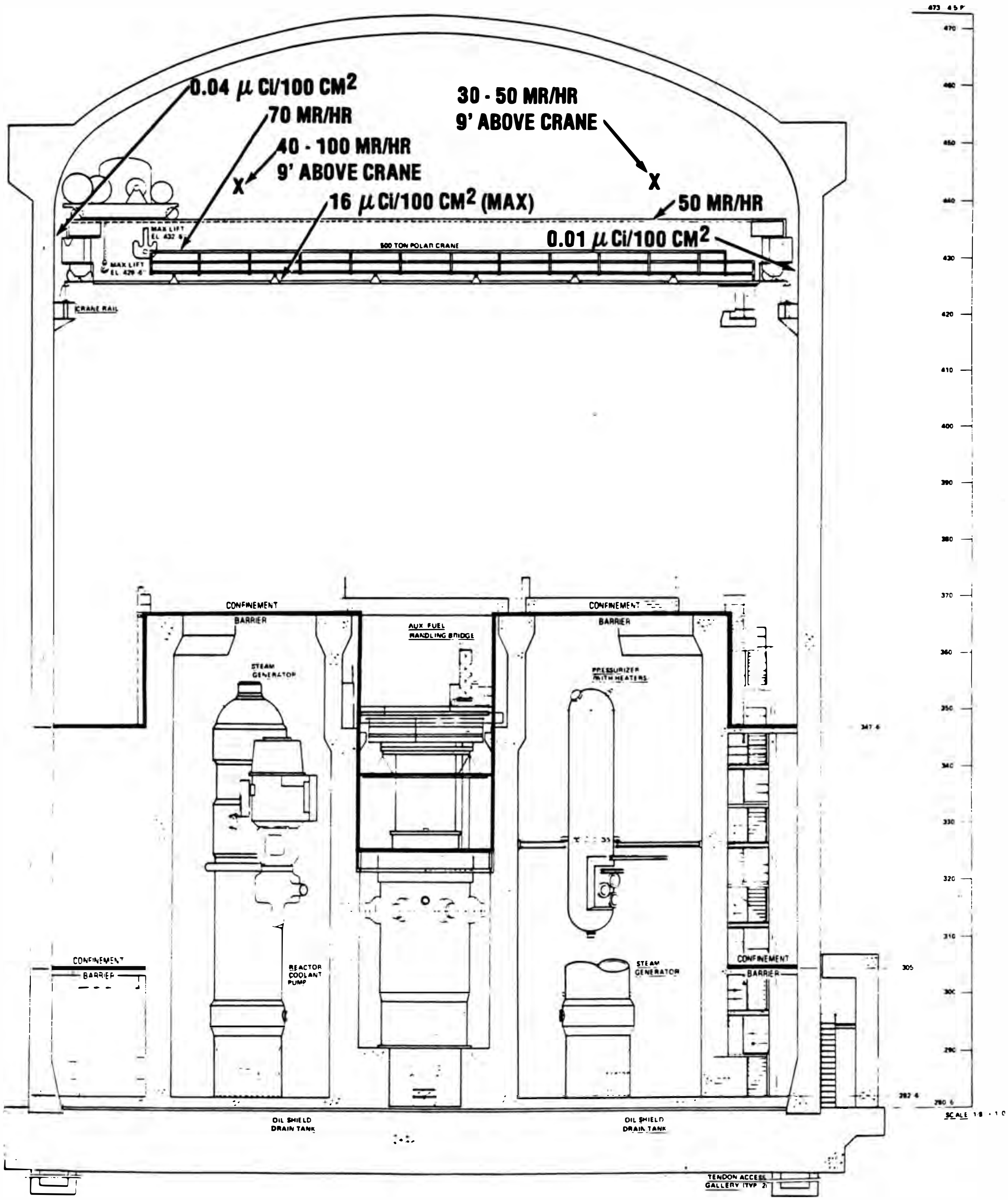
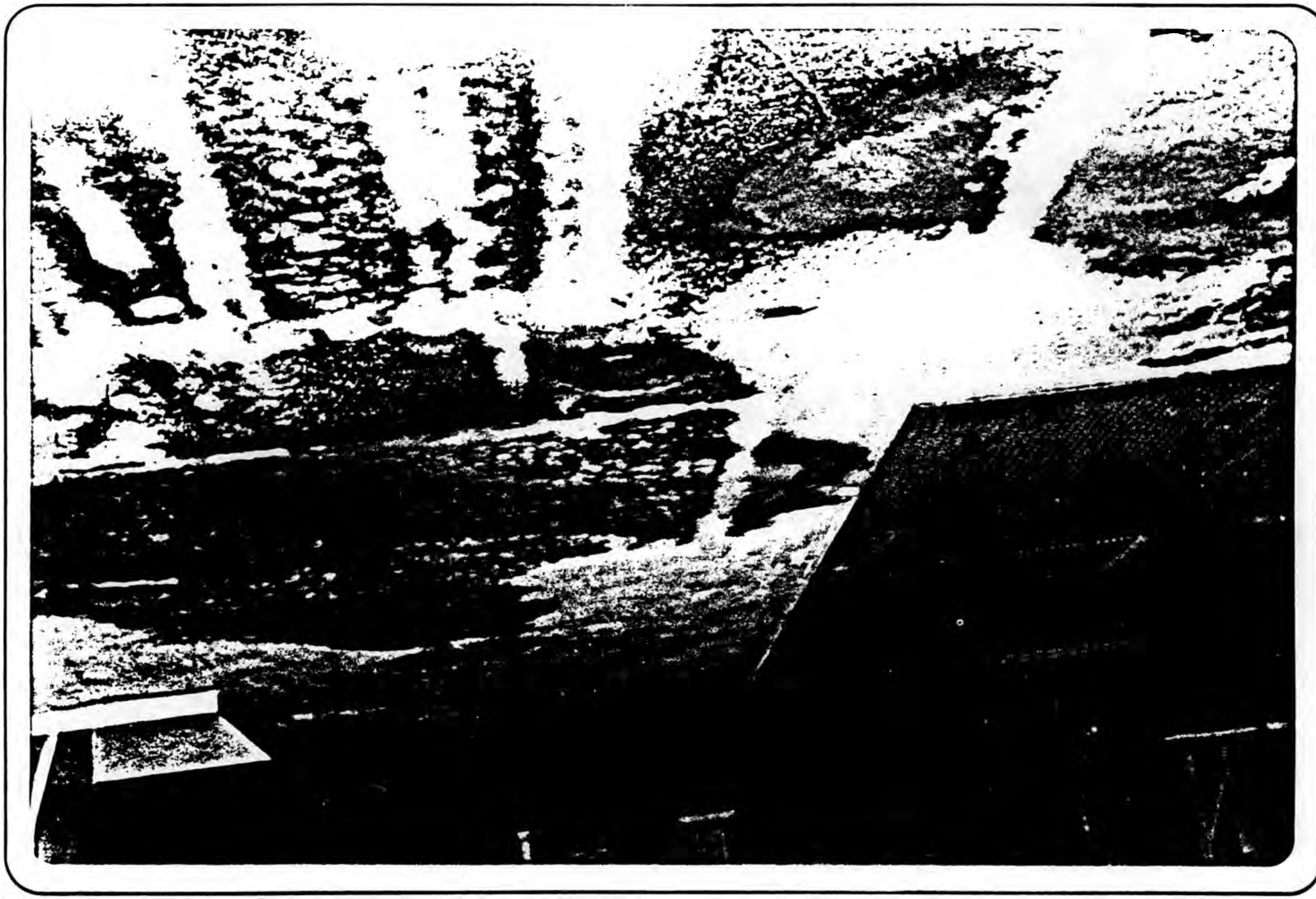
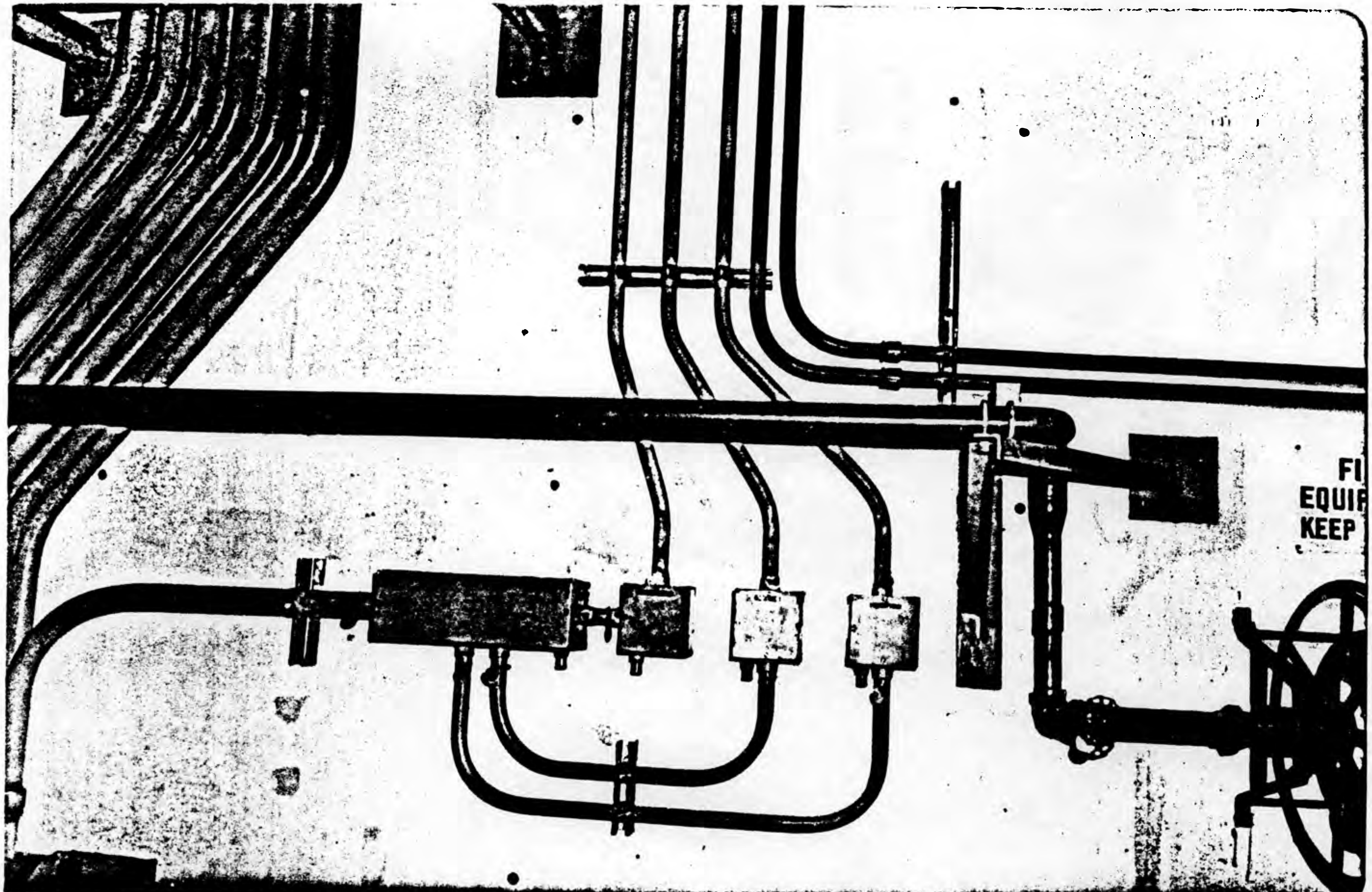


FIGURE 2 - GENERAL RADIATION LEVELS AT 347' 6" ELEVATION


0.04 μ Ci/100 CM2
70 MR/HR
40 - 100 MR/HR
9' ABOVE CRANE
30 - 50 MR/HR
9' ABOVE CRANE
16 μ Ci/100 CM2 (MAX)
50 MR/HR
0.01 μ Ci/100 CM2
500 TON POLAR CRANE
CRANE RAIL
CONFINEMENT
BARRIER
AUX FUEL
HANDLING BRIDGE
STEAM
GENERATOR
PRESSURIZER
WITH HEATERS
REACTOR
COOLANT
PUMP
OIL SHIELD
DRAIN TANK
TENDON ACCESS
GALLERY (TYP 2)
470
460
450
440
430
420
410
400
390
380
370
360
350
340
330
320
310
305
300
290




FI
EQUIF
KEEP

LARGE DECON TEST OBJECTIVES

RADIOLOGICAL CONDITIONS

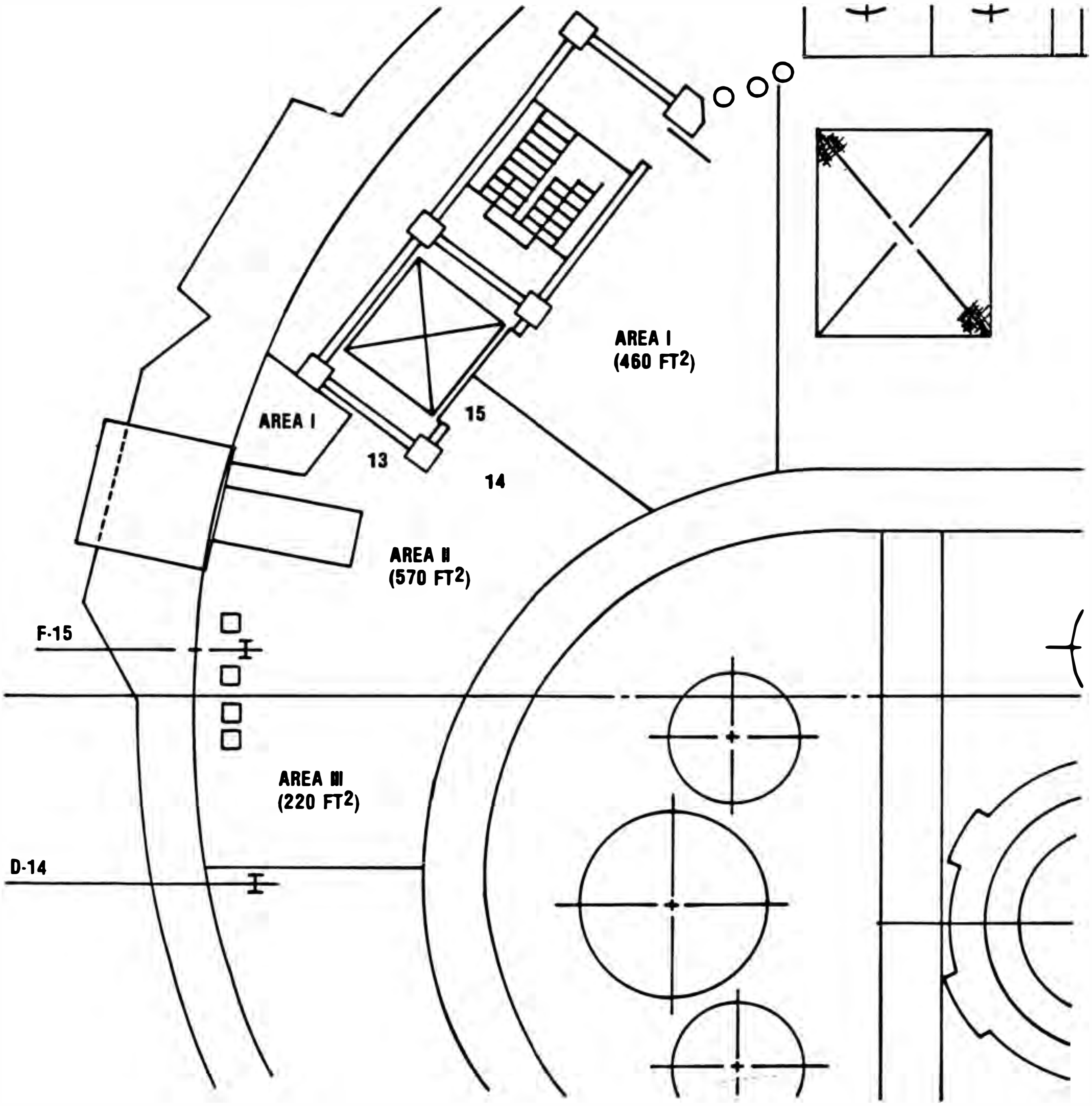
- DETERMINE REMOVABLE ACTIVITY
- PERFORM AREA RADIATION SURVEYS
- PERFORM SURFACE CONTAMINATION SURVEYS
- DETERMINE CHANGES IN AIRBORNE CONTAMINATION LEVELS

OPERATIONAL CONDITIONS

- PROVE ADEQUACY OF APPROACHES PRESENTED IN GROSS DECONTAMINATION PLAN
- ESTABLISH SUPPORT SYSTEMS AND EQUIPMENT REQUIREMENTS
- PROVIDE DATA TO ESTIMATE
    - WORKER PRODUCTIVITY
    - MAN-REM EXPOSURE VALUES
    - RATES OF WASTE GENERATION

TMI-2 DATA ACQUISITION PROGRAM
CONTAINMENT ENTRY DATED MAY 14, 1981

AREA I — LOW PRESSURE FLUSH ONLY
AREA II — LOW PRESSURE FLUSH FOLLOWED BY HIGH PRESSURE FLUSH
AREA III — HIGH PRESSURE FLUSH ONLY



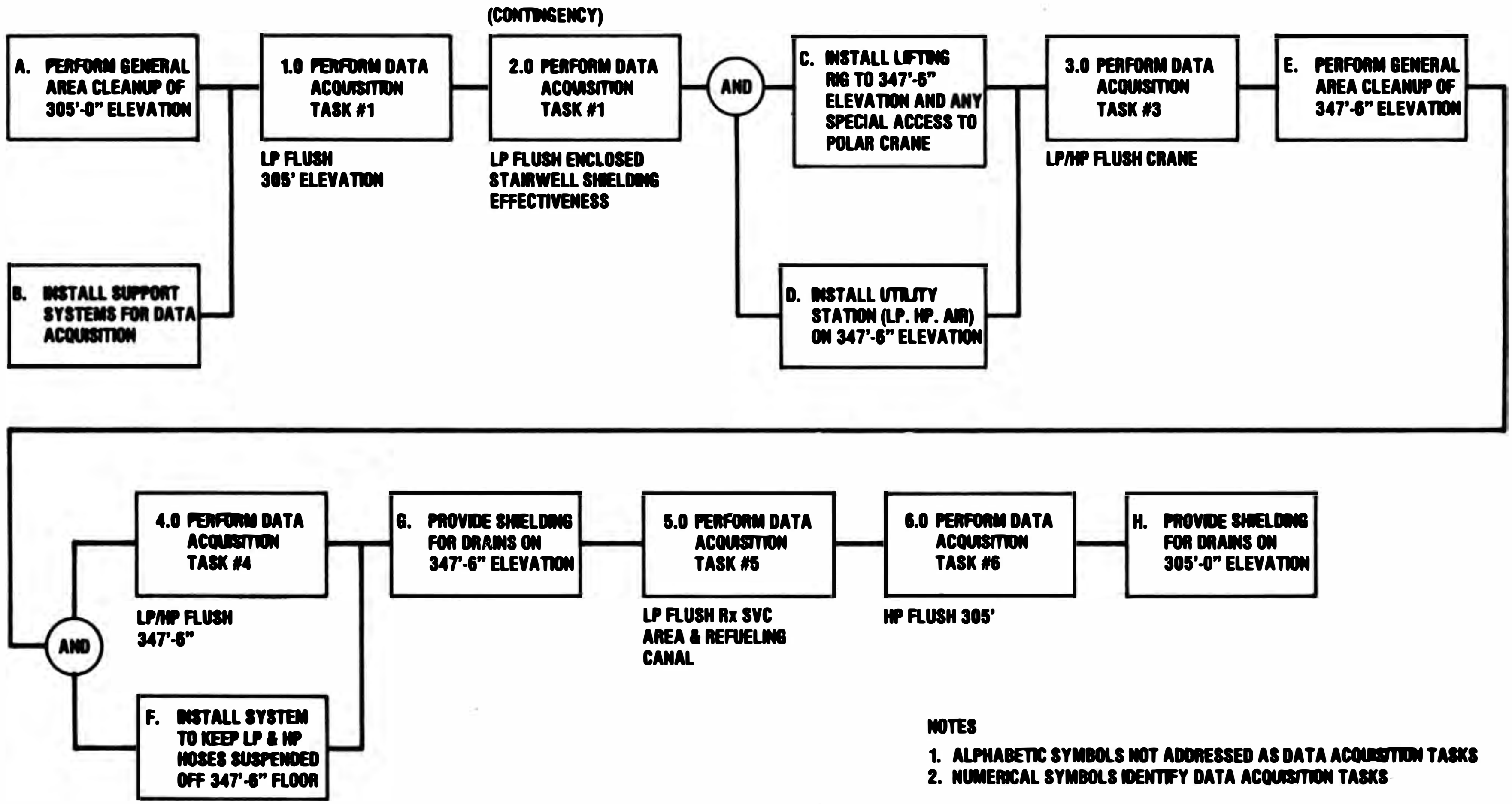
TENTATIVE CONCLUSIONS

- LP/HP HOT WATER COMBINATION PROVED EFFECTIVE IN REMOVING DIRT, GREASES, AND RADIOACTIVE CONTAMINATION
- 10^5 DPM/100 CM^2 ACHIEVED FOR ALL SURFACES EXCEPT FLOOR WHICH APPROACHED 10^5 DPM/100 CM^2
- AIRBORNE ACTIVITY REDUCED BY A FACTOR OF ABOUT 50
- DECONTAMINATION FACTOR (DF) FOR FLOOR SURFACES ESTIMATED AT 20-30
- APPROXIMATELY 0.3 μCI/CM^2 OF ACTIVITY REMAINS ON FLOOR SURFACE (DETERMINED BY CALCULATION)
- AREA RADIATION DOSE RATE WAS REDUCED BY A FACTOR OF 1.2 TO 1.4 (BY MEASUREMENT ONE METER ABOVE FLOOR)
- AIR-COOLED SUITS WORKED WELL FOR DURATION OF TEST
- LP/HP DECONTAMINATION RATE WAS ABOUT 1000 FT^2/HR (AVERAGE FOR HORIZONTAL & VERTICAL SURFACES)
- LIQUID WASTE GENERATION RATE ABOUT 0.1 GAL/FT^2
- IN-CONTAINMENT DECONTAMINATION CREW OF 3 PERSONNEL WAS ADEQUATE
- SUPPORT SYSTEMS LOCATED OUTSIDE REACTOR BUILDING PROVED EFFECTIVE FOR THIS TEST

DECONTAMINATION EXPERIMENT OBJECTIVES

CRITERIA DEVELOPMENT
TECHNIQUE DEVELOPMENT
DECONTAMINATION EFFECTIVENESS
ADMINISTRATIVE CONTROLS
TRAINING REQUIREMENTS
CONTAMINATION CONTROL
PERSONNEL DOSIMETRY
CHARACTERIZATION OF RADIATION CONDITIONS

DATA ACQUISITION PROGRAM FOR DECONTAMINATION EXPERIMENT



NOTES

1. ALPHABETIC SYMBOLS NOT ADDRESSED AS DATA ACQUISITION TASKS
2. NUMERICAL SYMBOLS IDENTIFY DATA ACQUISITION TASKS

DECONTAMINATION EXPERIMENT
SCOPE OF EFFORT

• LOW PRESSURE FLUSH	305' ELEVATION
• LOW PRESSURE FLUSH	CRANE
• *HIGH PRESSURE FLUSH	CRANE
• LOW & HIGH PRESSURE FLUSH	347'-6'' ELEVATION
• HIGH PRESSURE FLUSH	305' ELEVATION
• LOW PRESSURE FLUSH	REFUELING CANAL

*CONTINGENCY

DECONTAMINATION EXPERIMENT
EXPECTED RESULTS

- DOSE REDUCTION

LOCATION	MR/HR (BEFORE)	MR/HR (AFTER)
305' ELEVATION	200-1000	150-300
CRANE	50-70	10-50
347'-6" ELEVATION	100-500	50-100

- MAN-HOURS (PLANNED-IN CONTAINMENT) 290

- MAN-REM (ESTIMATED) 95

FUTURE PLANS
FOR DATA ACQUISITION PROGRAM

- ASSESS SURFACE CONDITIONS (AFTER GROSS DECON)
- OBTAIN PHOTOGRAPHS FOR DECON PLAN IMPLEMENTATION
- PERFORM 282' ELEVATION RADIATION AND CONTAMINATION SURVEY
- SAMPLE FOR SLUDGE ON 282' FLOOR
- OBTAIN REACTOR COOLANT DRAIN TANK (RCDT) SAMPLE
- PROVIDE DEFUELING OPERATIONS DATA SUPPORT
- PROVIDE RESTORATION OPERATIONS DATA SUPPORT

UTILITY WASTE MANAGEMENT PLAN

R.S. Daniels

Bechtel National, Inc.

TMI-2
DOMESTIC SEMINAR

Utility Waste Management Plan

Presented By

R. S. Daniels
Bechtel National, Inc.

December 1981

Goals:

- Define disposal endpoint for each waste stream
    - DOE/NRC memo of understanding resolved outstanding problems
- Evaluate all elements of waste generation, processing, solidification, packaging, interim onsite storage, transportation, permanent disposal in cost benefit comparison using ALARA techniques
- Provide adequate waste processing to assure minimum waste volumes for handling and disposal
- Provide adequate onsite storage for wastes generated during recovery operations

Current Objectives:

- Document current liquid processing systems, e.g., EPICOR-II and SDS
- Identify future waste streams
- Evaluate alternative processing methods
- Recommend preferred approach using cost benefit technique, e.g., dollars and person-rem

Future Waste Problems

- Volume reduction of solid wastes from decontamination
  - compaction, incineration
- Processing of chemical decontamination solutions
  - chelate deactivation or solidification
  - evaporation of chemical solutions
- RCS decontamination
  - mechanical
  - chemical
- Refueling Canal cleanup during defueling
  - soluble and particulate source terms

Utility Waste Management Plan

- Summary
- Introduction
  - Waste Management Planning
  - Waste Characterization
  - Processing Methods
  - Packaging
  - Onsite Storage Facilities
  - Transportation Methods & Shipping Containers
  - Final Disposal Options
  - Cost Bases
- Waste Streams - (physical, chemical, radiological, untreated quantity f (time))
  - Gases
  - Liquids
  - Solids

Utility Waste Management Plan (Cont.)

- Waste Processing
  - Gases - filtration, sorption, storage
  - Liquids - filtration, IX, solidification
  - Solids - compaction, incineration, disassembly/sectioning
- Waste Packaging & Handling
  - LSA boxes, 55-gallon drums, liners-EPICOR II, SDS
- Waste Storage
  - Liquids-processed water
  - Solids-liners & drums
- Waste Disposal
  - transportation mode
  - shipping containers
  - Disposal endpoint
- Quality Assurance

DEPARTMENT OF ENERGY FUTURE PLANS

N. Gerstein

U.S. Department of Energy

TMI-2 DOMESTIC SEMINAR

DEPARTMENT OF ENERGY FUTURE PLANS

PRESENTED BY

NORMAN GERSTEIN

U.S. DEPARTMENT OF ENERGY

DECEMBER 1981

MEMORANDUM OF UNDERSTANDING

JULY 15, 1981

- BETWEEN DOE AND NRC
- REMOVAL AND DISPOSITION OF SOLID NUCLEAR WASTES FROM CLEANUP OF THREE MILE ISLAND UNIT 2 PLANT

CURRENTLY
IDENTIFIED TMI-2 SOLID WASTES

- EPICOR-II SYSTEM WASTES
- SUBMERGED DEMINERALIZER SYSTEM WASTES
- REACTOR FUEL
- TRANSURANIC CONTAMINATED WASTE MATERIALS
- MAKEUP AND PURIFICATION SYSTEM RESIN AND FILTERS
- OTHER SOLID RADIOACTIVE WASTES

DOE ROLE AND RESPONSIBILITIES

- DETERMINE GENERICALLY BENEFICIAL RESEARCH DEVELOPMENT AND TESTING ACTIVITIES ON TMI-2 SOLID WASTES
- CONDUCT ACTIVITIES AT APPROPRIATE DOE FACILITIES
- REIMBURSABLE DISPOSAL OF WASTES NOT SUITABLE FOR COMMERCIAL FACILITIES
- PROVIDE TECHNICAL SUPPORT TO NRC AND LICENSEE

WASTE IMMOBILIZATION PROGRAM

R. E. Holzworth

EG&G Idaho, Inc.

TMI-2
Domestic
Seminar

Waste Immobilization Program

Presented by

R.E. Holzworth
EG&G Idaho, Inc.

December 1981

TMI WIP-1

Purpose

Provide Generic Information on Accident Radioactive Waste Handling, Processing, and Disposal.

TMI-2 Special Wastes and Routine LWR Wastes

Waste Form	TMI-2 Volume/Activity Level	Routine LWR Waste Volume/ Activity Level
Combustible Waste	200,000 - 400,000 ft^3/5 yrs 1.7×10^{-3} Ci/ft^3	7,000 - 10,000 ft^3/yr 0.1×10^{-3} Ci/ft^3
Zeolites	88 to 592 ft^3 $<$7500 Ci/ft^3	None
High Activity Resins	$<$1380 ft^3 54,500 Ci	None
Low burnup fuel debris	6-12 drums	None

TMI-2 Wastes and Routine LWR Wastes

Waste Form	TMI-2 Volume/Activity Level	Routine LWR Waste Volume/ Activity Level
Sludges	250 ft^3 1.6 - 60 Ci/ft^3	Negligible
Filters	490 ft^3 $<$400 R/hr	Trace MFP and TRU $<$1 R/hr
Low Activity Resins	4240 ft^3 maximum $<$0.25 Ci/ft^3	7,000 - 10,000 ft^3/yr $<$1 Ci/ft^3

Elements

- Resin characterization
- Resin disposition technology
  - Resin Disposition Technology Development Program
  - High Integrity Container Program
- Zeolite disposition technology
  - Zeolite Disposition Technology Development Program
  - Zeolite Vitrification Demonstration Program
- Filter technology

Waste Immobilization Program

Resin Characterization Program

Objectives

Provide Information and Requirements

- Interim storage
- Further processing
- Transportation and disposal
- Shelf life projections

TMI WIP-6

Waste Immobilization Program

Resin Characterization Program

Accomplishments:

- PF-16 liner shipped to BCL
- Completed examinations of gases, liquids, resins, and liner

Resin Characterization Examination Results

Post Venting Gas Analysis

Major constituents	Volume percent
Carbon Dioxide	5.5
Oxygen	0.2
Nitrogen	80.0
Carbon Monoxide	0.2
Hydrogen	12.4
	PPM by volume
Hydrocarbon gases	550

Waste Immobilization Program

Resin Characterization Examination Results

Liner Visual Exam

- Exterior - clean, good condition
- Interior - generally good condition (some blistering)
- Manway cover - corroded (rusty with black deposits due to no protective coating)

Waste Immobilization Program

Resin Characterization Examination Results

Ion Exchange Media Inspection

- Core sample indicates three layers
- Majority of gamma activity in top layer (about 6 inches)
- Organic resins in good condition
- Temperature profile: $\Delta T = 2^0F$

TMI WIP-10

Resin Characterization Examination Results

Liquid Analysis

• pH	5.3
• Conductivity	30 μmho
• Sulfates	5.2 mg/ml
• Chlorides	3.0 mg/ml
• Visual inspection	Very clean

Resin Characterization Examination Results

Preliminary Conclusions

- Examination results consistent with previous GPU analysis

  On-island temporary storage acceptable

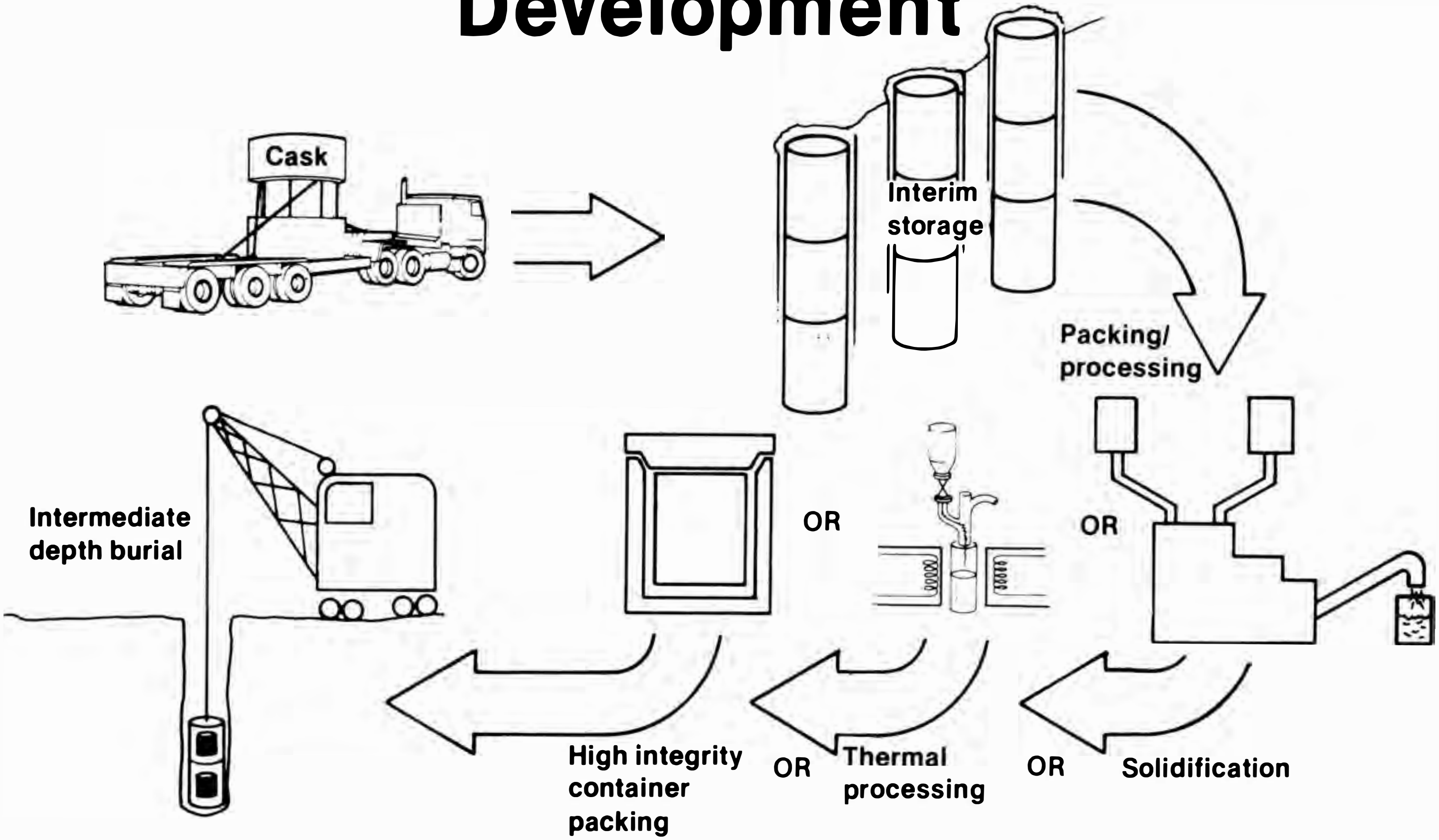
Resin Disposition Technology

Objective

- Effect a generic, safe, cost effective disposal demonstration program
- Utilize EPICOR II prefilters to support program

Waste Immobilization Program

Resin Disposition Technology Development



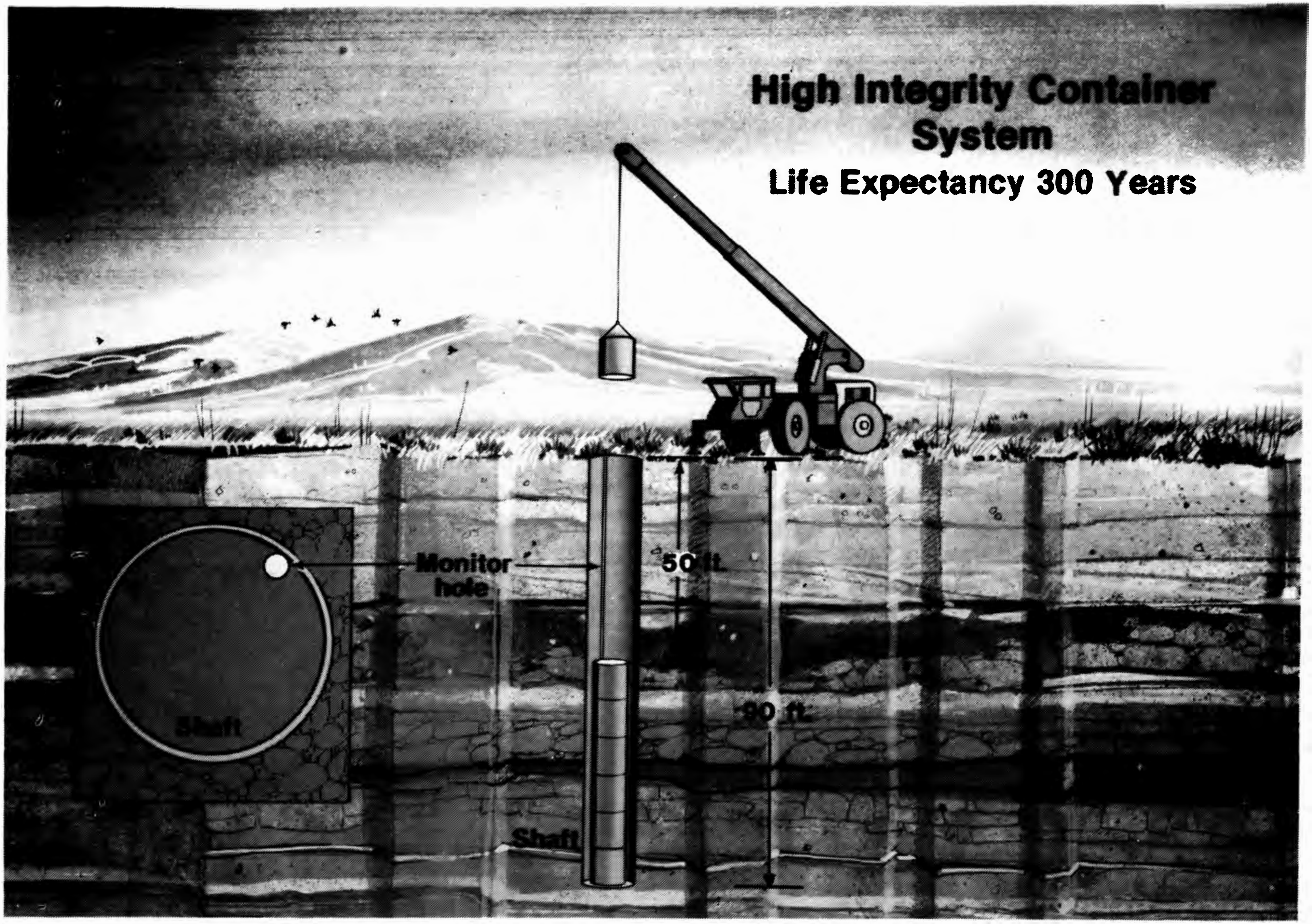
TMI WIP-14

Waste Immobilization Program

High Integrity Container Program

Objective

- Provide generic, cost effective waste disposal option using EPICOR II resin and liner as a reference base


High Integrity Container System
Life Expectancy 300 Years
Monitor hole
50 ft.
90 ft.
Shaft
Shaft

TMI WIP-16

Internal Environment

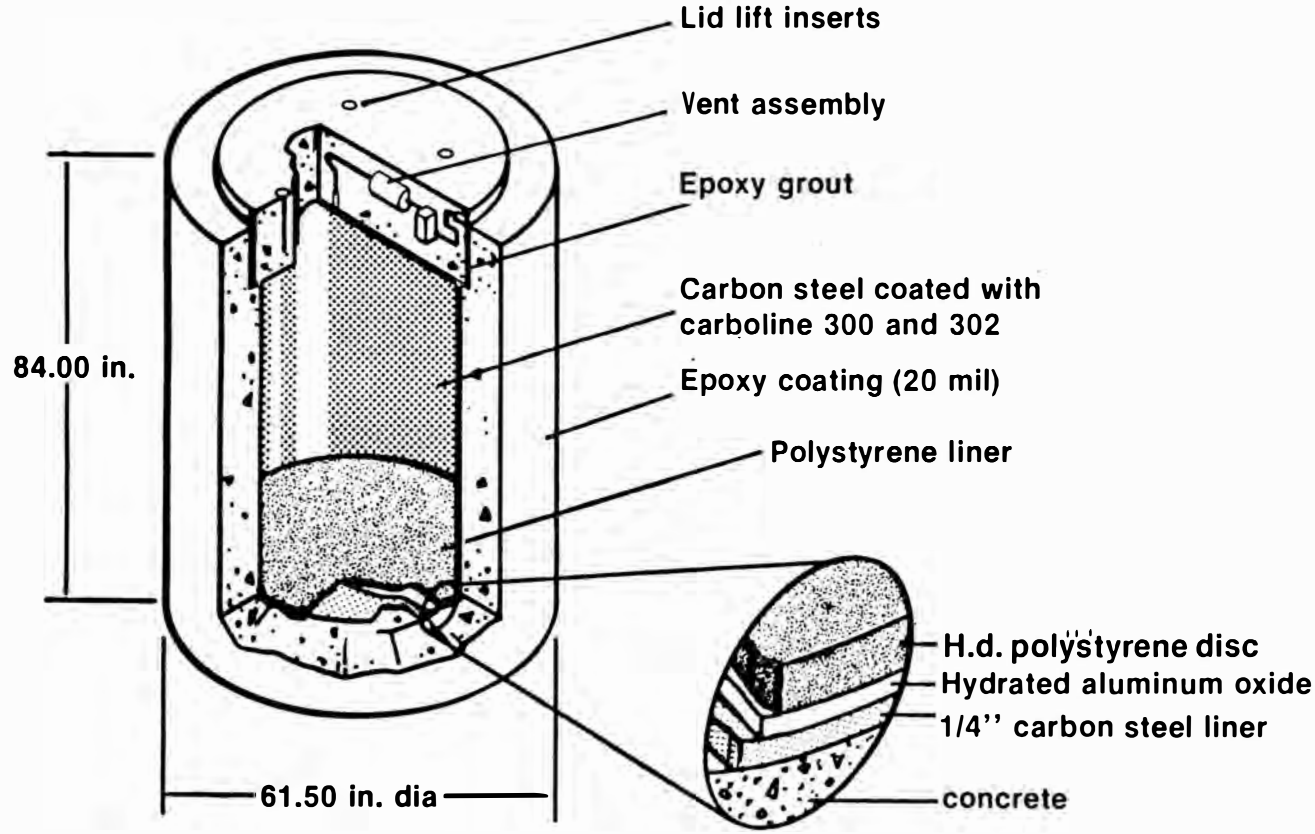
Initial Heat Generation:	8 watts maximum
Atmosphere:	H_2, SO_x, CH_4, NO_x, CO, CO_2, H_3
Chloride Content:	2 — 200 ppm
pH:	2 to 11 (free liquid)
Major Isotopic Contents:	1060 Ci Cesium 64 Ci Strontium
Total Integrated Dose:	10^9 R — Beta 10^9 R — Gamma
Internal Pressure:	10 psig

External Environment

• Soil temperature	$20^0 \pm 10^0C$
• Soil chloride content	0 to 300 ppm
• Soil pH	4.0 to 9.0
• Combined pressure	150 psig

Waste Immobilization Program

Corrosion Barrier Concrete Reinforcing



TMI WIP-19

Waste Immobilization Program

Zeolite Disposition Technology

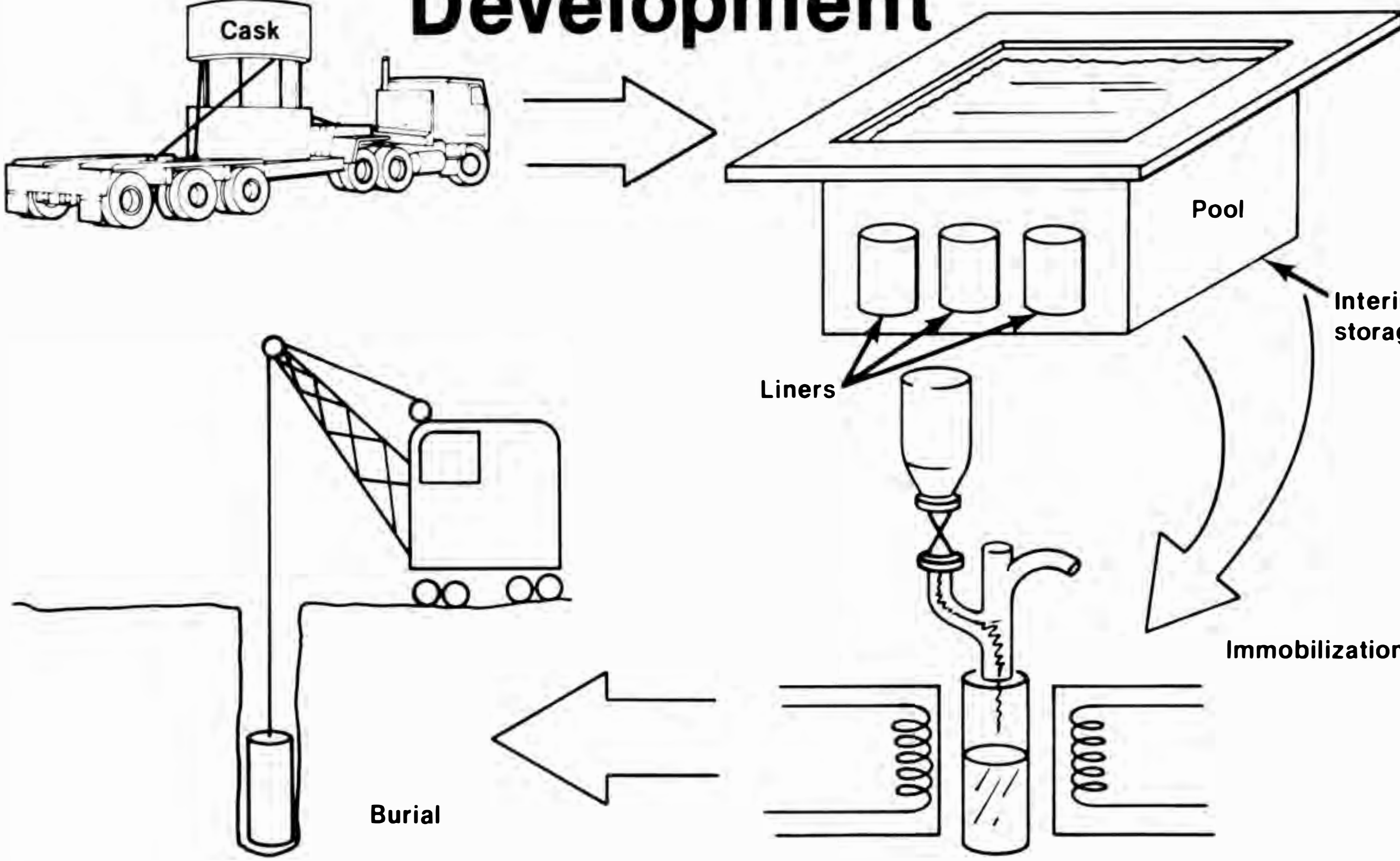
Objective

Effect an R&D program for disposal demonstration of the SDS zeolite liners

TMI WIP-20

Waste Immobilization Program

Zeolite Disposition Technology Development



TMI WIP-21

Waste Immobilization Program

Zeolite Vitrification Demonstration Program

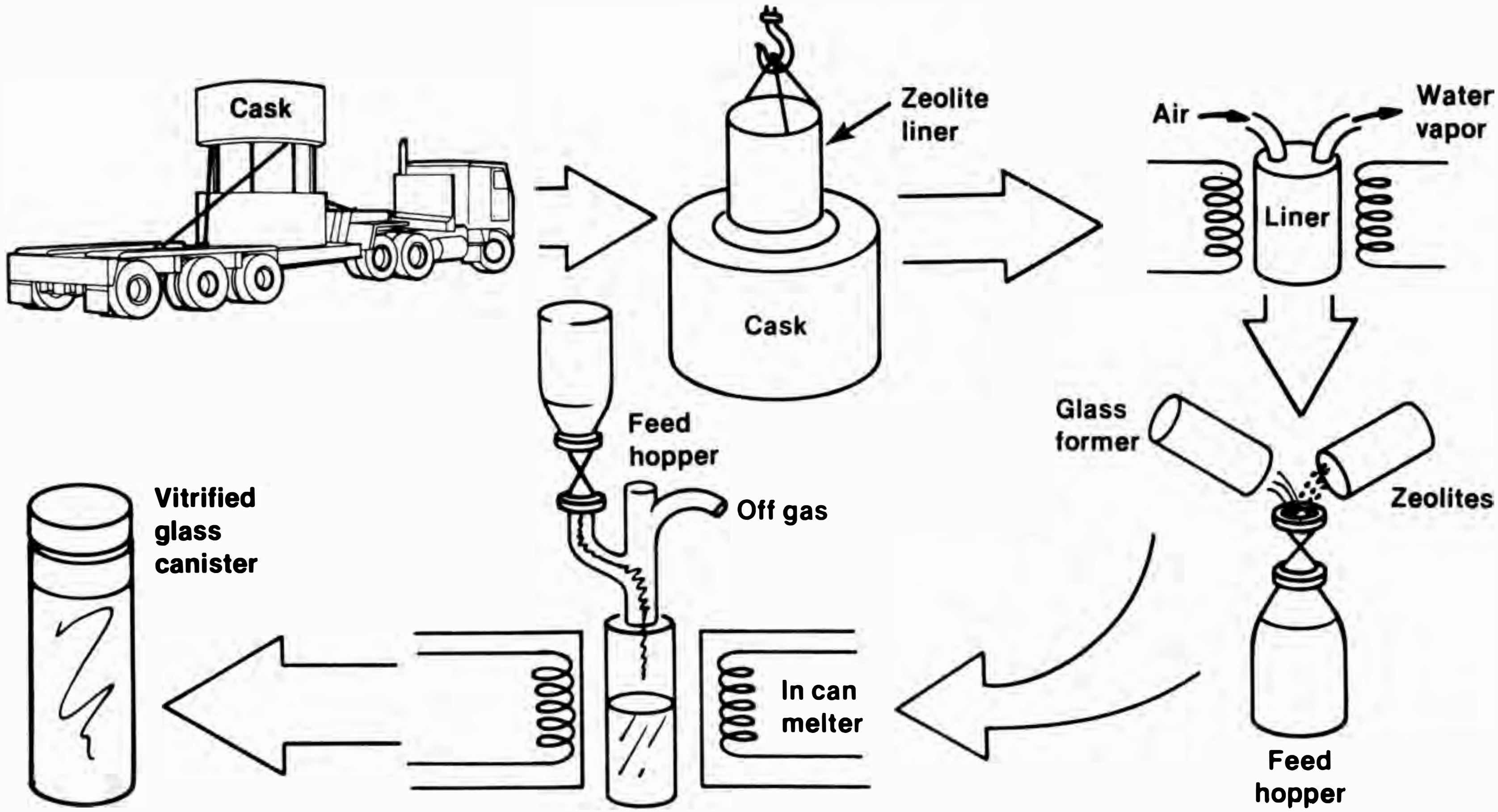
Objectives

- Establish technical feasibility of vitrifying zeolites
    - Develop a means of immobilizing high specific activity inorganic ion exchange media
    - Provide characterization of vitrified waste
- Conduct full scale demonstration utilizing loaded TMI ion exchanger liners

TMI WIP-22

Waste Immobilization Program

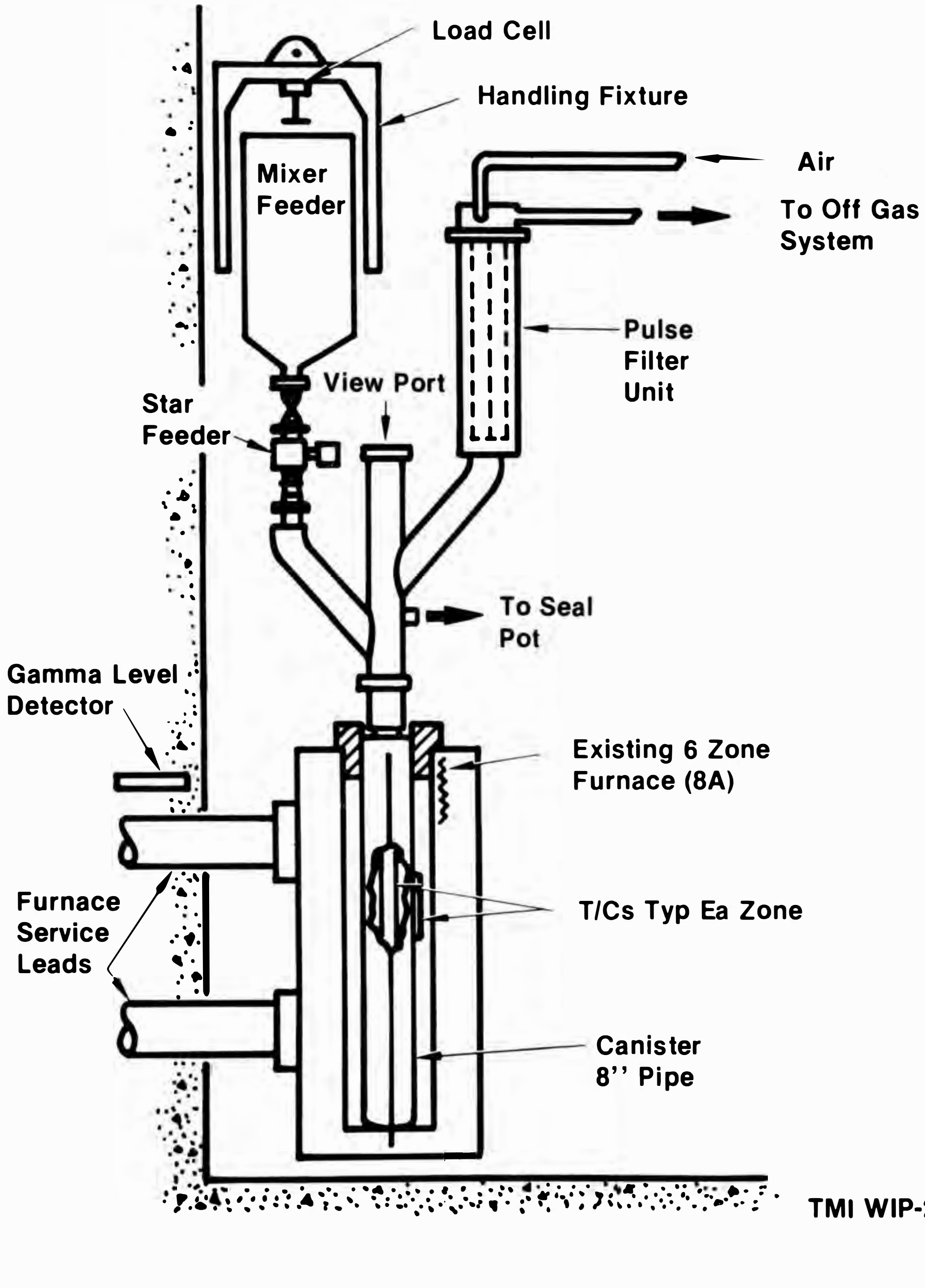
Zeolite Vitrification Process



TMI WIP-23

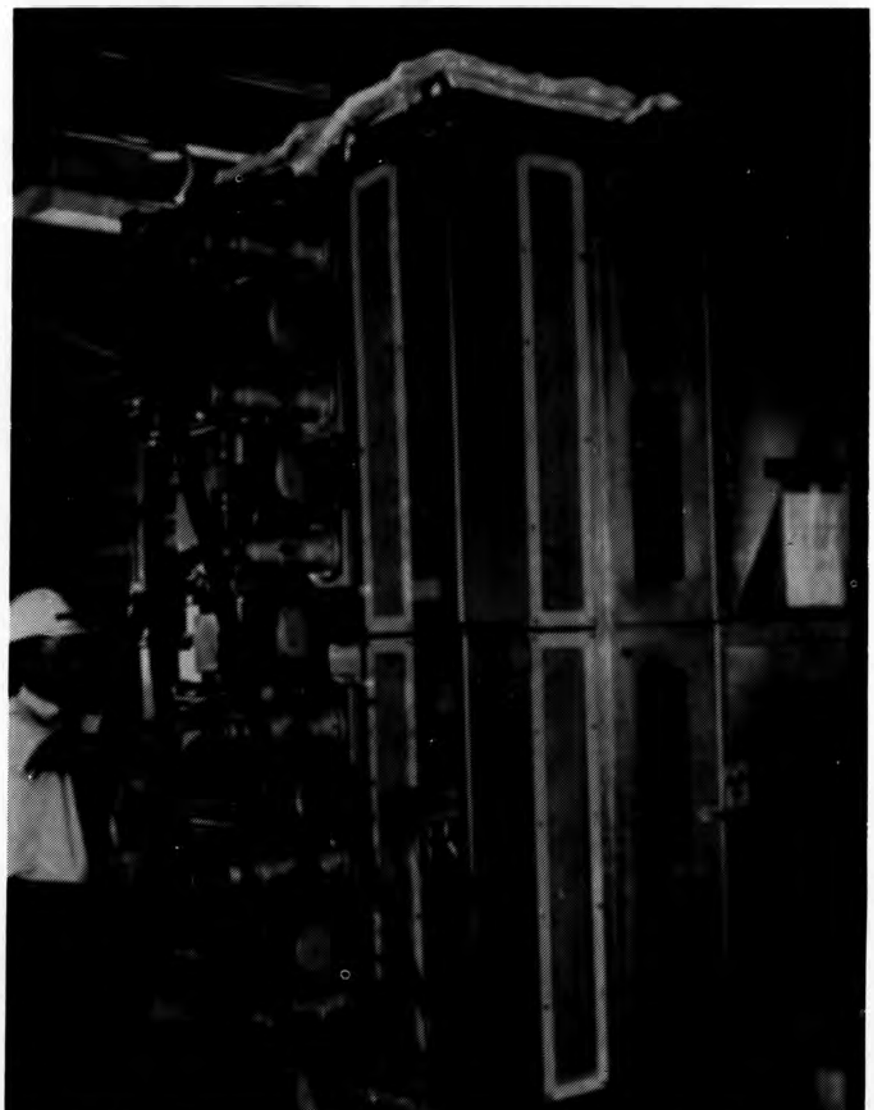
Waste Immobilization Program

Zeolite Vitrification System



TMI WIP-24

Vitrification Process
In-Can Melter



TMI WIP-25

Waste Immobilization Program

Zeolite Vitrification Demonstration Program

Accomplishments

- Flowsheet work conducted
- Four full-scale non-radioactive melts conducted
- Transportation safety analysis performed
- Preparations underway for radioactive melts

Waste Immobilization Program

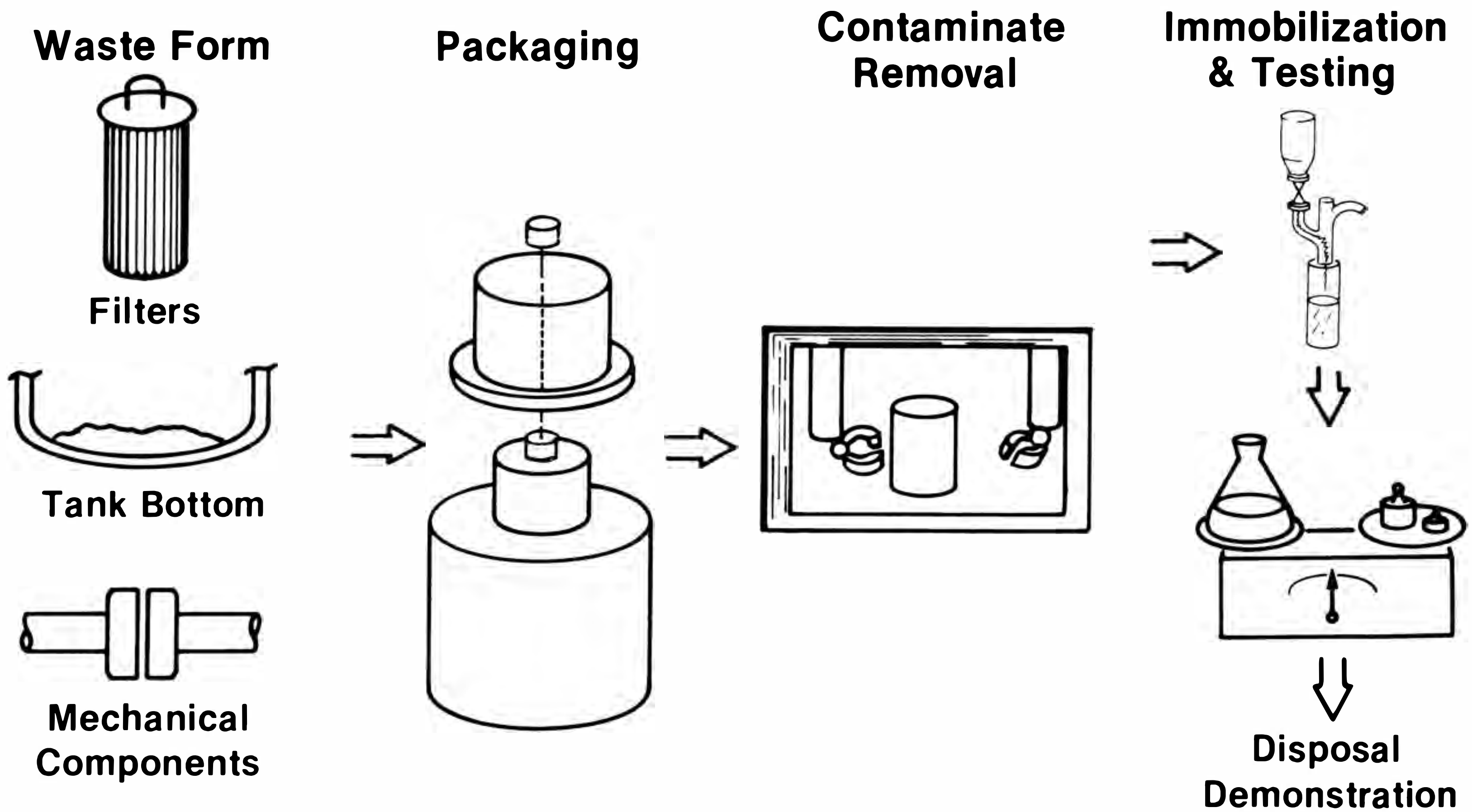
Filter Technology

Objective

Effect a generic, safe, and cost effective R&D program for TMI-2 wastes unsuitable for commercial land burial

Waste Immobilization Program

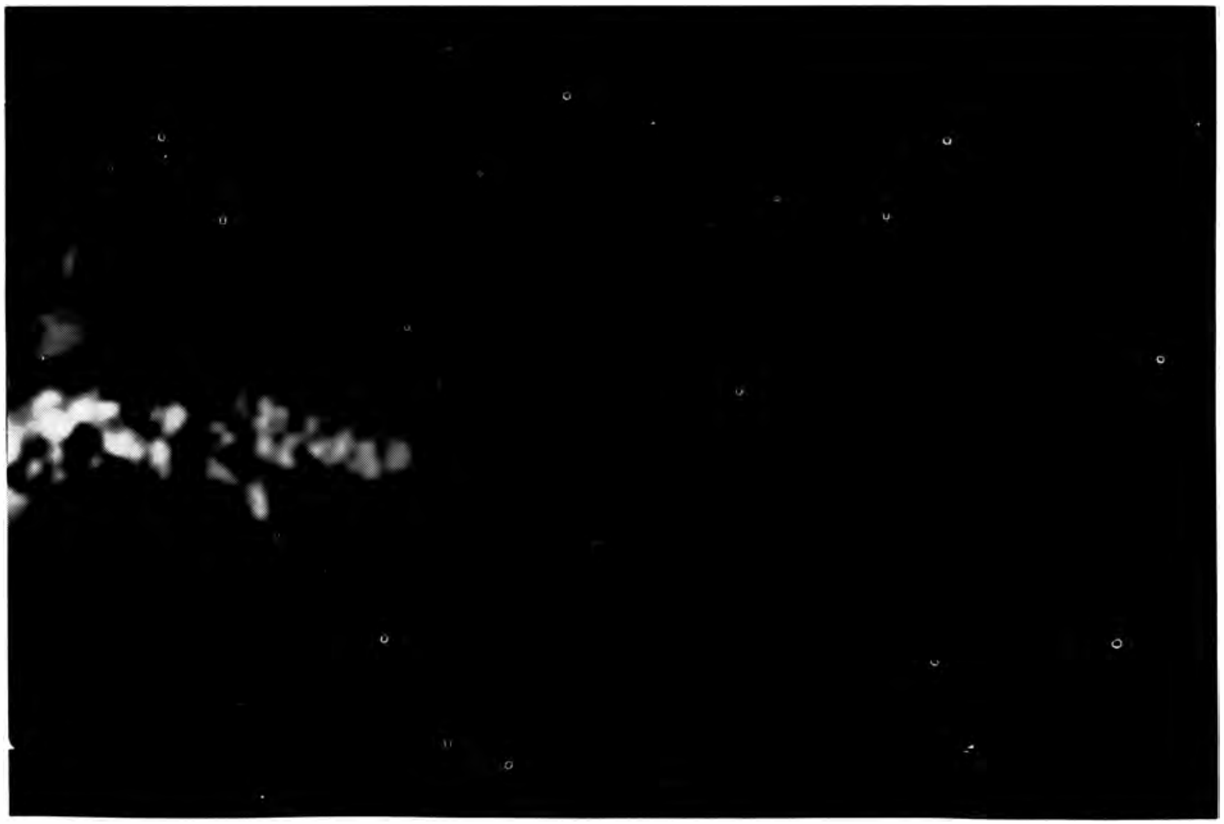
Filter Technology



TMI WIP-28

Waste Immobilization Program

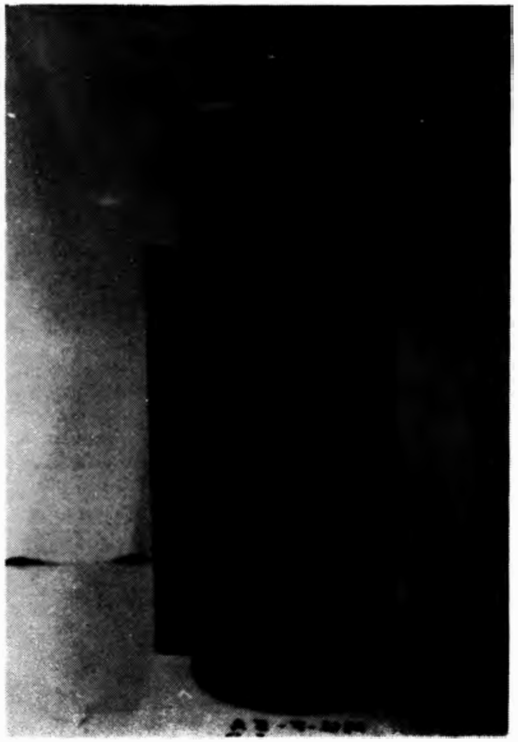
Radioactive Debris on Tank Manway



TMI WIP-29

Waste Immobilization Program

Makeup Purification System Filter Cartridge



TMI WIP-30

Summary

- TMI-2 offers unique opportunity for handling special waste forms
- Information available for commercial radwaste management application
- Not setting precedent

INFORMATION AND EXAMINATION PROGRAM

DATA BANK

F. J. Kocsis III

EG&G Idaho, Inc.

TMI-2 Domestic Seminar

Information & Examination Program

Data Bank

Presented by:

Frank J. Kocsis III

EG&G Idaho, Inc.

December 1981

TMI I&EP-1

Information & Examination Program

Data Bank

Automated Document Control System (ADOCS) Objectives:

- Central point for collection of TMI-2 research and development data
- Centralized management of data
- Reduced time in data search and retrieval
- Historical reporting medium for TMI-2 R&D activities
- Technical information transfer to nuclear industry

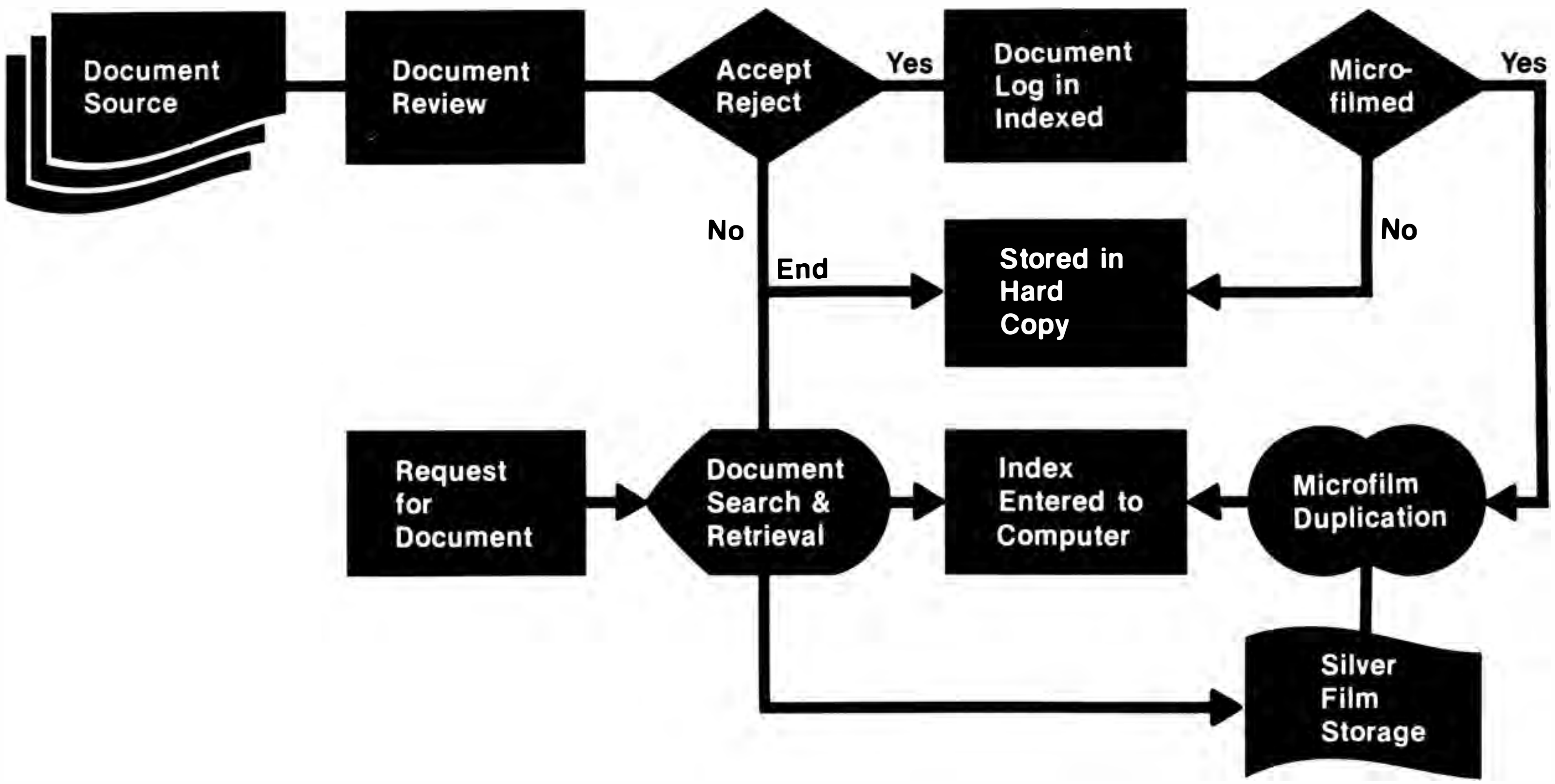
Information & Examination Program
Data Bank

Document Control Center

- 6800 Documents indexed in data bank system
  - All research and development documentation
  - Reports
  - Correspondence
- 345 Titles in library
  - Federal regulations
  - Generic R&D reports
- 70 Videotapes on file

Information & Examination Program
Data Bank

Document Flow Process



TMI I&EP-5

Current Activities

- Document Control Center fully operational
  - Control of all TMI-2 R&D documentation
  - Copy and microfilm control
  - Technical publications control
- Data bank at EPRI/NSAC operational
- Technical information transfer
  - TI&EP UPDATE
  - Nuclear Notepad
  - GEND reports

Information & Examination Program
Data Bank

GEND Documents Available

- GEND 001 — GEND Planning Report
- GEND 002 — Hershey Decontamination Meeting Report
- GEND 003 — TI&EP Annual Report (FY-80)
- GEND 004 — Interim Status Report of the TMI-2 Personnel Dosimetry Project
- GEND 005 — Characterization of the TMI-2 Reactor Building Atmosphere Prior to Building Purge
- GEND 007 — TMI-2 Core Status Summary
- GEND 008 — The Citizens Radiation Monitoring Program for the TMI Area
- GEND 009 — Measurement of I-129 and Radioactive Particulate Concentrations in the TMI-2 Containment Atmosphere During and After Venting

GEND Documents Available (cont'd)

• GEND 010 Vol. I	In-vessel Inspection Before Head Removal (Conceptual Development)
• GEND 010 Vol. II	In-vessel Inspection Before Head Removal (Tooling & System Design)
• GEND 011	Canister Design Considerations for Packaging TMI-2 Damaged Fuel and Debris
• GEND 013	Reactor Building Purge and Kr-85 Venting
• GEND 016	Accountability Study for TMI-2 Fuel
• GEND 019	Task Plan for the U.S. DOE TMI-2 Programs

Information & Examination Program

Data Bank

Requesting Gend Reports

National Technical Information Service (NTIS)

5285 Port Royal Road
Springfield, Virginia 22161
Phone (703) 487-4600

TMI I&EP-9

Information & Examination Program

Data Bank

DOE Sponsored Program Information

TIO Document Control Center

P.O. Box 88

Middletown, Pennsylvania 17057

Phone (717) 948-1019

EPRI Sponsored Program Information

Nuclear Safety Analysis Center

3412 Hillview Avenue

P.O. Box 10412

Palo Alto, California 94303

Phone (415) 855-2999

CORE EXAMINATION PROGRAM OVERVIEW

A. C. Millunzi

U. S. Department of Energy

TMI-2
Domestic
Seminar

Core Examination Program Overview

Presented by

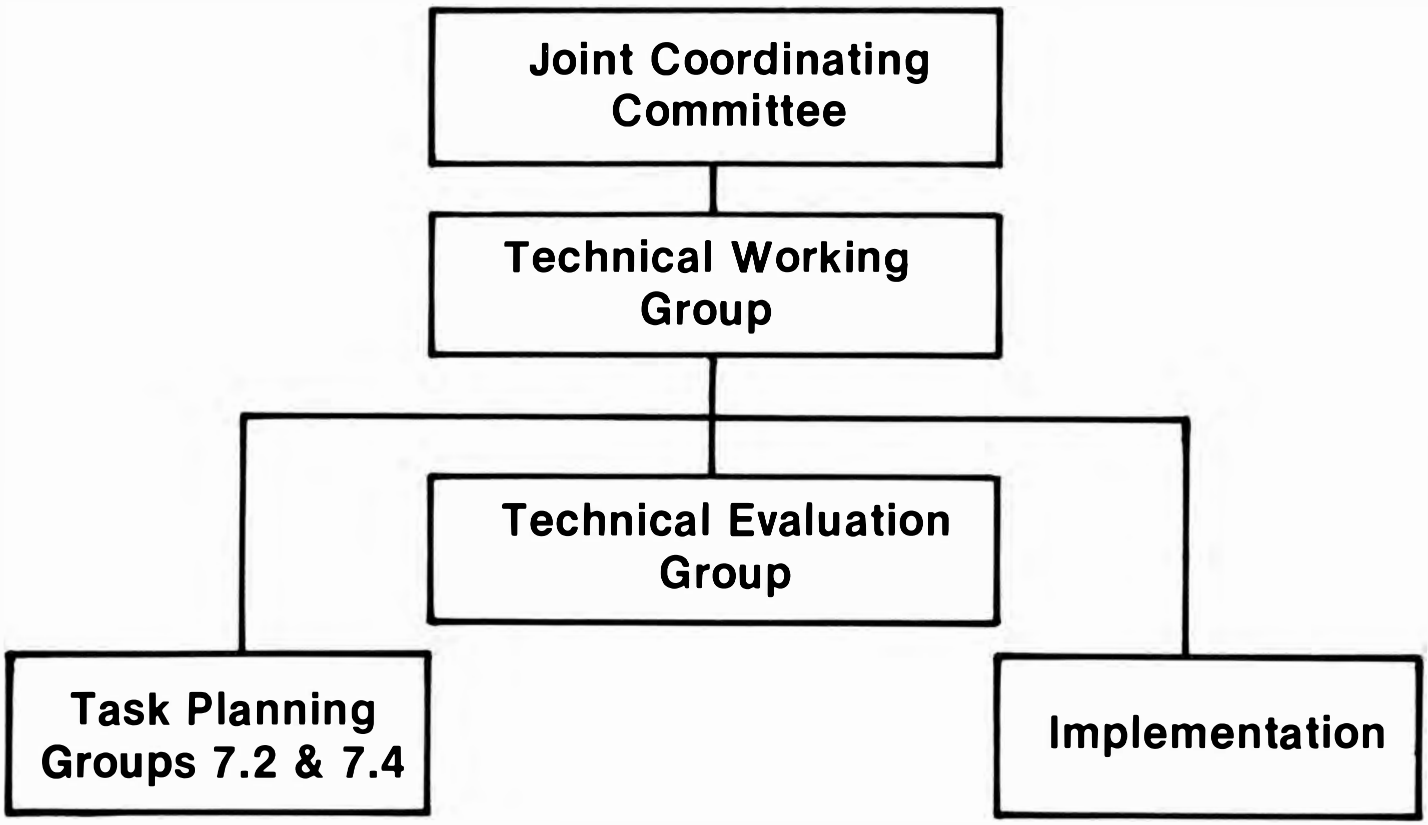
A.C. Millunzi
DOE

December 1981

TMI CEP-1

Core Examination Program Plan

Organization



TMI CEP-2

Objectives

Provide industry & NRC with scientific & engineering data for

Enhanced understanding of course & consequences of the accident

- Assessing present & future accident analysis methods
- Technical bases for future licensing criteria
- Accident consequence mitigation
- Improved designs
- Improved operation & maintenance procedures

Scope

- In situ data acquisition
- Off-site detailed examinations

In Situ Data Acquisition

- Before head removal
- Before plenum removal
- Before fuel removal
- During fuel removal
- After fuel removal

Off-Site Data Acquisition

- Detailed physical, mechanical, metallurgical and chemical analyses of selected core samples to quantify the response of the core to the accident.

Industry Representation for Planning

— NSSS vendors
— EPRI
— IDCOR program
— NRC
— DOE
— TI&EP
— Sandia
— LANL
— EG&G Idaho

Charter

- Review existing plans and programs
- Assess R&D data requirements
- Formulate data acquisition criteria
- Recommend revisions or additions
- Evaluate data
- Enhance information transfer

Product

- Updated core damage assessment plan
- Preliminary data acquisition requirements and specification outlines
- Data evaluation summary review

CORE REMOVAL APPROACH

R. L. Freemerman

Bechtel National, Inc.

TMI-2
DOMESTIC SEMINAR

CORE REMOVAL APPROACH

PRESENTED BY
R. L. FREEMERMAN
BECHTEL NATIONAL, INC.

DECEMBER 1981

PLANNING OBJECTIVES

- PROVIDE ACCESS TO THE REACTOR FUEL BY METHODICAL, PREPLANNED DISASSEMBLY OF THE REACTOR BOTH EXTERNALLY AND INTERNALLY.

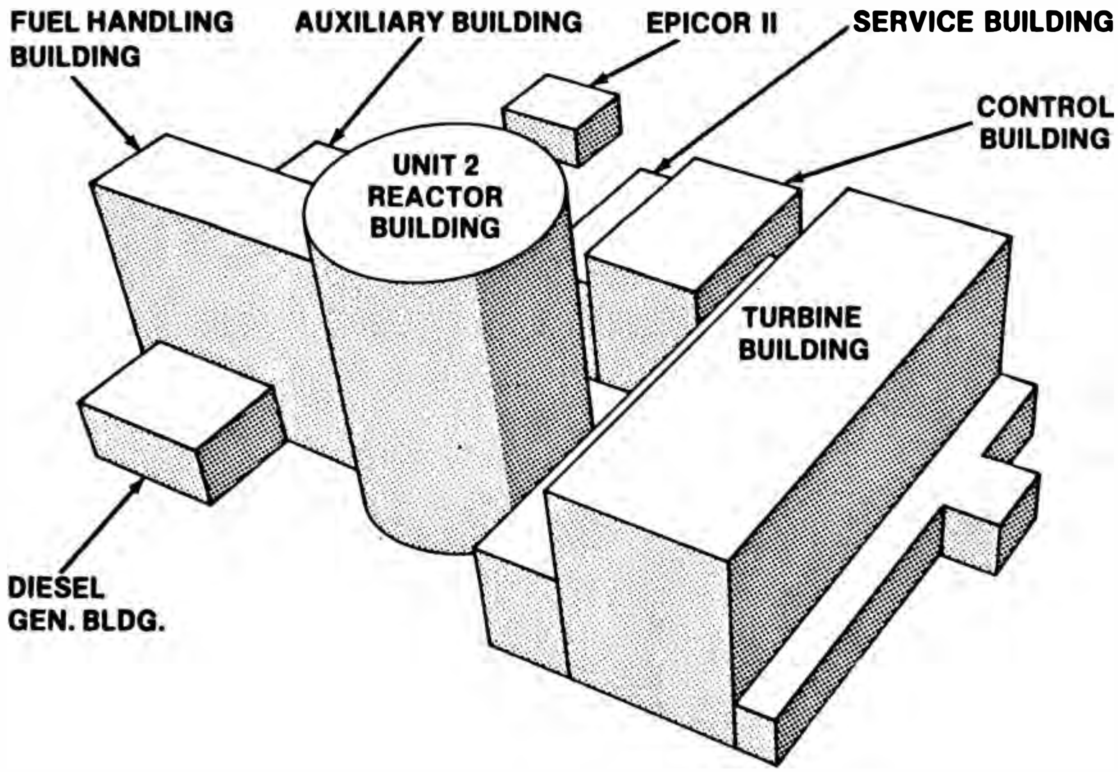
- REMOVE THE CORE FROM THE REACTOR AND STABILIZE IT BY ENCAPSULATION IN SEALED CONTAINERS WHICH WILL BE TEMPORARILY STORED IN THE SPENT FUEL POOL.

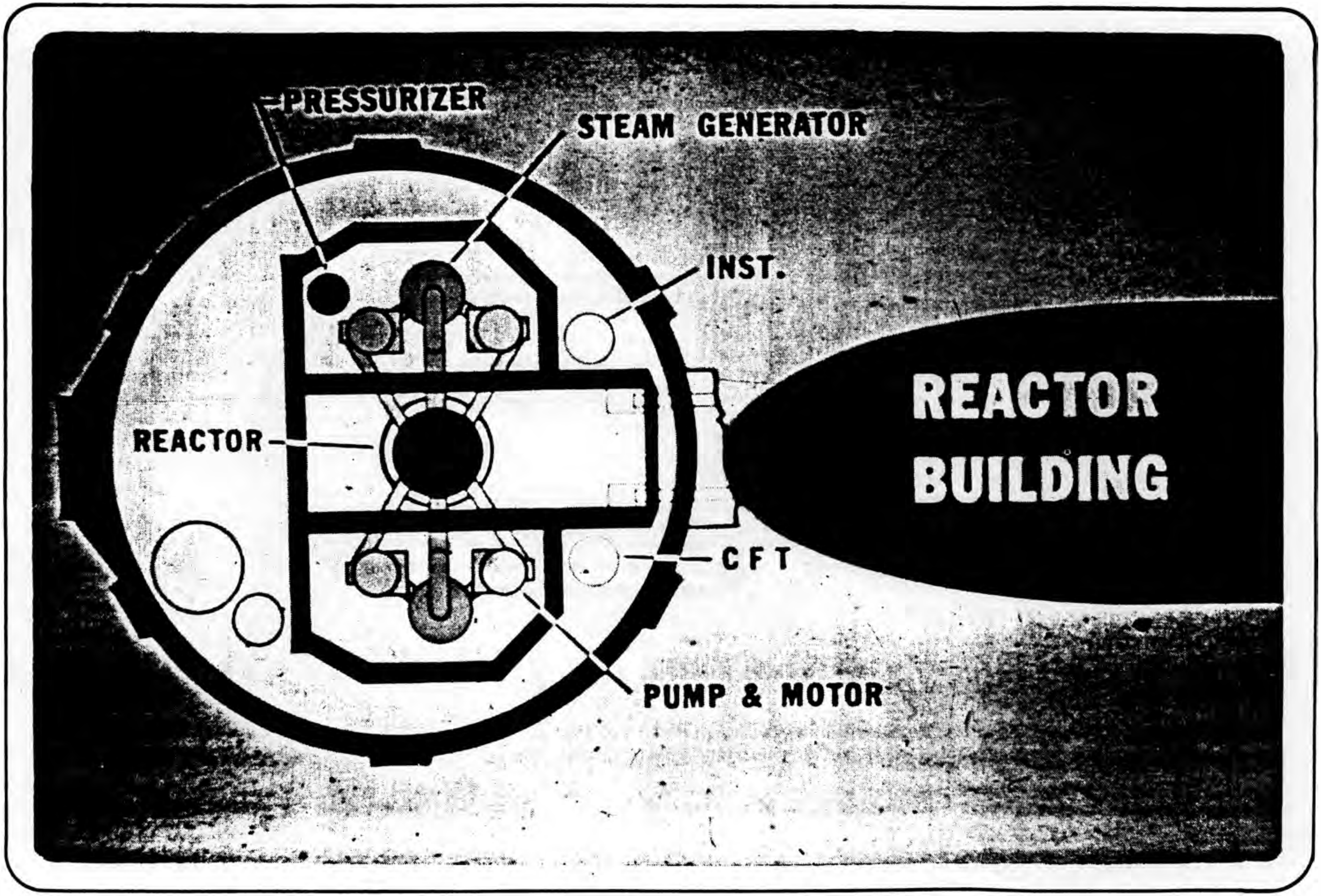
- PROVIDE DETAILED INFORMATION AS TO THE POST-ACCIDENT CONDITIONS OF THE CORE AND OTHER REACTOR INTERNALS THROUGH INSPECTION PROGRAMS INTEGRAL TO THE DISASSEMBLY/DEFUELING PROGRAMS.

PLANNING CRITERIA

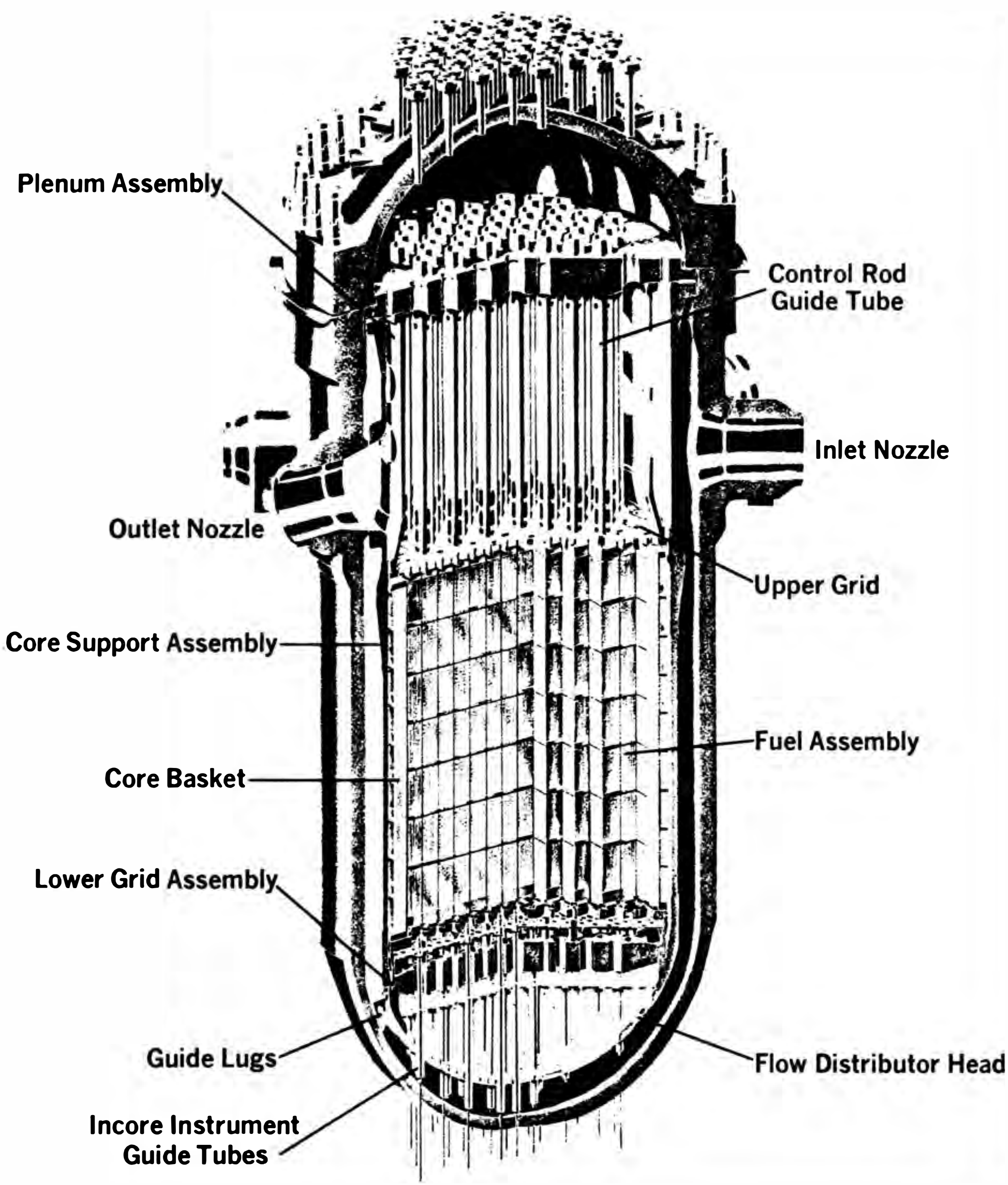
- MAXIMIZE EFFICENCY SO AS TO MINIMIZE THE DISASSEMBLY/DEFUELING TIME PERIOD.
- STRESS ALARA CONSIDERATIONS FOR ALL DISASSEMBLY/DEFUELING OPERATIONS.
- WHENEVER PRACTICABLE, PRESERVE THE AS IS CORE CONDITION SO AS TO MAXIMIZE THE EFFECTIVENESS OF THE DATA ACQUISITION PROGRAMS.
- PROVIDE FOR MAXIMUM REUSE OF PRESENTLY INSTALLED REACTOR COMPONENTS.
- DEVELOP CONTINGENCY TECHNIQUES IN THE EVENT THAT IMPLEMENTATION OF PROPOSED TECHNIQUES PROVES UNSUCCESSFUL OR INAPPROPRIATE.
- CRITICALITY NOT POSSIBLE IF BORON CONCENTRATION MAINTAINED WITHIN PRESCRIBED LIMITS.

TMI UNIT 2
SCHEMATIC LAYOUT



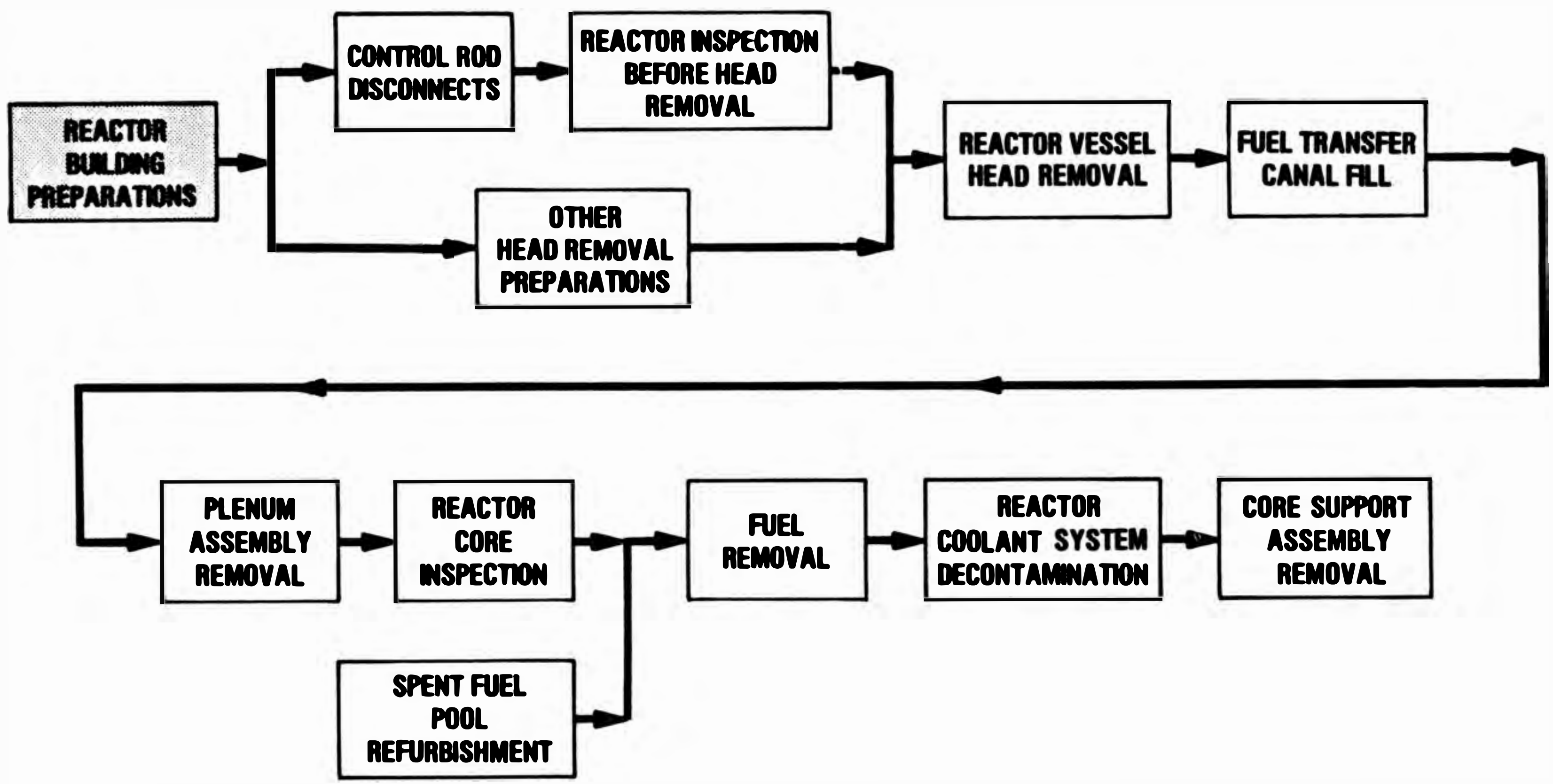

PRESSURIZER
STEAM GENERATOR
INST.
REACTOR
REACTOR BUILDING
CFT
PUMP & MOTOR

Pressurized Water Reactor



Babcock & Wilcox

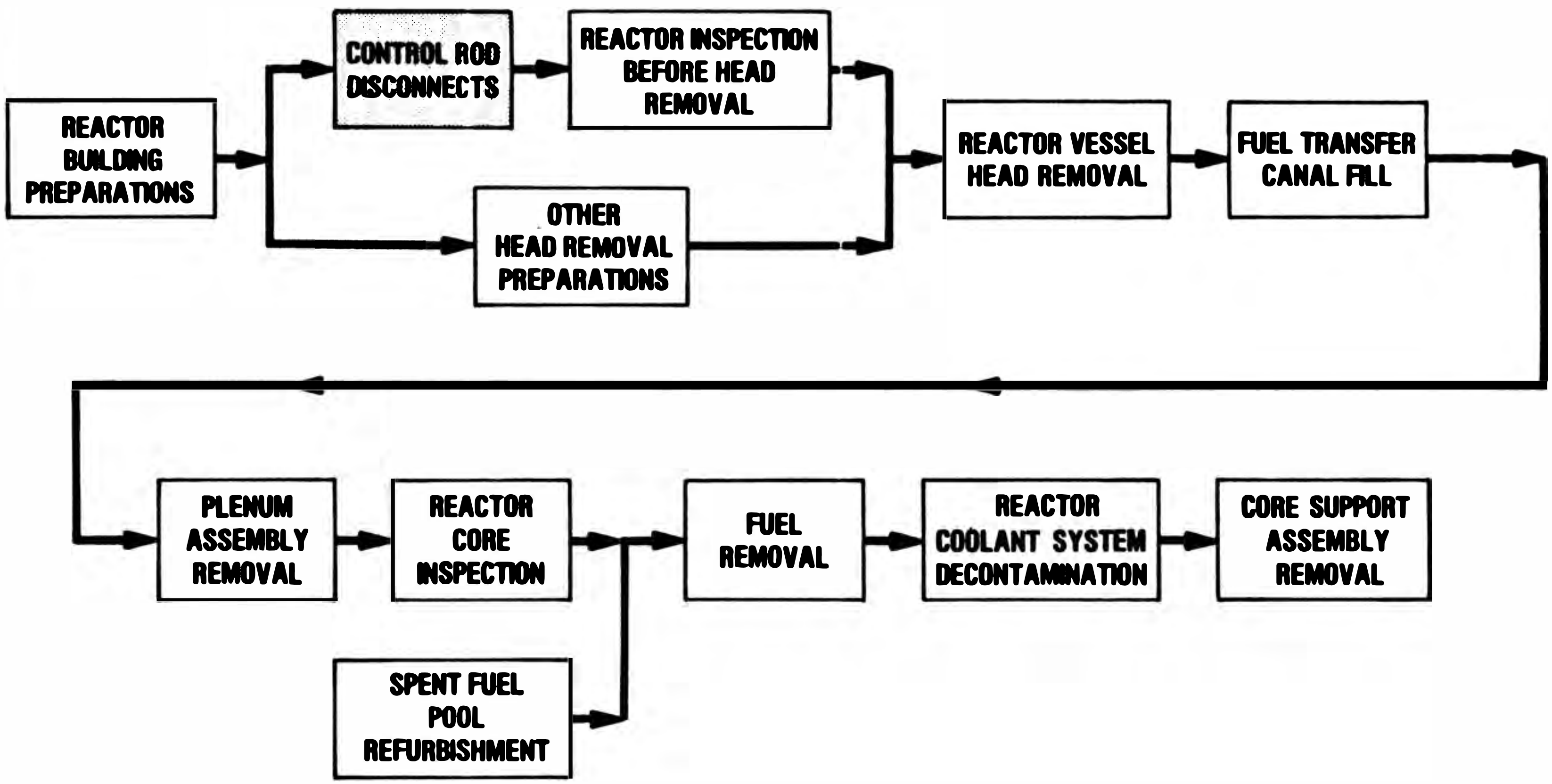
SEQUENCE FOR
REACTOR DISASSEMBLY AND DEFUELING

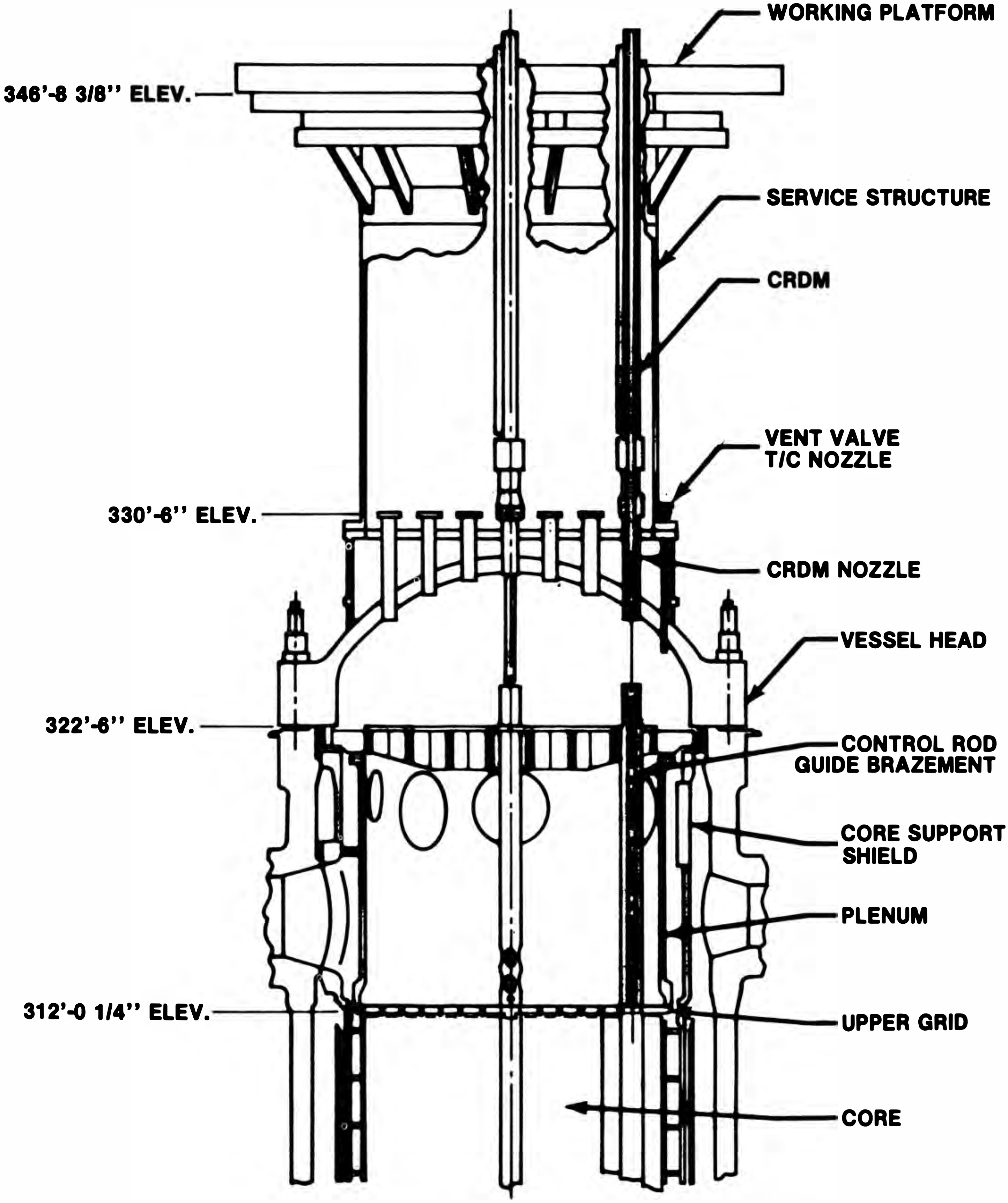


REACTOR BUILDING PREPARATIONS

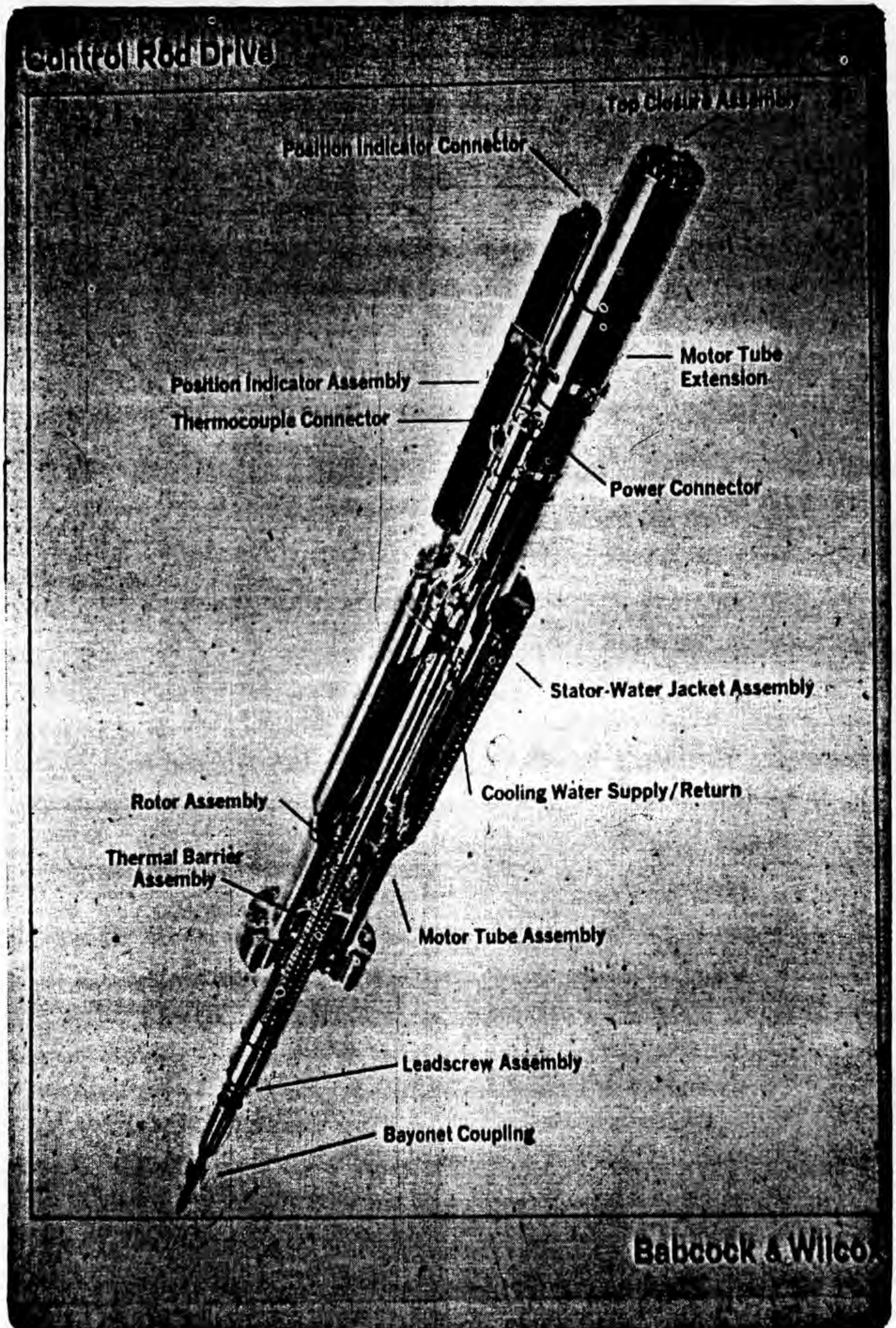
- DECONTAMINATION OF THE OPERATING FLOOR FOR DOSE REDUCTION
- DEVELOPMENT AND INSTALLATION OF SUPPORT SYSTEMS
- ESTABLISHMENT OF FACILITIES FOR EQUIPMENT AND PERSONNEL ACCESS
- CLEANUP OF THE REACTOR COOLANT SYSTEM WATER
- TRAINING AND QUALIFICATION OF PERSONNEL, PROCEDURES, AND EQUIPMENT
- REFURBISHMENT OF POLAR CRANE
- OBTAINING REGULATORY APPROVALS

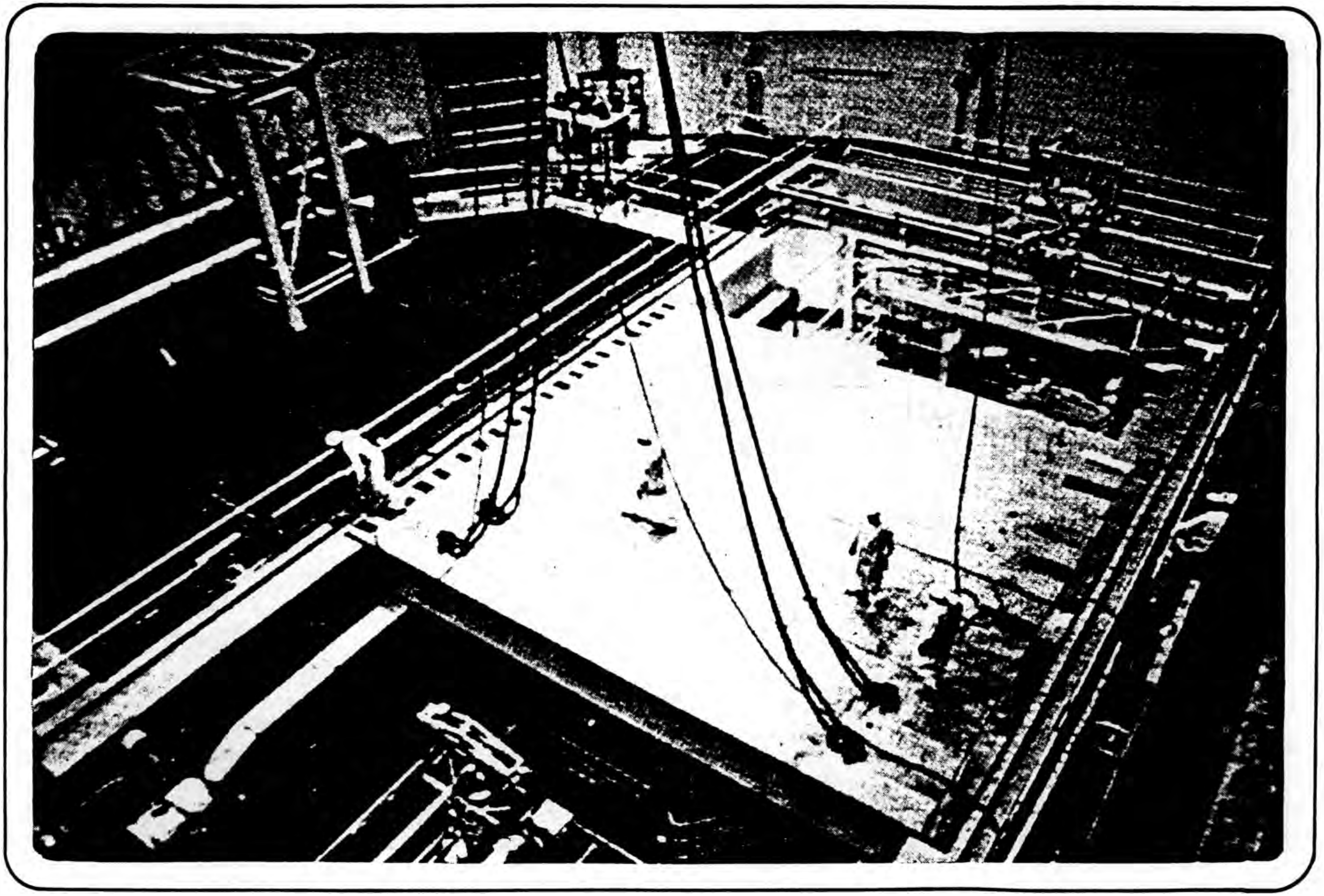
SEQUENCE FOR
REACTOR DISASSEMBLY AND DEFUELING

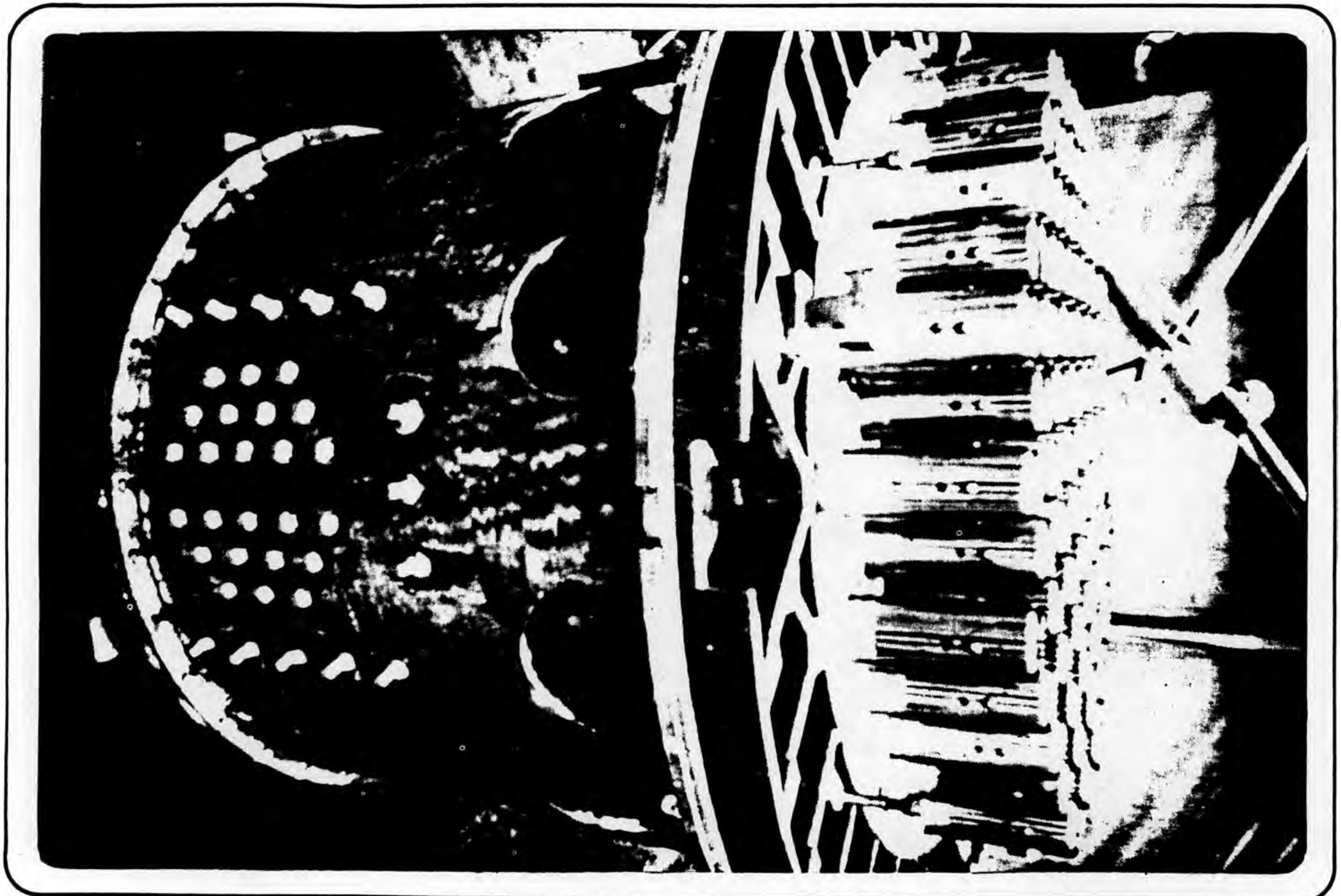


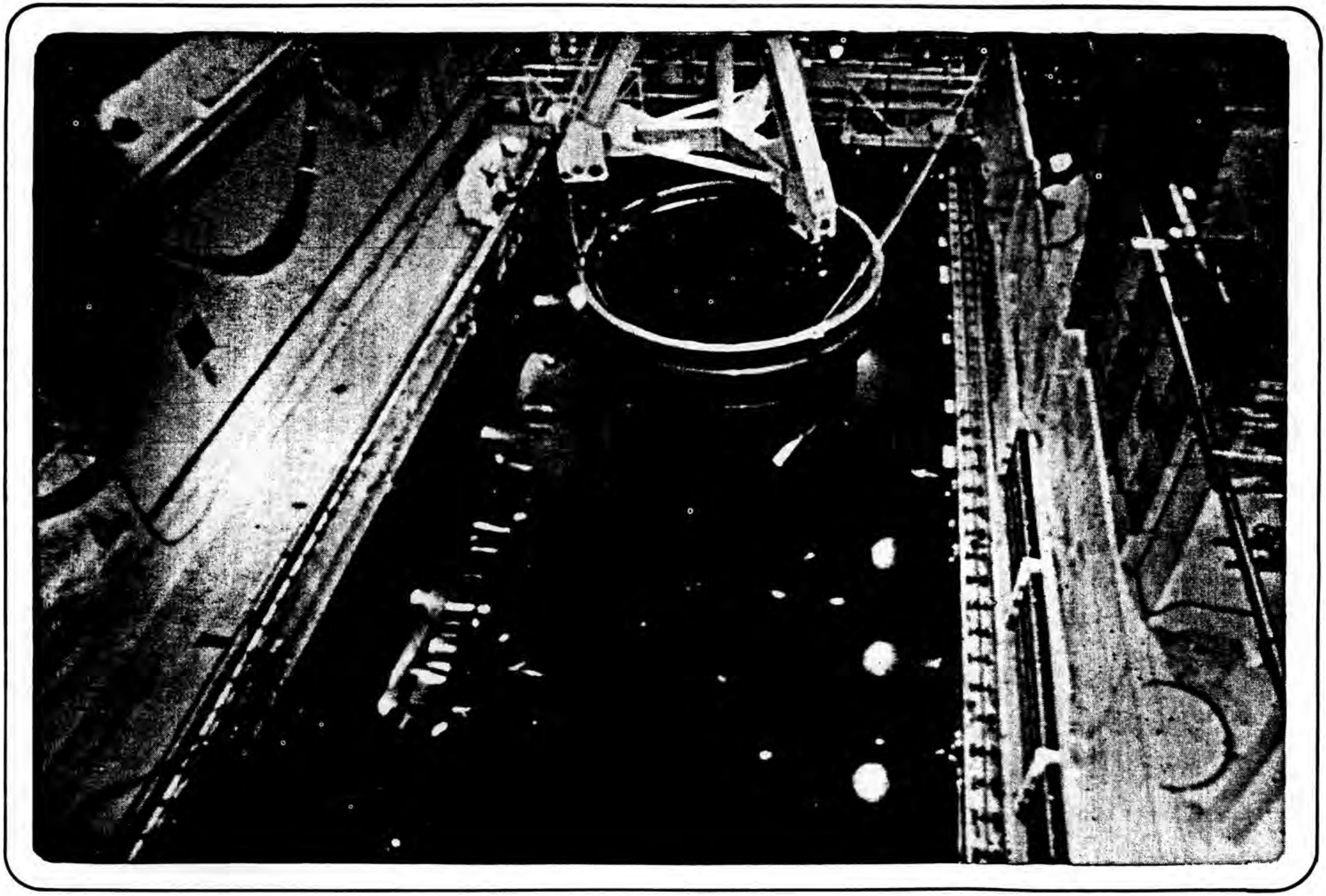


REACTOR AND SERVICE STRUCTURE

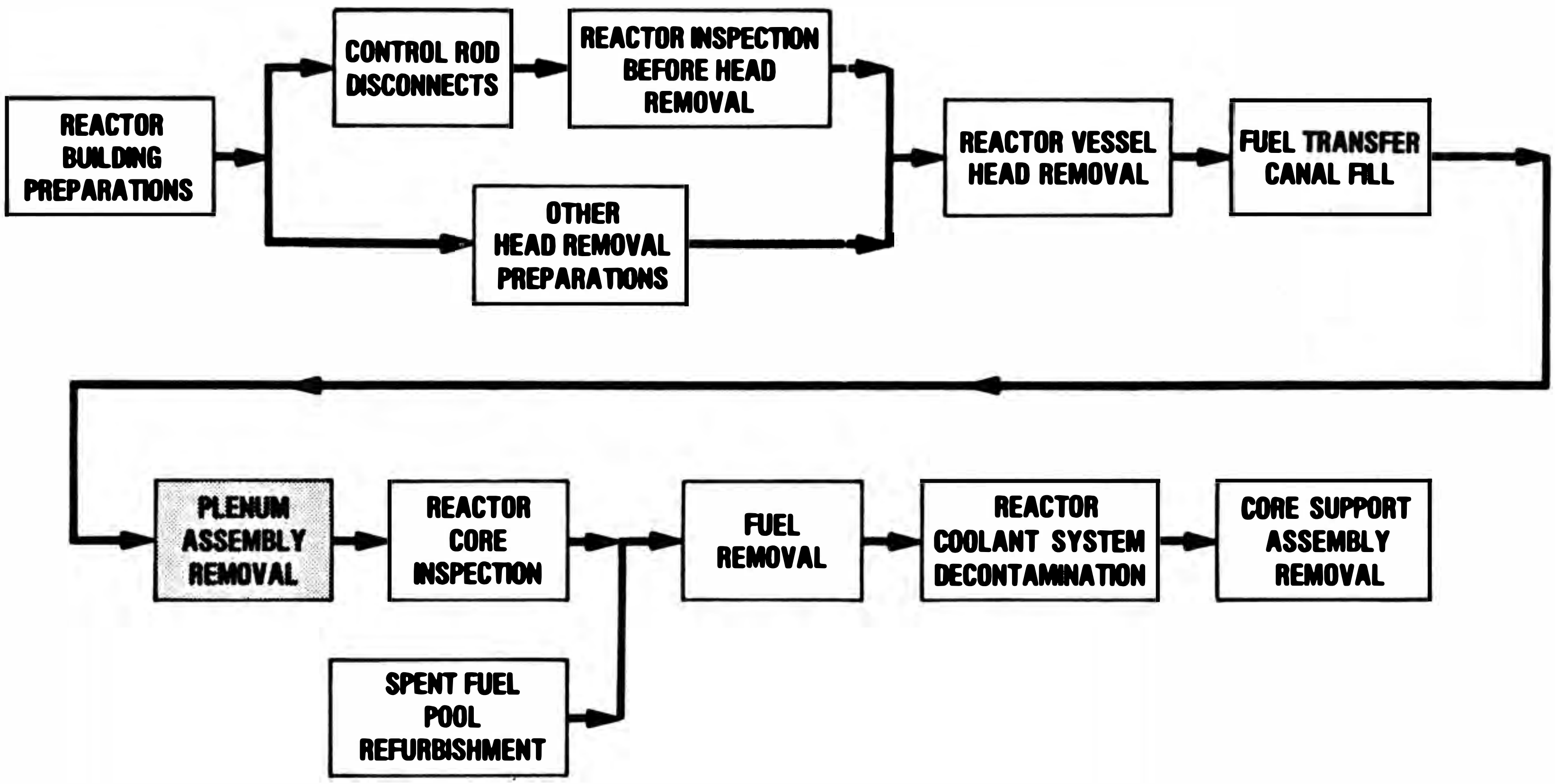

Control Rod Drive
Top Closure Assembly
Position Indicator Connector
Motor Tube Extension
Position Indicator Assembly
Thermocouple Connector
Power Connector
Stator-Water Jacket Assembly
Cooling Water Supply/Return
Rotor Assembly
Thermal Barrier Assembly
Motor Tube Assembly
Leadscrew Assembly
Bayonet Coupling
Babcock & Wilco







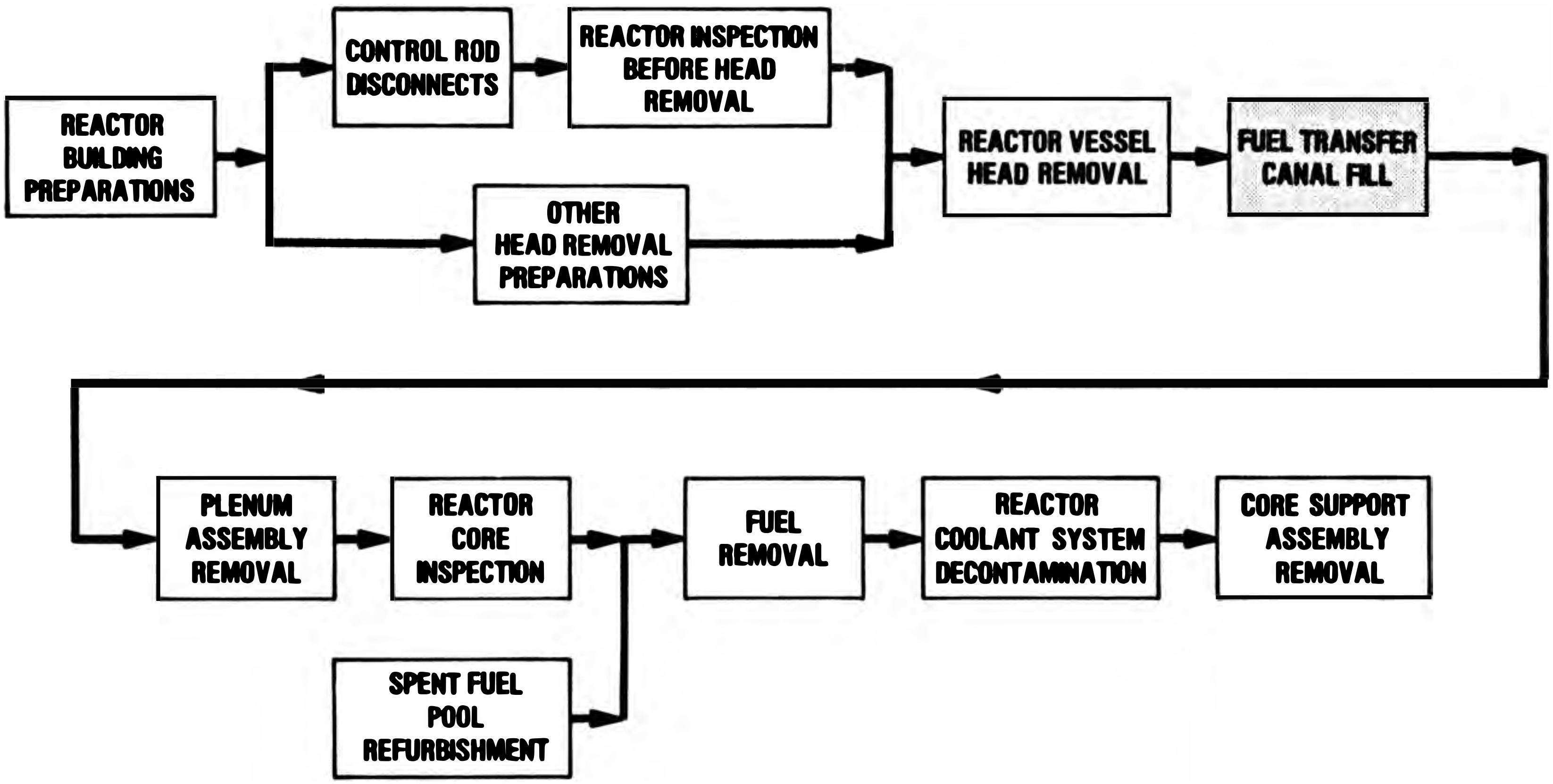
SEQUENCE FOR
REACTOR DISASSEMBLY AND DEFUELING



CONSIDERATIONS FOR CANAL CLEANUP SYSTEM

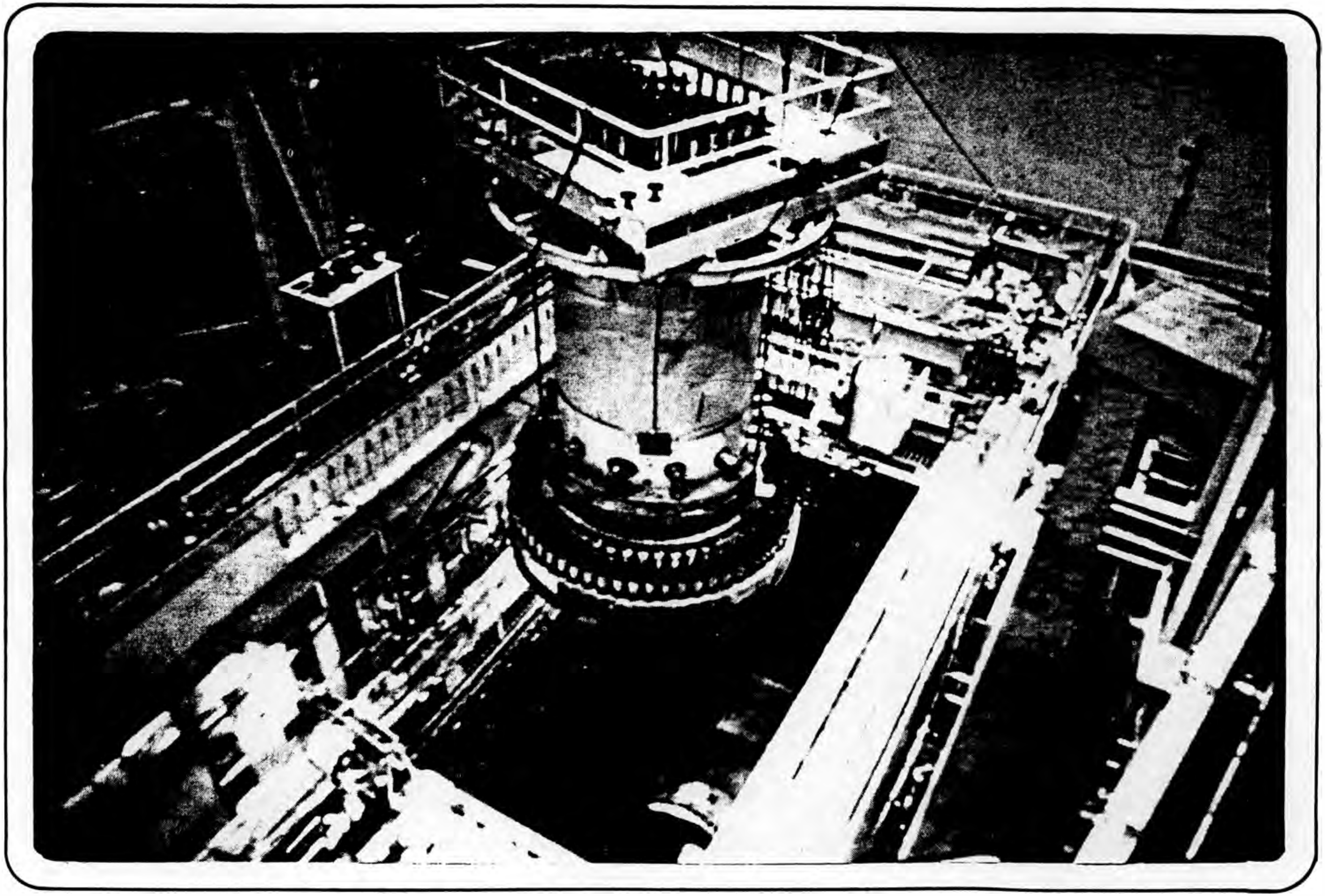
- Must control potential high radiation levels from canal due to suspended particulate and soluble contamination from exposed core
- Must control water clarity in canal for visibility
- Must maintain high boron concentration in canal water
- System design, including flowrate filtration efficiency and curie loading, must accommodate the above concerns

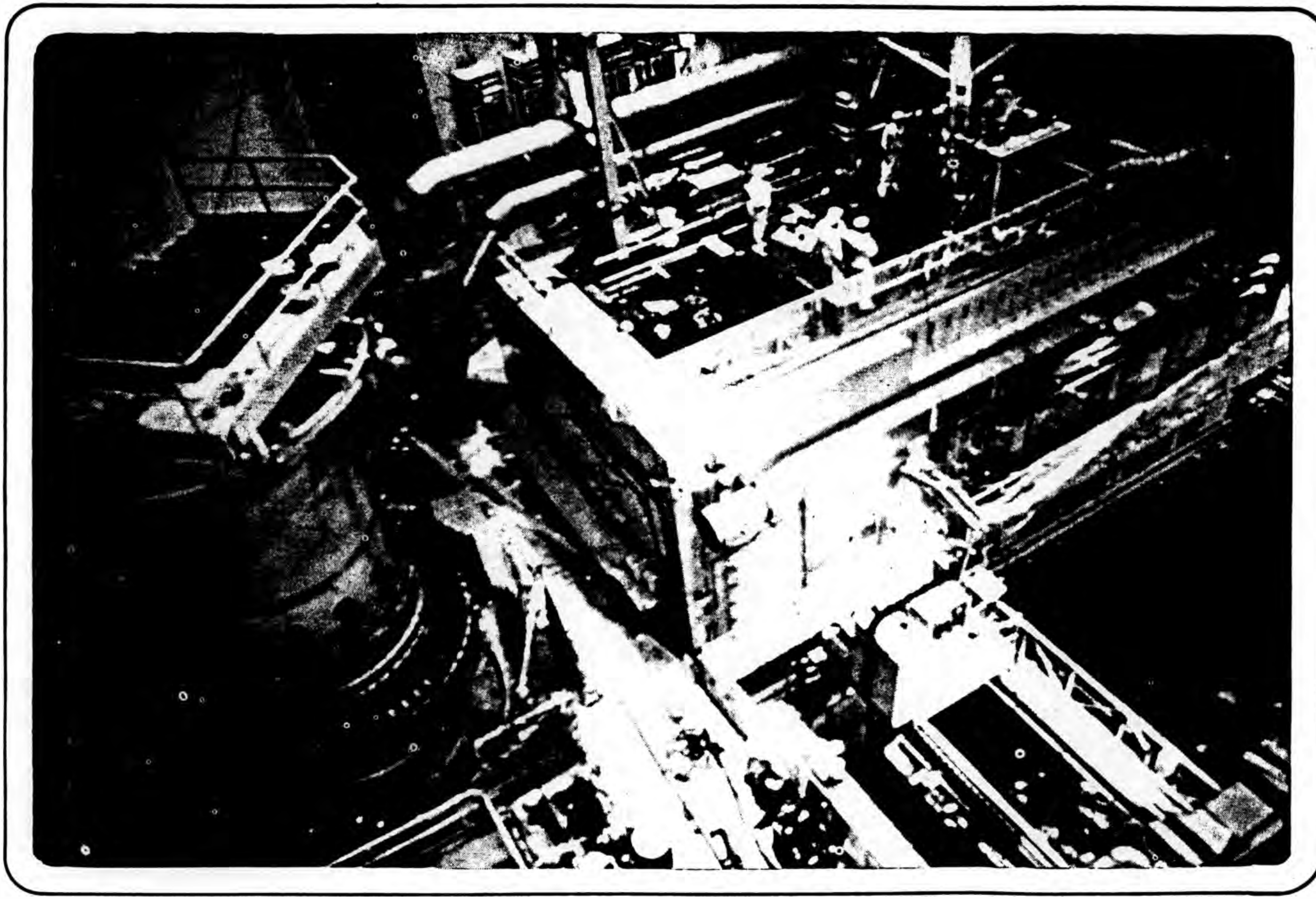
SEQUENCE FOR REACTOR DISASSEMBLY AND DEFUELING

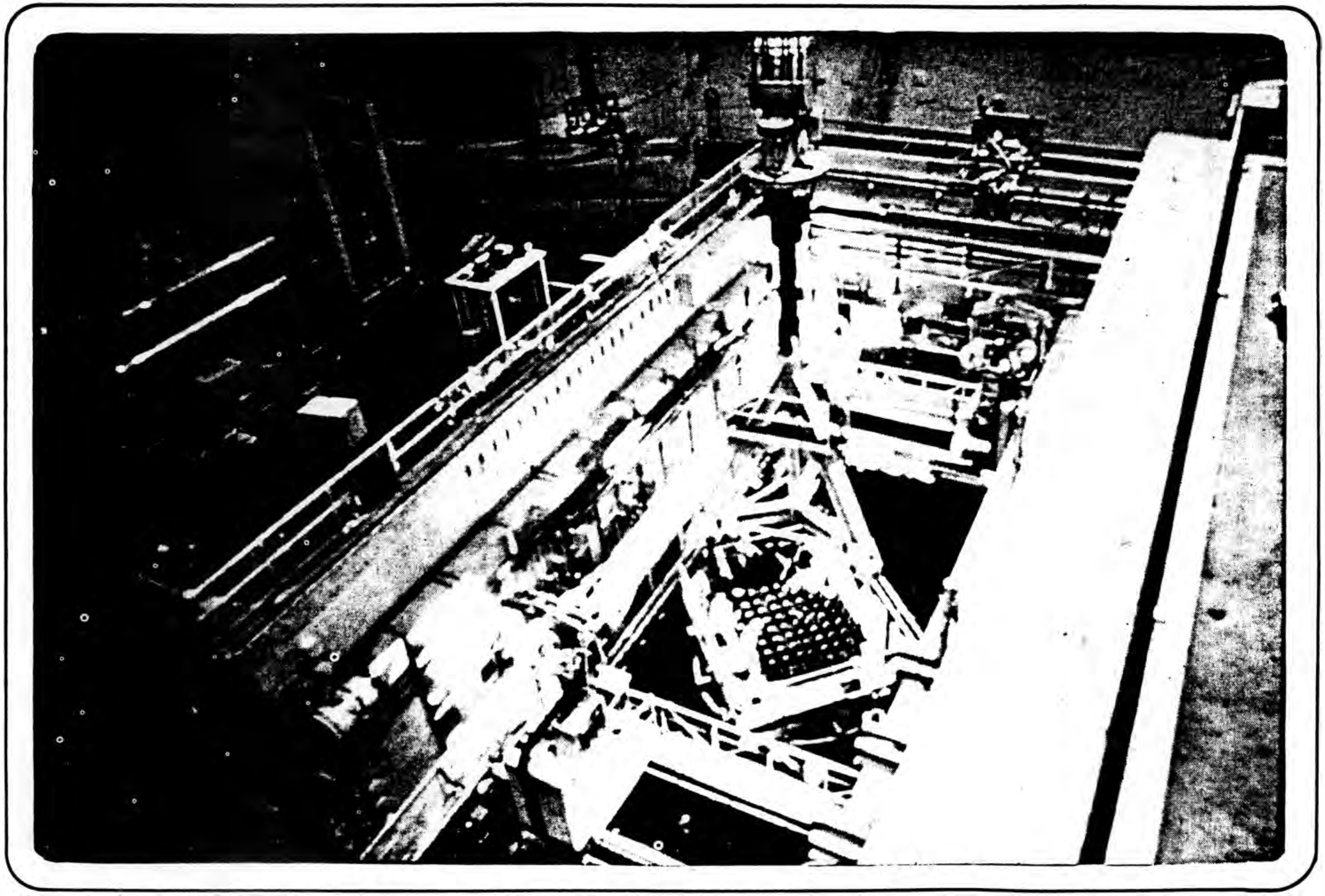


FUEL TRANSFER CANAL FILL

- Installation of seal plate between the reactor vessel flange and bottom of the canal
- Development and installation of a canal cleanup system with filters and/or demineralizers
- Installation of fuel handling equipment and modifications to existing fuel transfer system
- Filling the canal with borated water



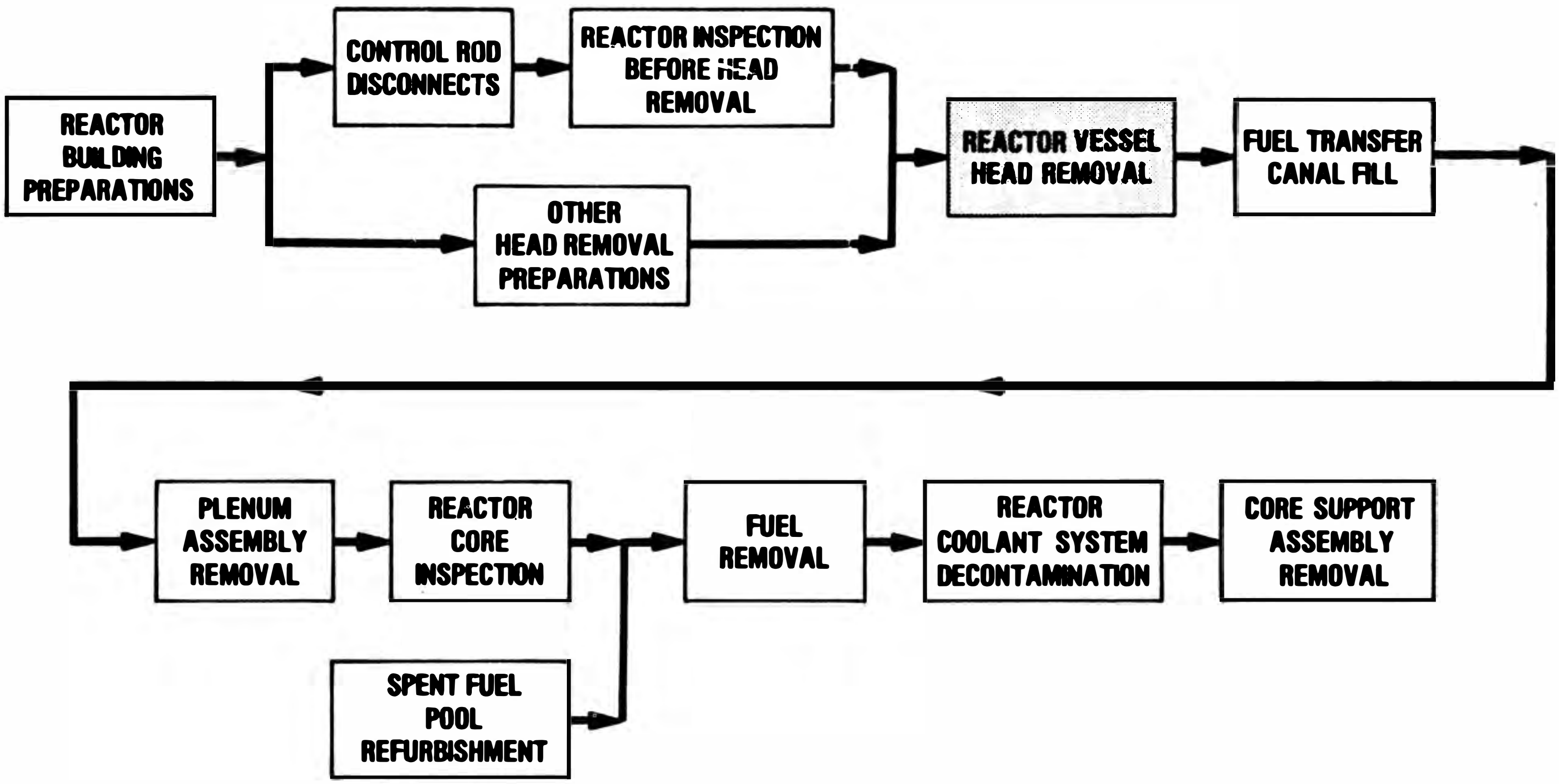


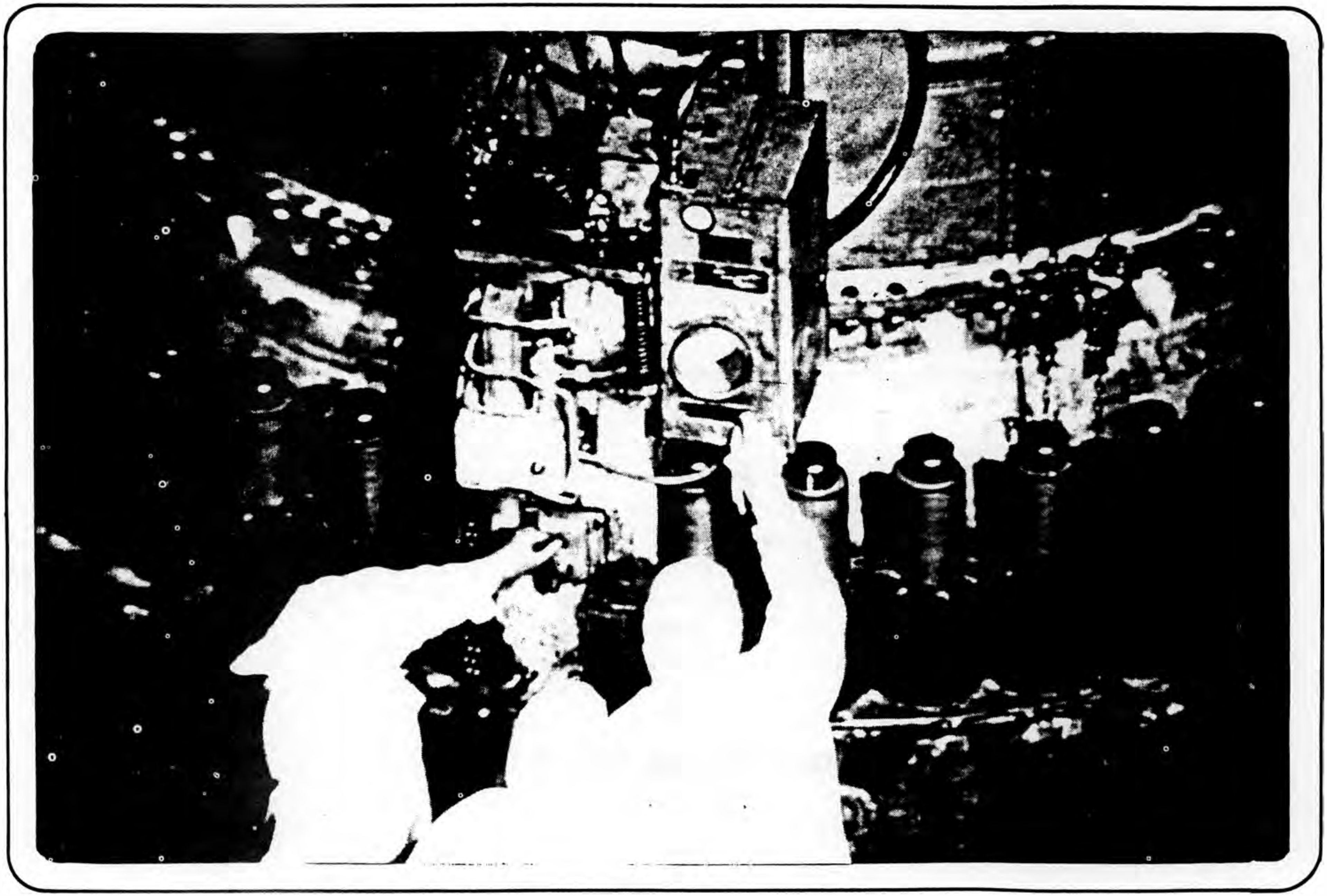


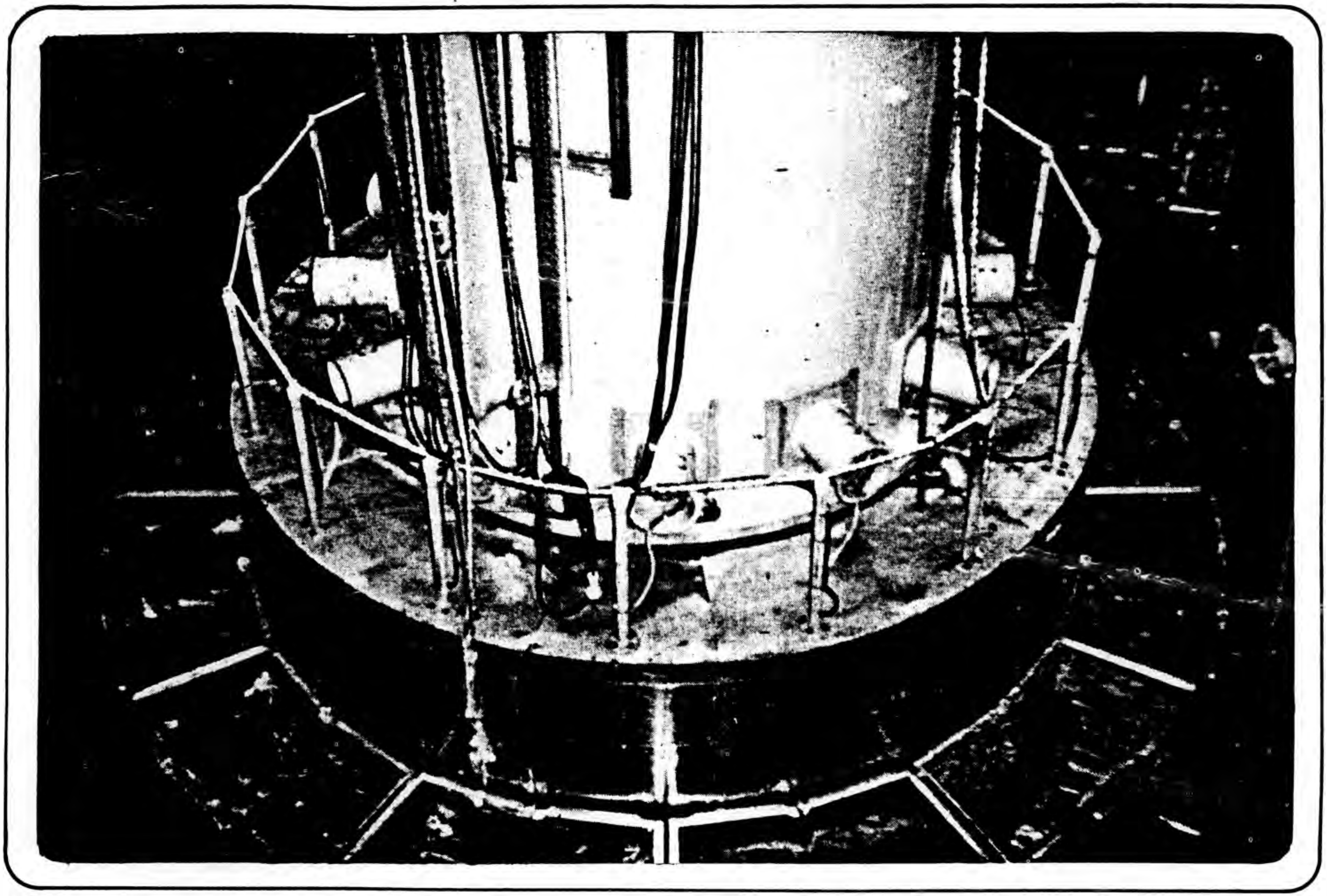
REACTOR VESSEL HEAD REMOVAL

- Attachment of lifting equipment to the head and polar crane
- Lifting the reactor vessel head and placement on the storage stand

SEQUENCE FOR REACTOR DISASSEMBLY AND DEFUELING



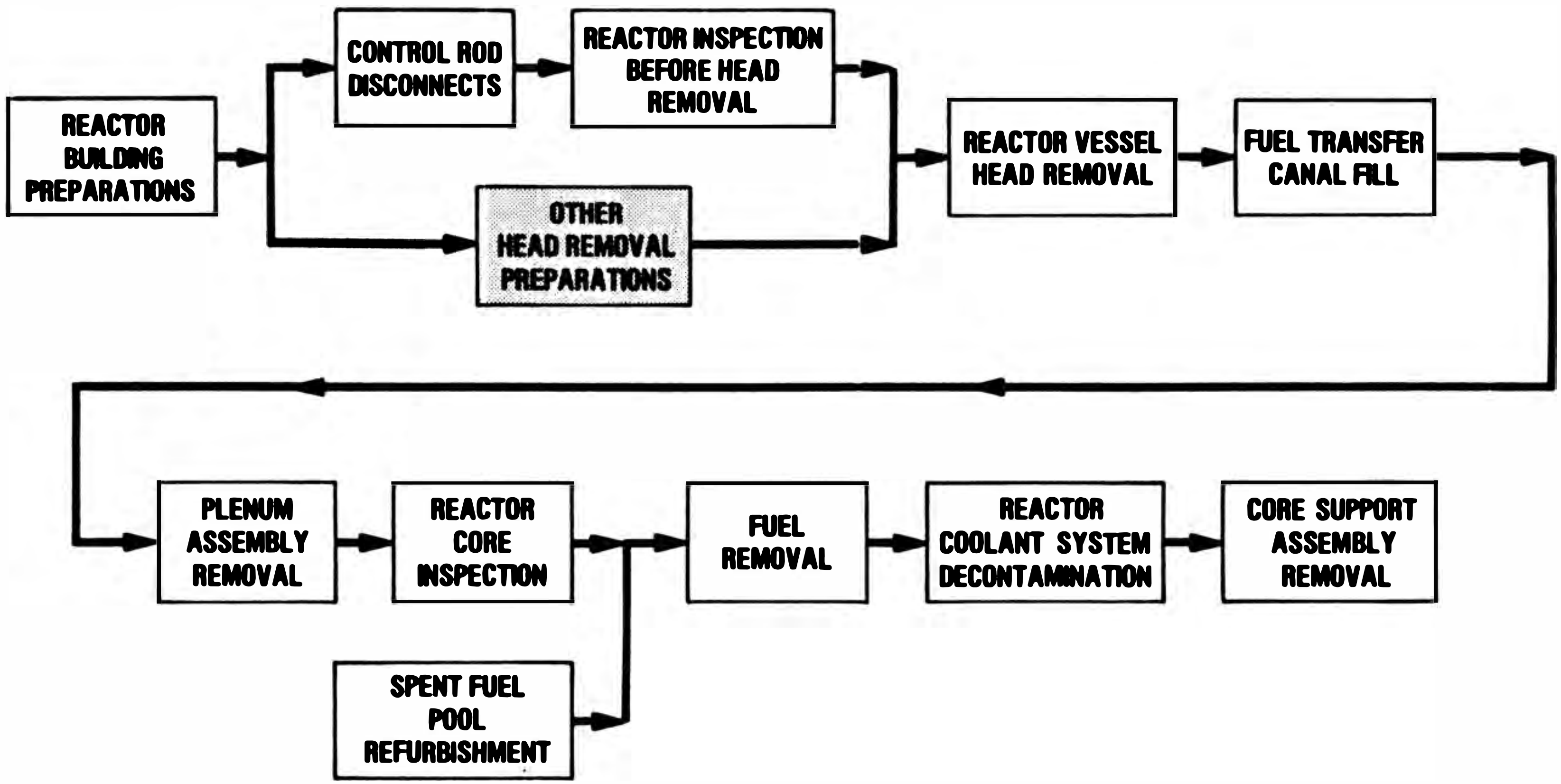




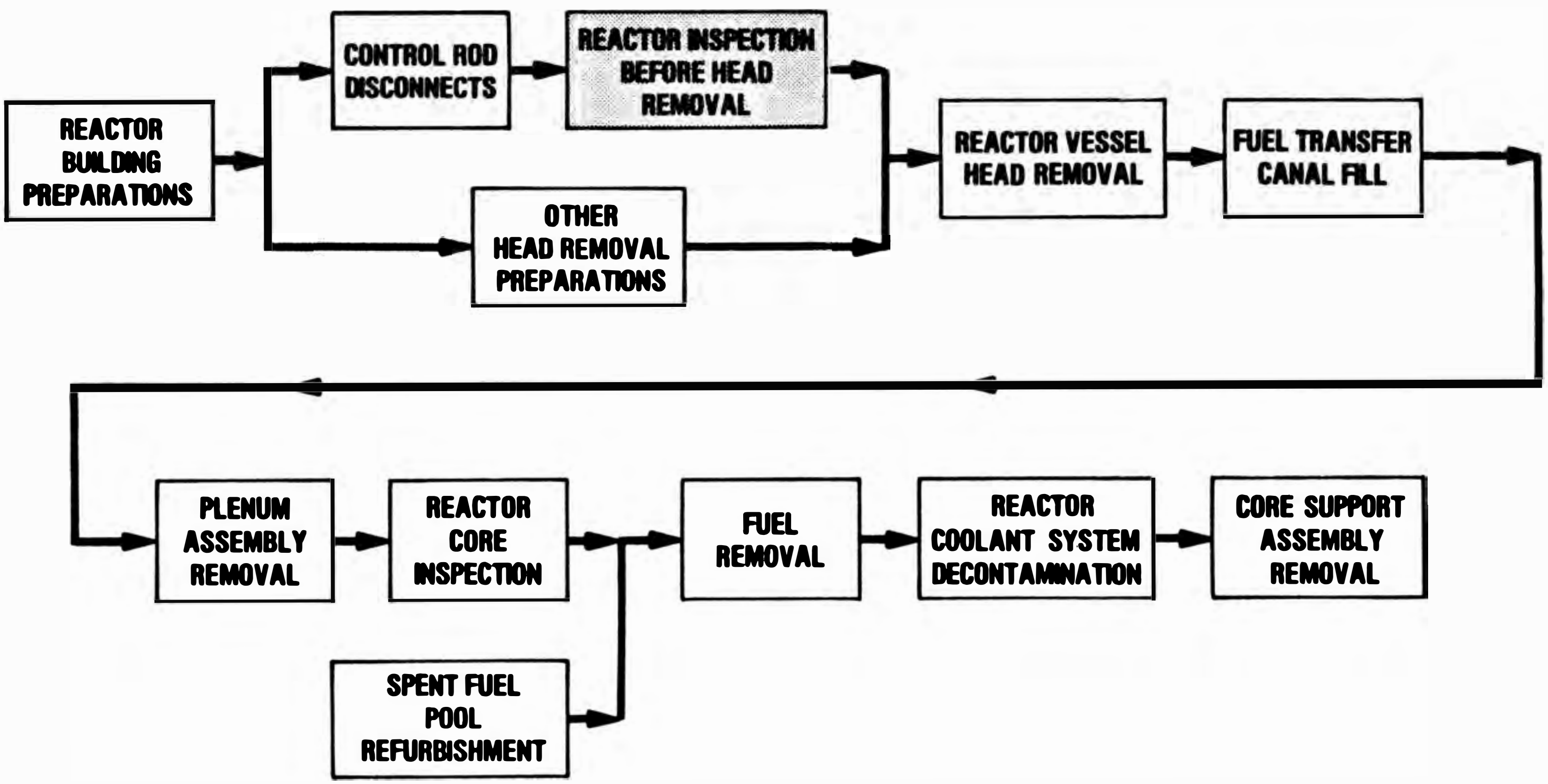
OTHER HEAD REMOVAL PREPARATIONS

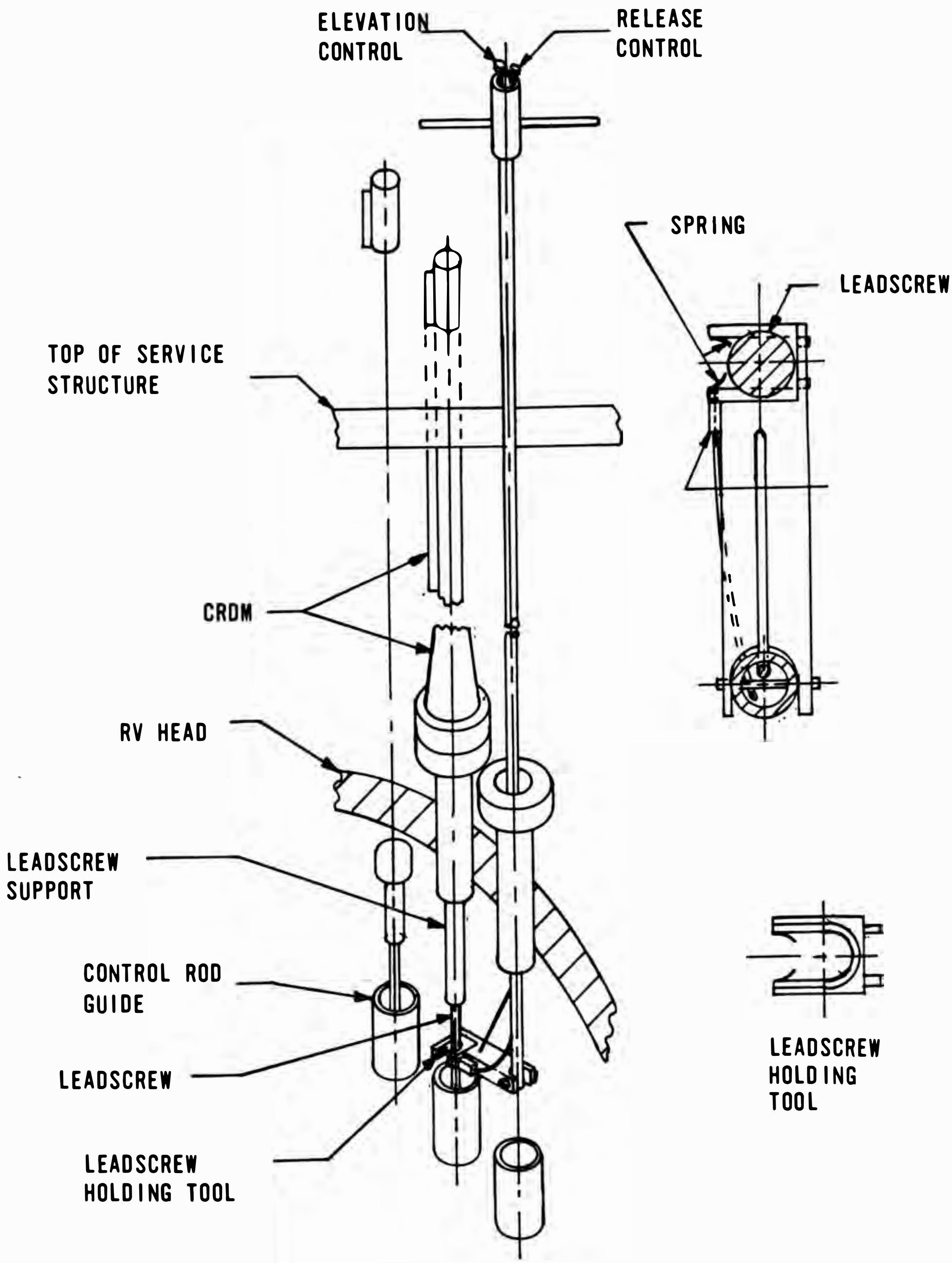
- Removal of neutron shield tanks and insulation panels at bottom of reactor vessel head
- Flushing the underside of the reactor vessel head and top of plenum assembly
- Detensioning and removal of the 60 studs which attach the head to the reactor vessel

SEQUENCE FOR
REACTOR DISASSEMBLY AND DEFUELING

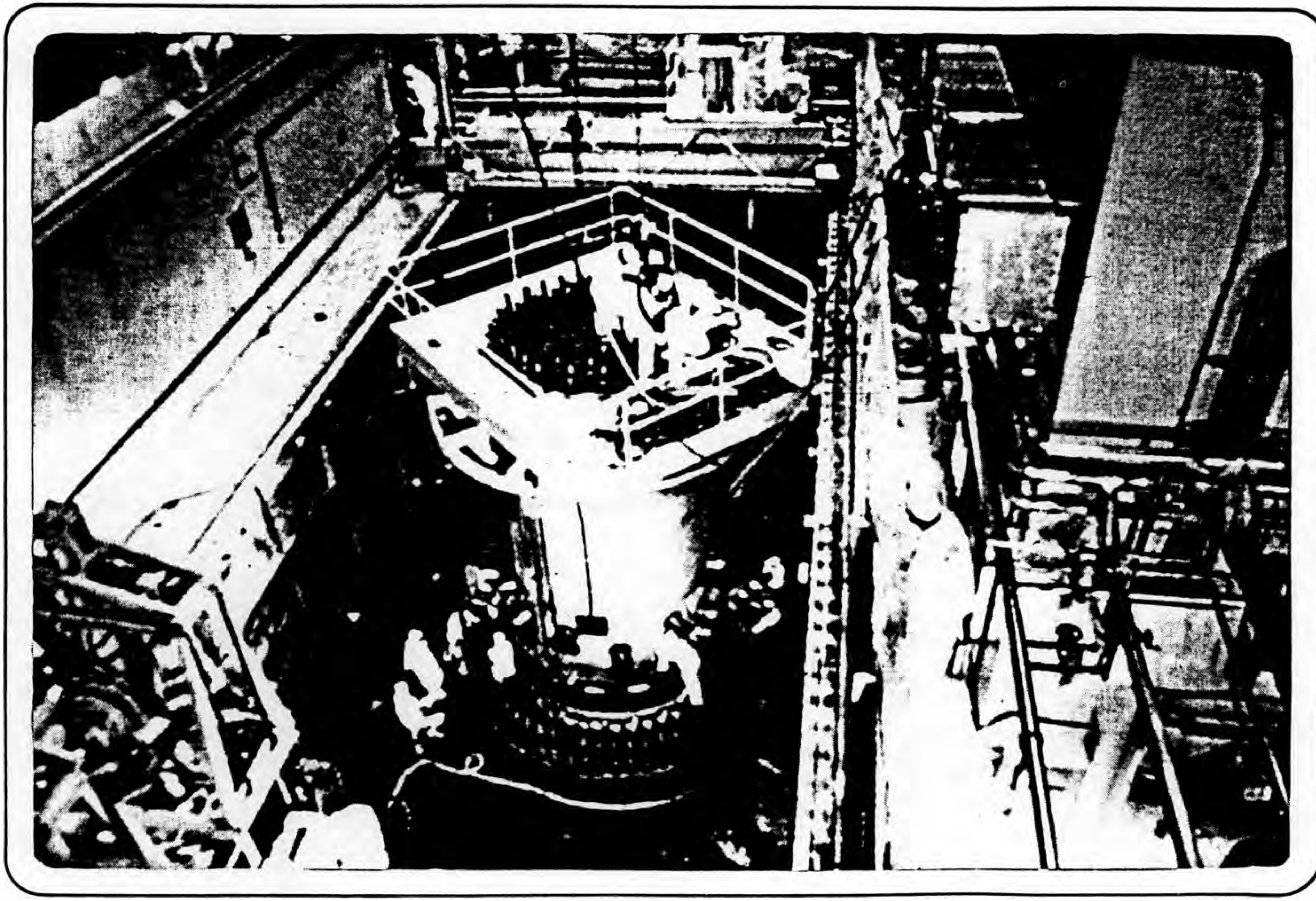


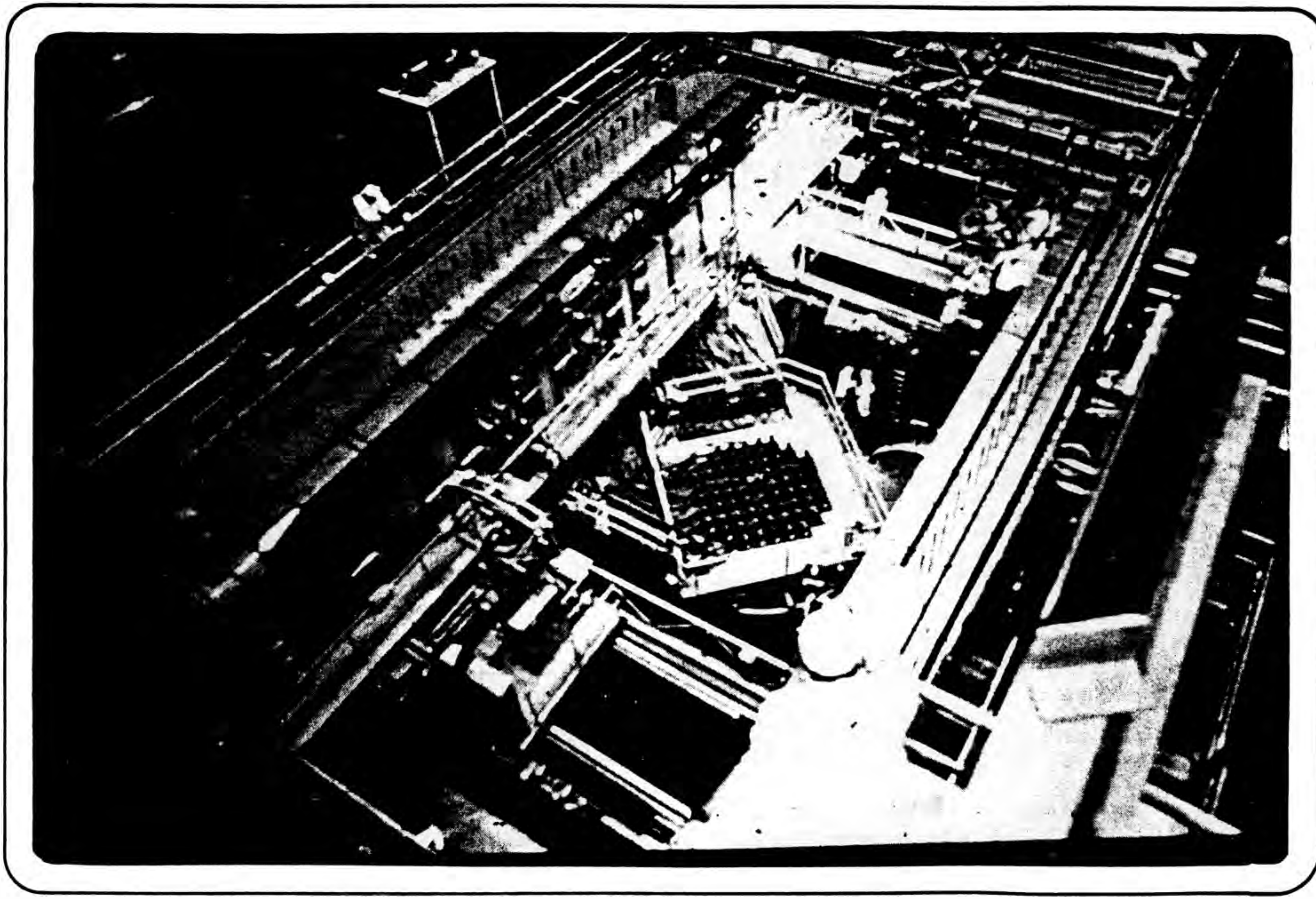
SEQUENCE FOR REACTOR DISASSEMBLY AND DEFUELING

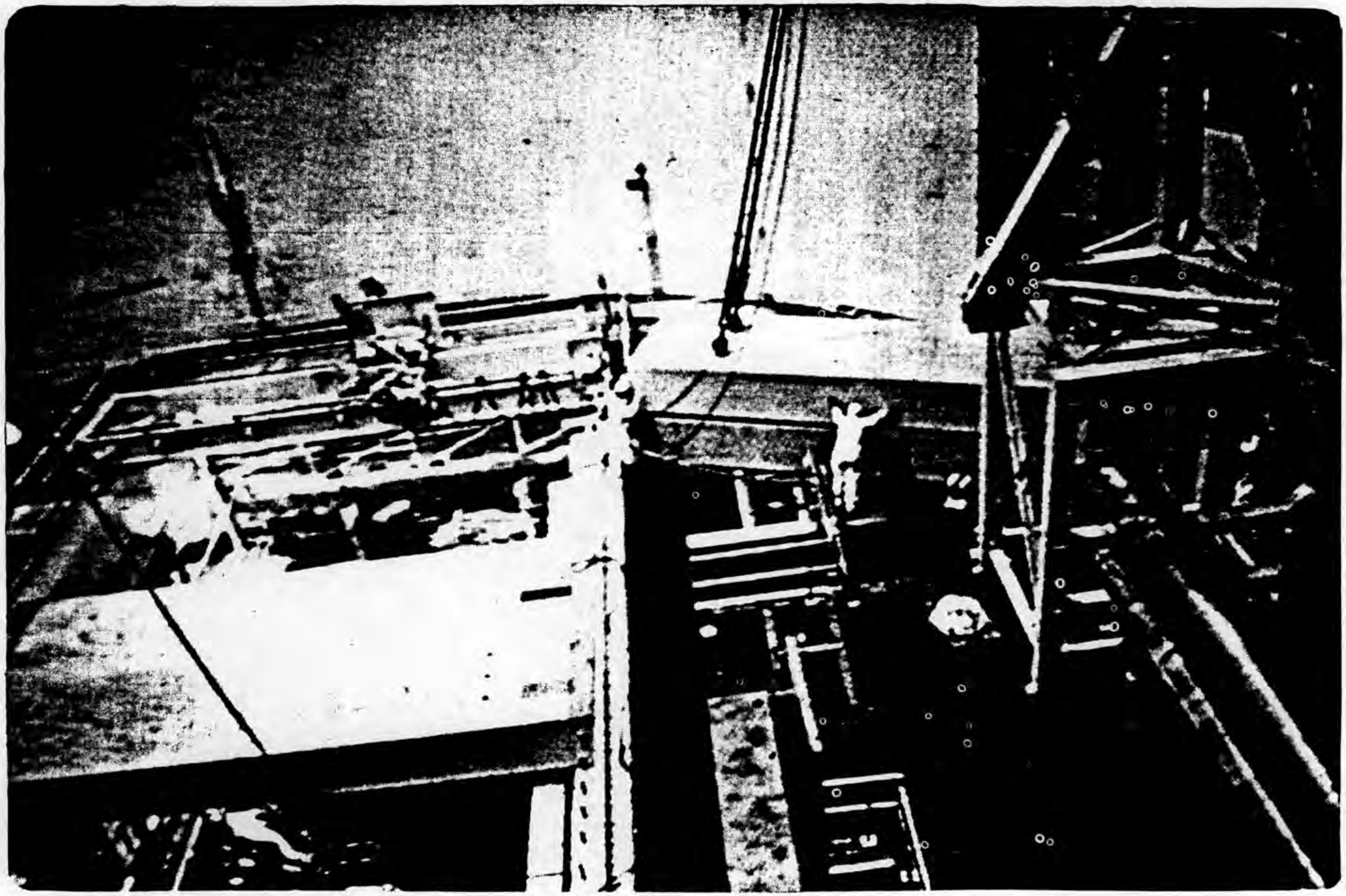


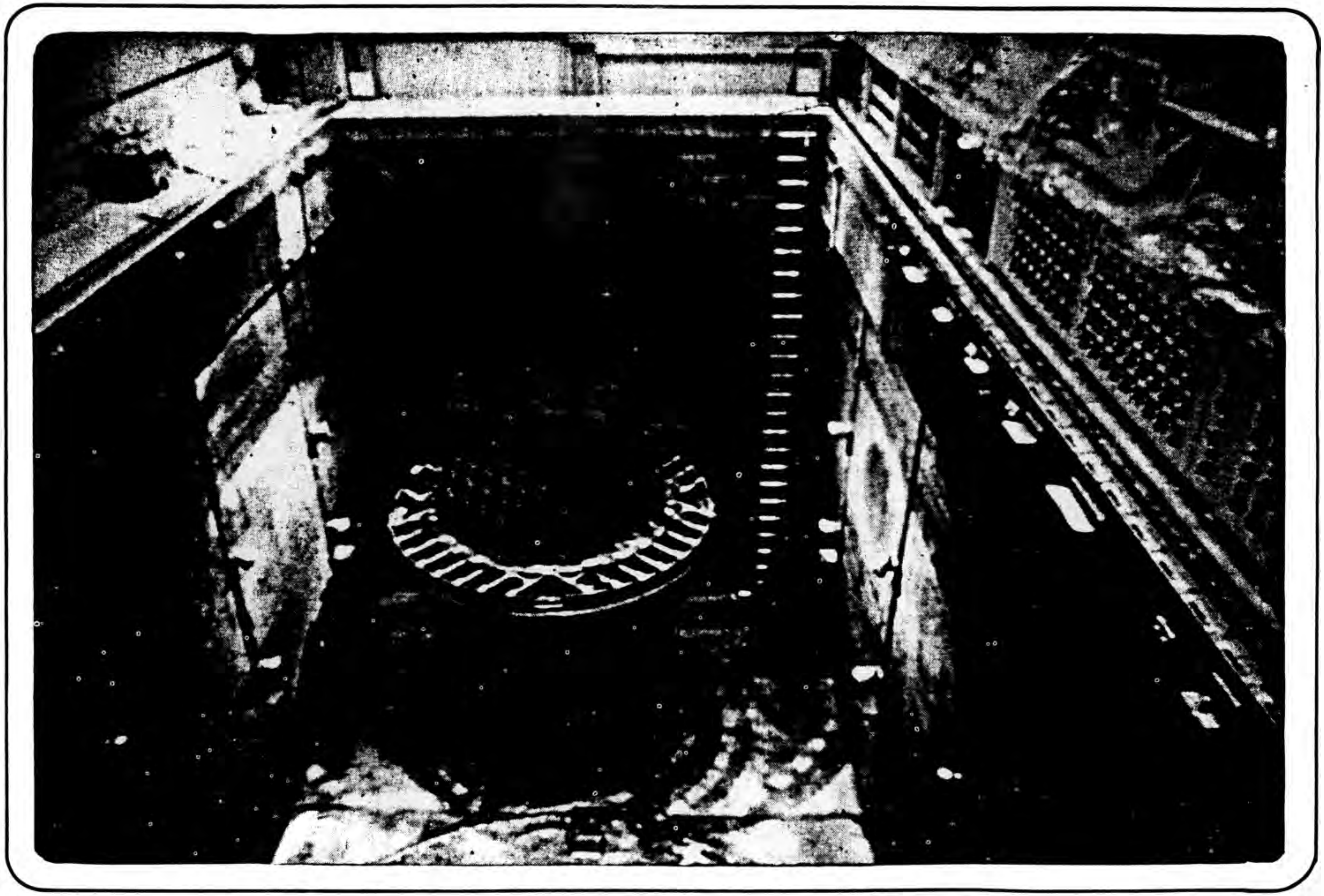


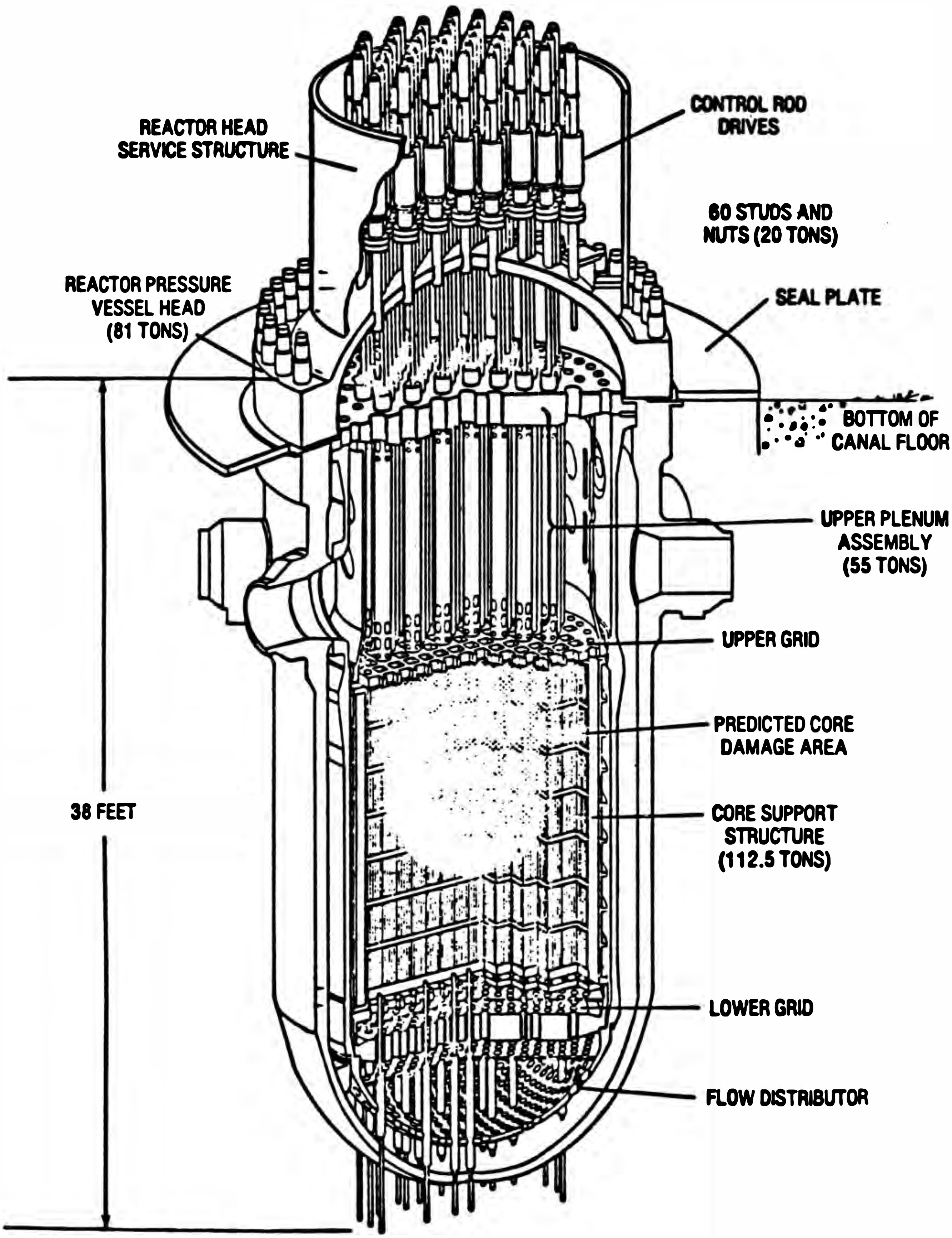
IN-HEAD LEADSCREW HOLDING TOOL AND MANIPULATOR



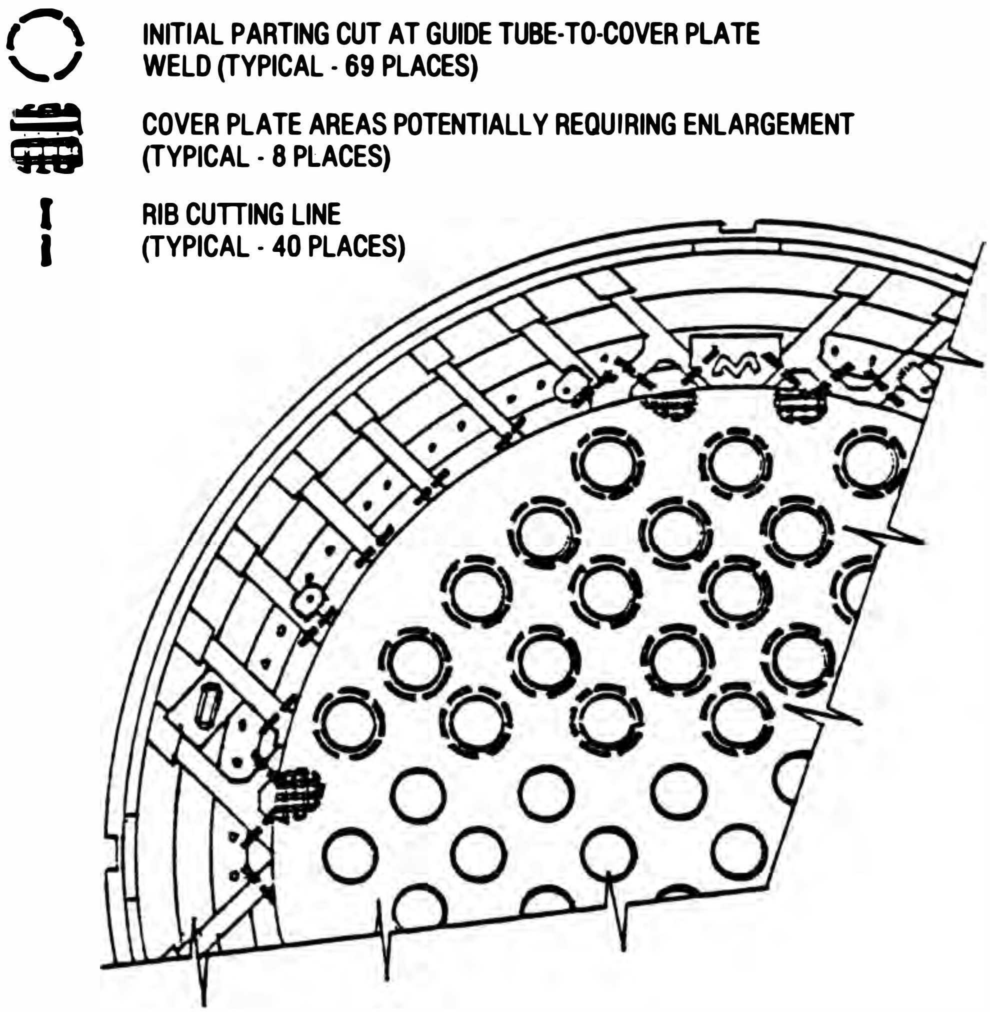




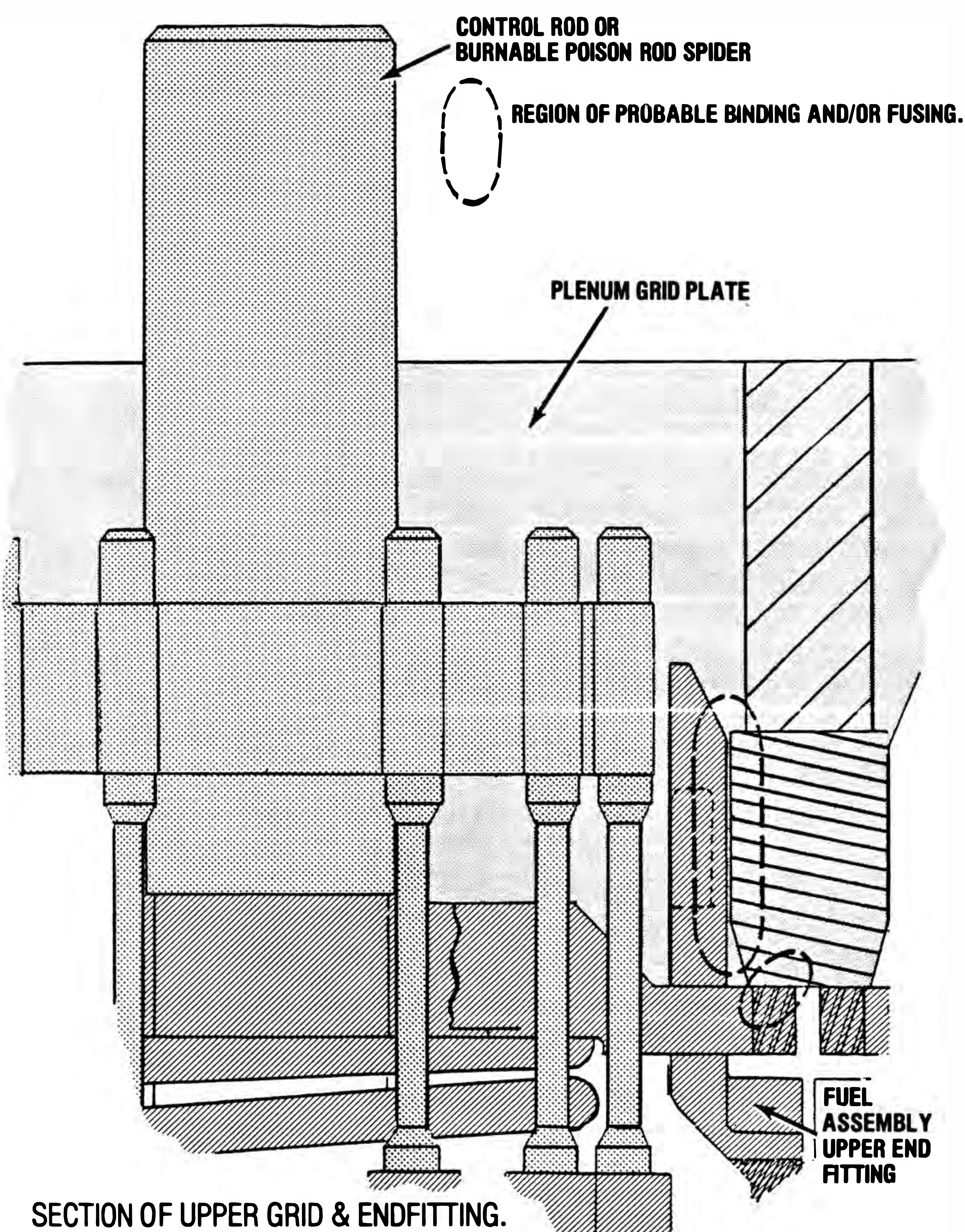




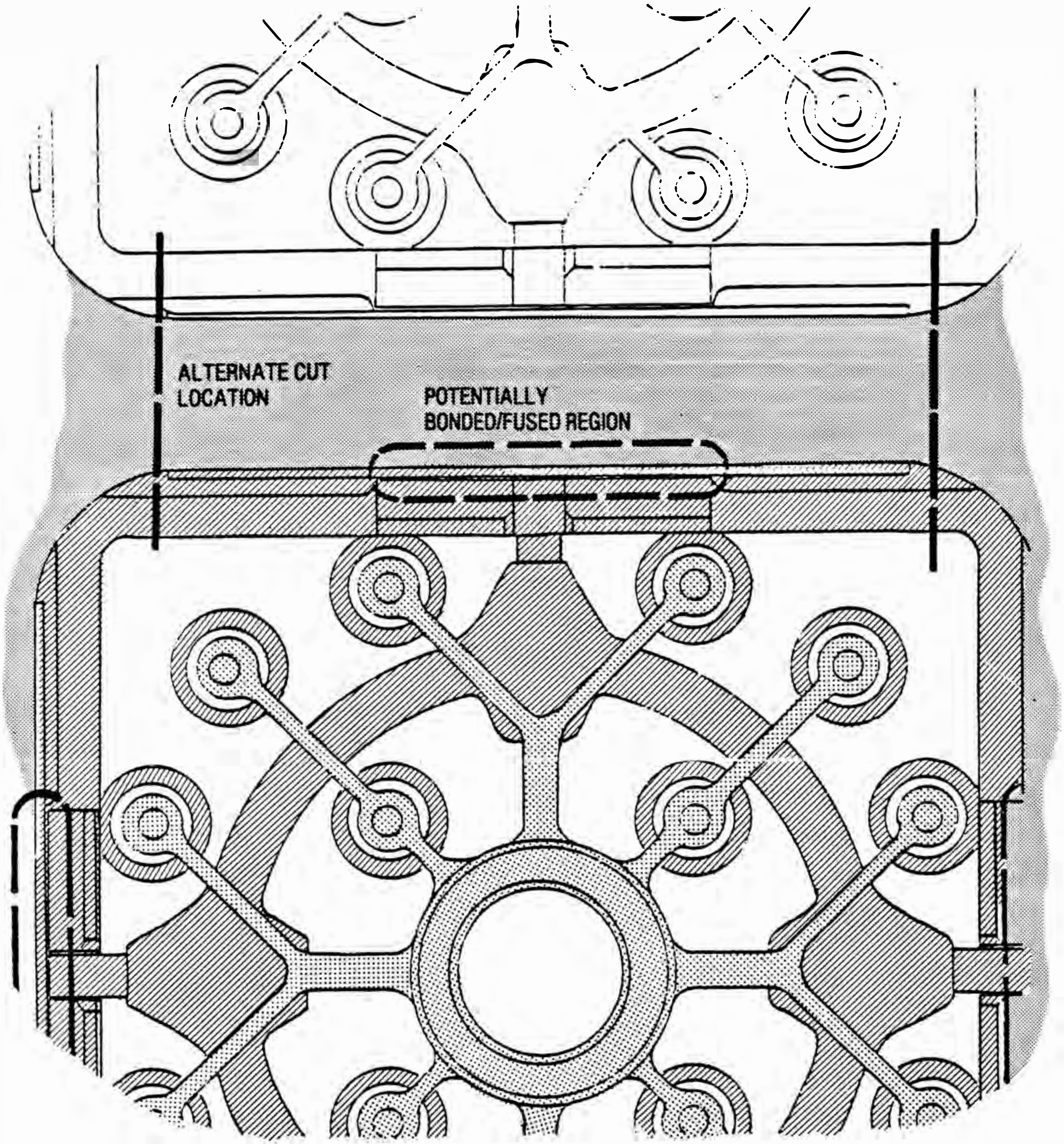
CUTAWAY VIEW OF REACTOR PRESSURE VESSEL



PARTIAL PLAN VIEW OF UPPER PLENUM SURFACE SHOWING COVER PLATE AND RIB SECTIONING LOCATIONS.

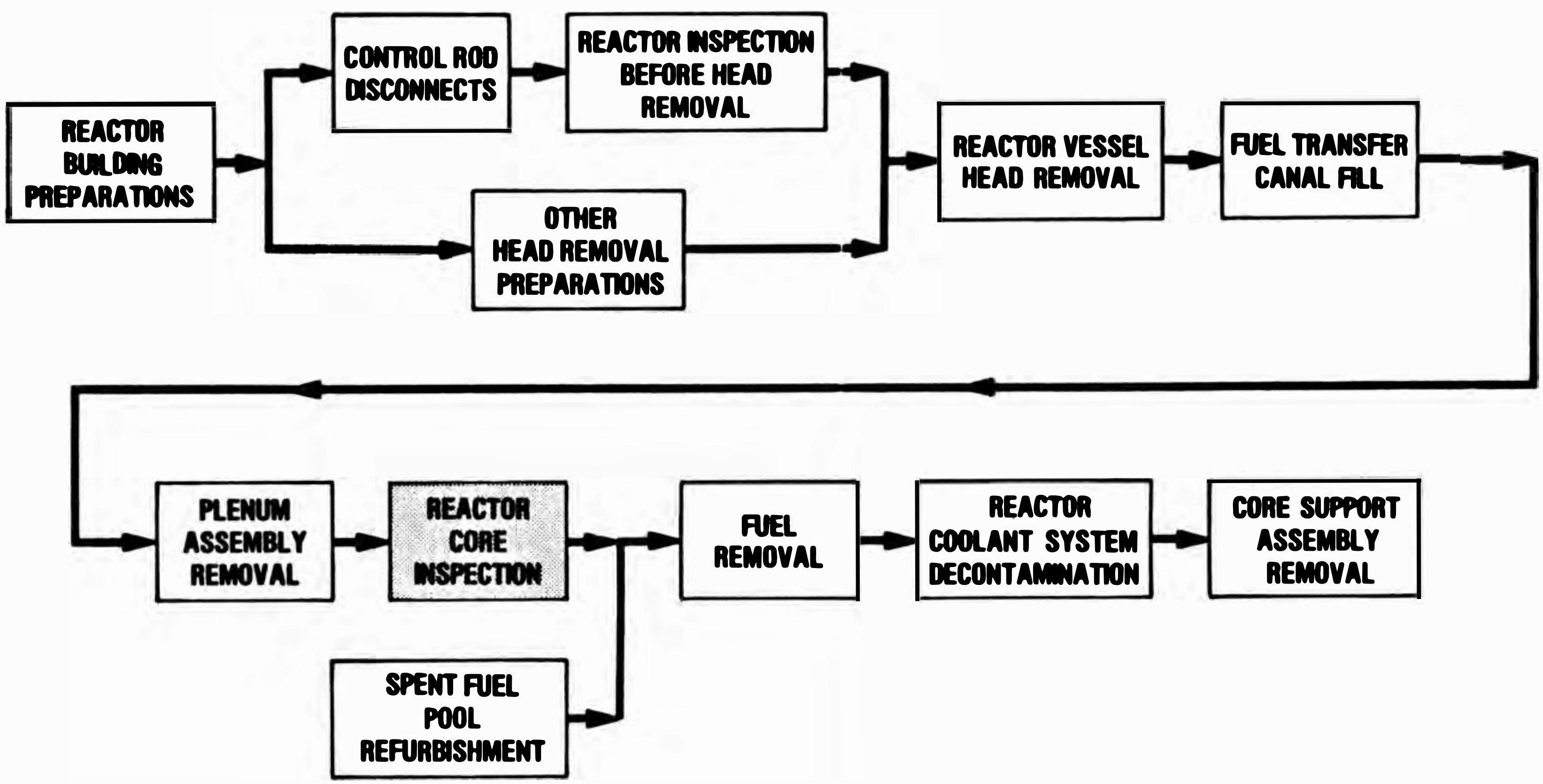


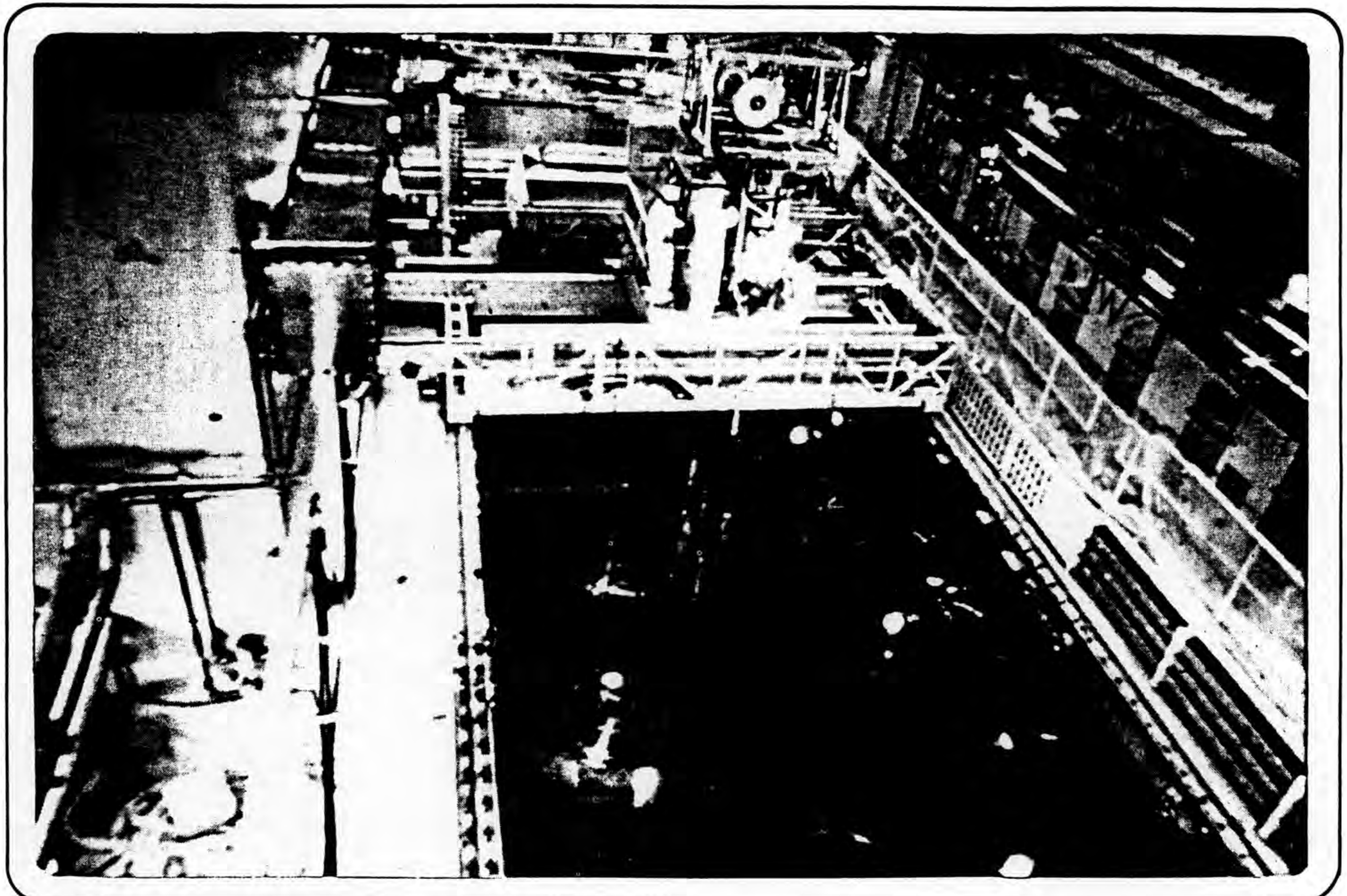
SECTION OF UPPER GRID & ENDFITTING.

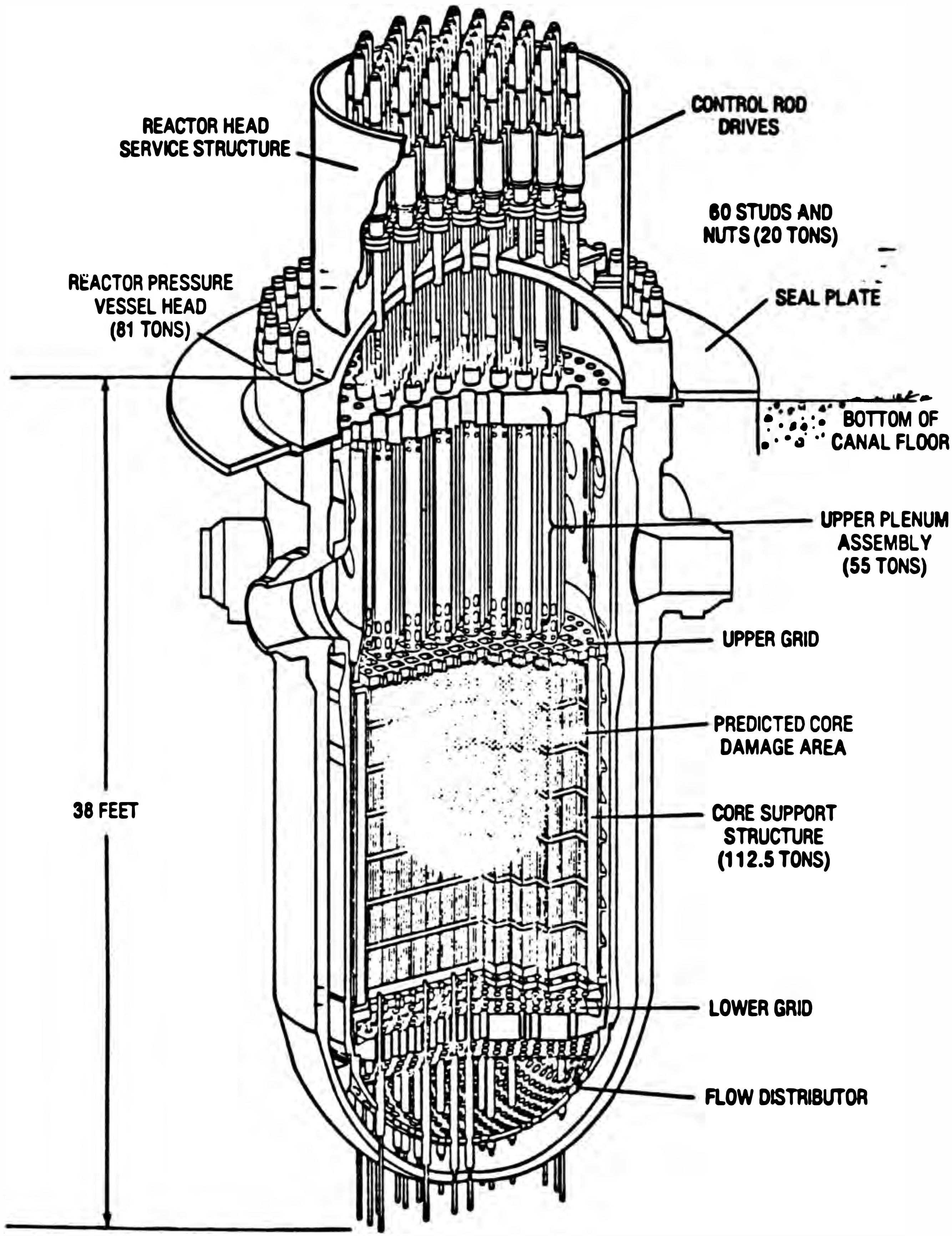


PLAN VIEW OF UPPER GRID AND FUEL ASSEMBLY ENDFITTING, SHOWING AREA OF PROBABLY BONDING AND/OR FUSING AND ALTERNATE CUT LOCATION.

SEQUENCE FOR REACTOR DISASSEMBLY AND DEFUELING

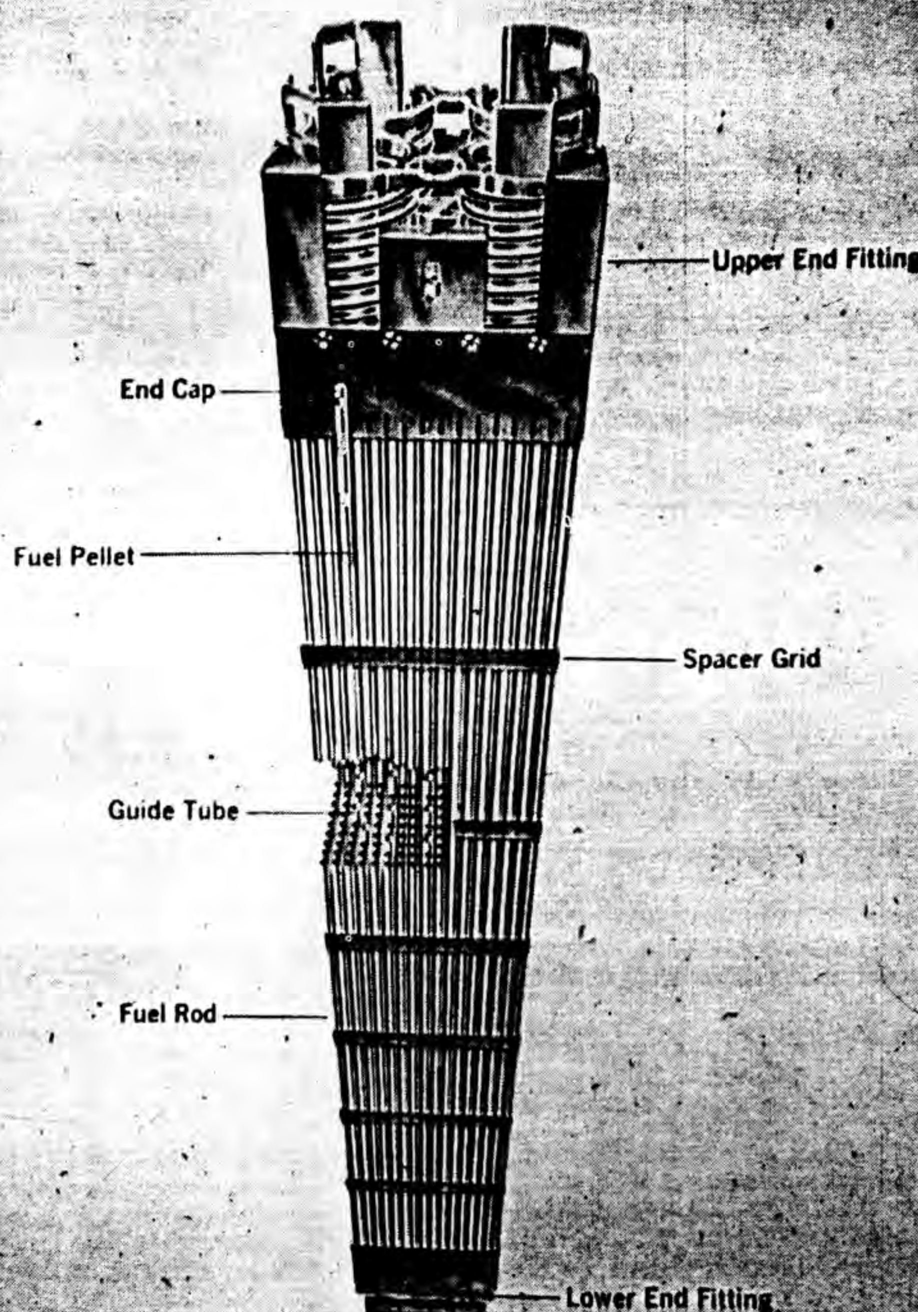






CUTAWAY VIEW OF REACTOR PRESSURE VESSEL

Fuel Assembly



Babcock & Wilcox

CORE DATA

NUMBER OF FUEL ASSEMBLIES	177
FUEL RODS PER FUEL ASSEMBLY	208
NUMBER OF CONTROL RODS	69
WEIGHT OF FUEL ASSEMBLY	1535 LBS.
TOTAL CORE WEIGHT	300,000 LBS.
FUEL ASSEMBLY LENGTH	166 IN.

ESTIMATED PEAK CORE TEMPERATURES

• NRC SPECIAL INQUIRY GROUP (ROGOVIN)	4400 F
• BATTELLE COLUMBUS LABS	4130 F
• WESTINGHOUSE — NUCLEAR ENERGY SYSTEMS	4760 F
• PRESIDENT'S COMMISSION	4000 F
• NSAC	3140 F
• LASL	4220 F

MELTING POINTS OF CORE MATERIALS

MATERIAL	MELTING TEMPERATURE (F)
FUEL (UO_2)	5080
CLADDING ON FUEL (ZIRCALOY - 4)	3362
CLADDING ON CONTROL RODS (STAINLESS STEEL(	2600
END FITTINGS (STAINLESS STEEL)	2600
SPACER GRIDS (INCONEL)	2300
CONTROL ROD POISON (AG-IN-CD)	1472
BURNABLE POISON (Al_2O_3 - B_4C)	3686
ZrO_2 (BY-PRODUCT, METAL - WATER REACTION)	4919
RANGE OF ESTIMATED PEAK CORE TEMPERATURES	3140-4760

DAMAGE ESTIMATES

	MINIMUM	MAXIMUM
FAILED FUEL RODS (%)	80	100
FUEL TEMPERATURE (K)	3100	4800
CLADDING OXIDIZED IN ACTIVE FUEL REGION (%)	40	60
LIQUIFIED FUEL	LOCALLY POSSIBLE	PRESENT OVER MOST OF CORE RADIUS, PERHAPS EXTENDING DOWNWARD TO 1M ABOVE CORE BOTTOM.
MOLTEN FUEL	NONE	POSSIBLE IN A FEW LOCALIZED AREAS OF CENTRAL CORE
CORE SLUMPING	PROBABLE	YES

CONTINUED...

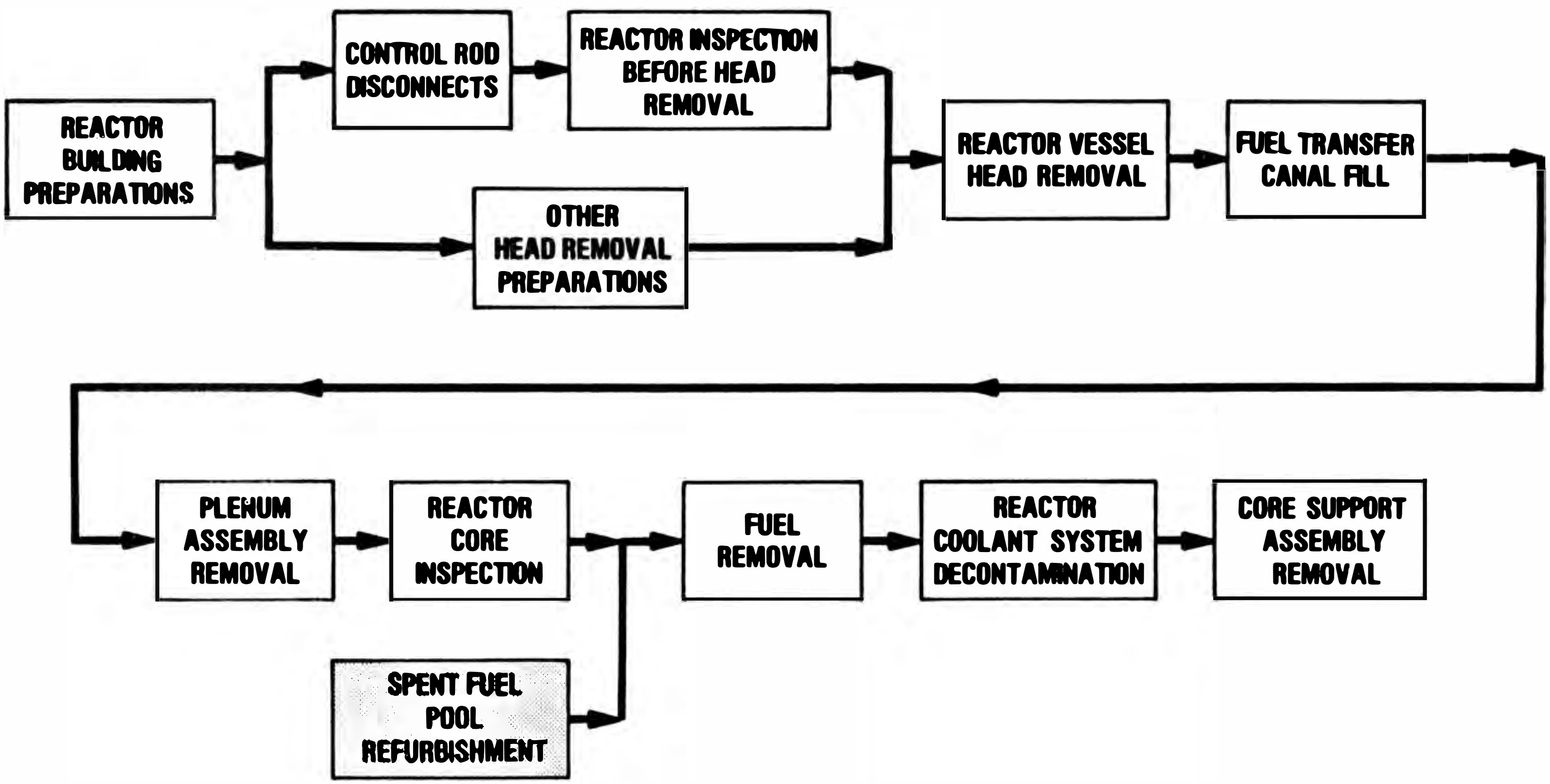
DAMAGE ESTIMATES (CONTINUED)

	MINIMUM	MAXIMUM
FUEL ROD FRAGMENTATION, DEBRIS BED FORMATION	YES	YES
PERIPHERAL RODS	A FEW NOT BREACHED, SOME EMBRITTLED	ALL FAILED AND EMBRITTLED, MANY WITH LIQUIFIED FUEL
CONTROL RODS AND SPACER GRIDS	SOME MELTING	EXTENSIVE MELTING
INSTRUMENT TUBES	MOST INTACT	ALL FAILED
EMBRITTLEMENT LEVEL (M ABOVE BOTTOM OF CORE AT CENTERLINE)	1.8	0.9
UPPER PLENUM ASSEMBLIES	NO DISTORTION, MELTING, OR FUSING TO OTHER STAINLESS STEEL COMPONENTS	MELTING OVER CENTRAL LOWER REGION, MAJOR SLUMPING POSSIBLE.

SUMMARY OF POTENTIAL RANGE OF CORE CONDITIONS

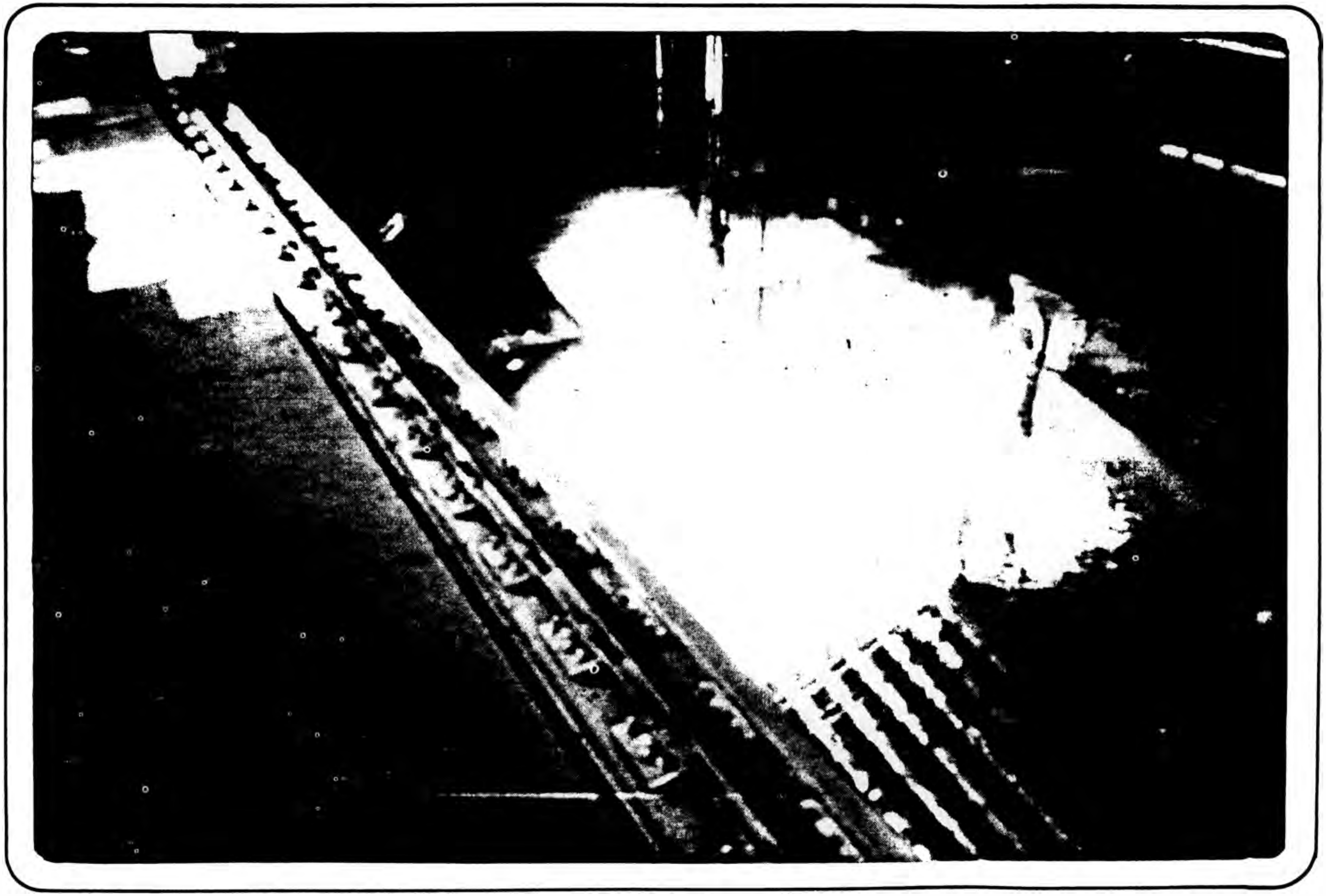
MATERIAL	QUANTITATIVE ASSESSMENT
LOOSE CORE DEBRIS	70,000 TO 128,000 LB
FUSED CORE DEBRIS	LENGTH OF FUSED REGION 0 TO 6.5 FT
EMBRITTED CLADDING	29,000 TO 70,000 LB
STRUCTURALLY INTACT RODS	70,000 TO 113,000 LB LENGTH, 0 TO 12.8 FT

SEQUENCE FOR
REACTOR DISASSEMBLY AND DEFUELING

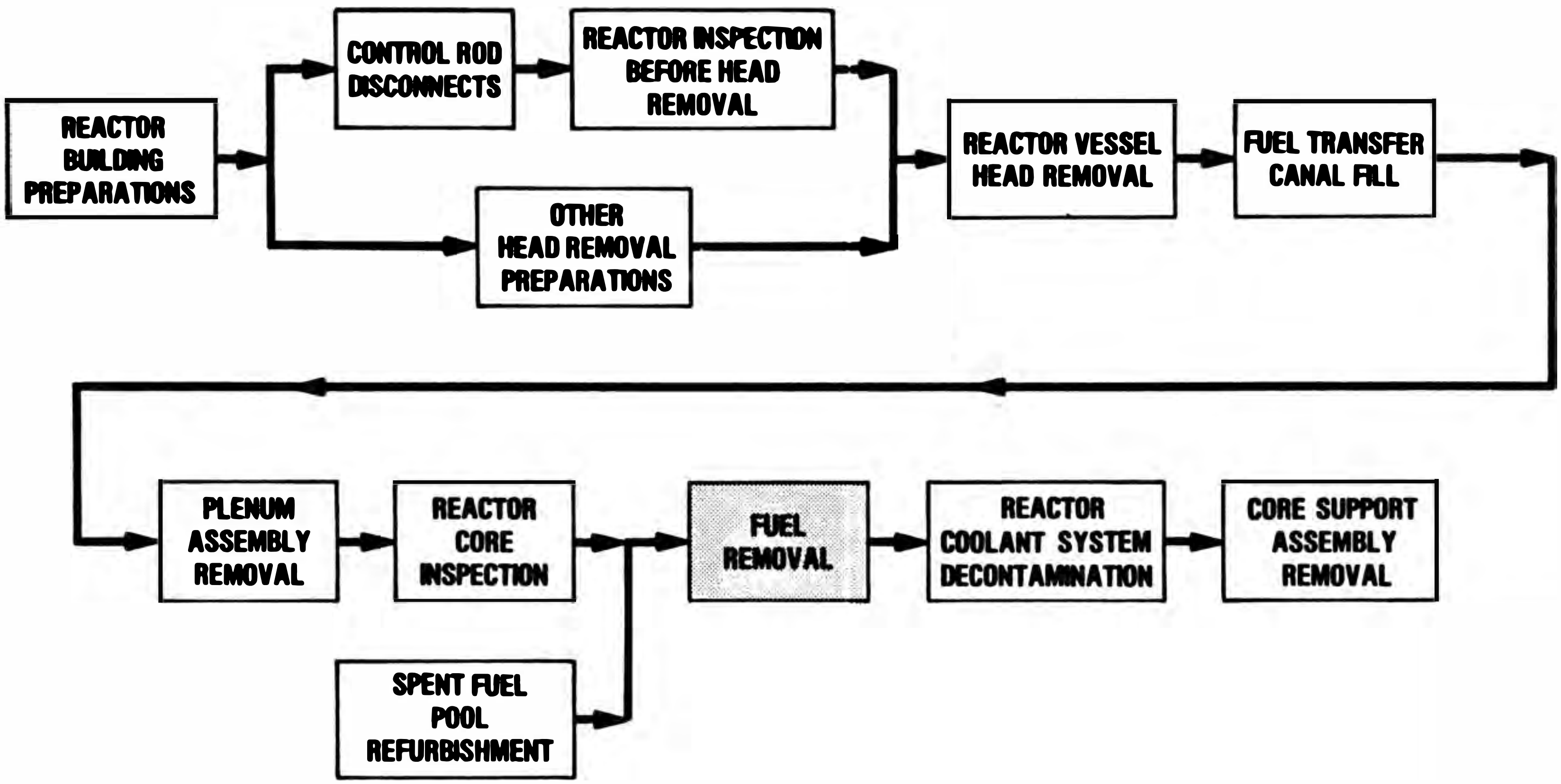


SPENT FUEL POOL REFURBISHMENT

- Removal of previously installed submerged demineralizer system (SDS)
- Development and installation of new storage racks for the removed fuel
- Filling the pool with borated water



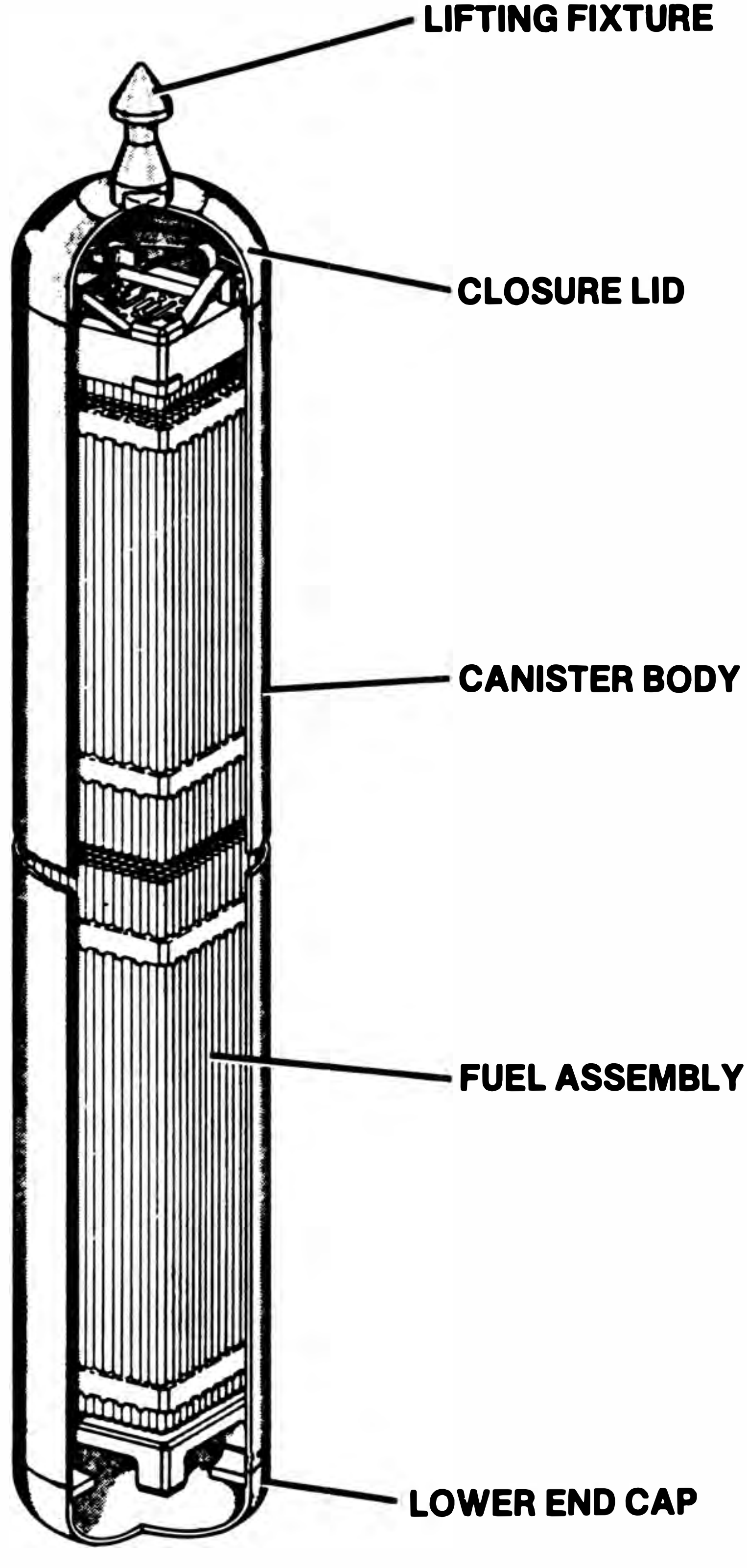
SEQUENCE FOR REACTOR DISASSEMBLY AND DEFUELING

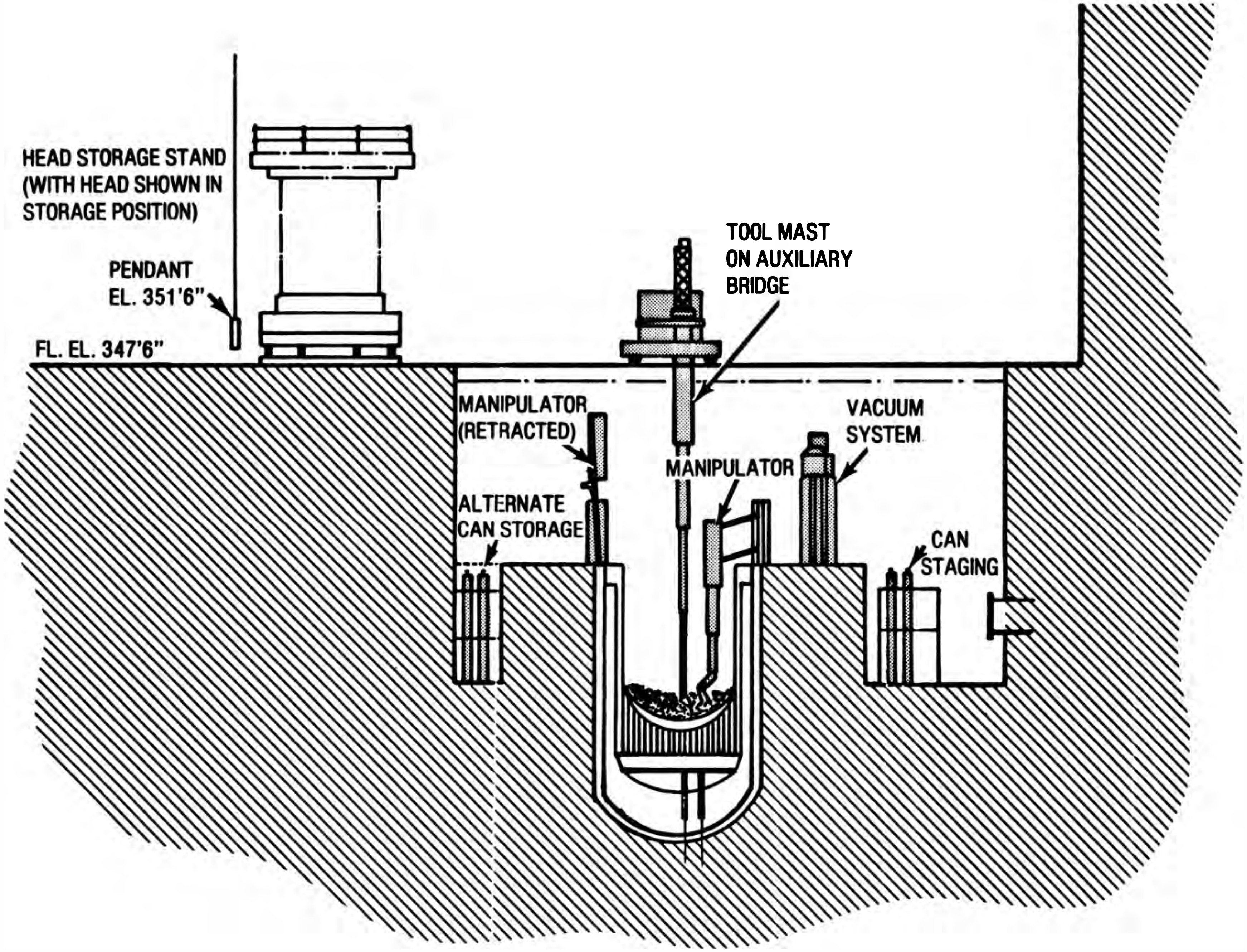


FUEL REMOVAL

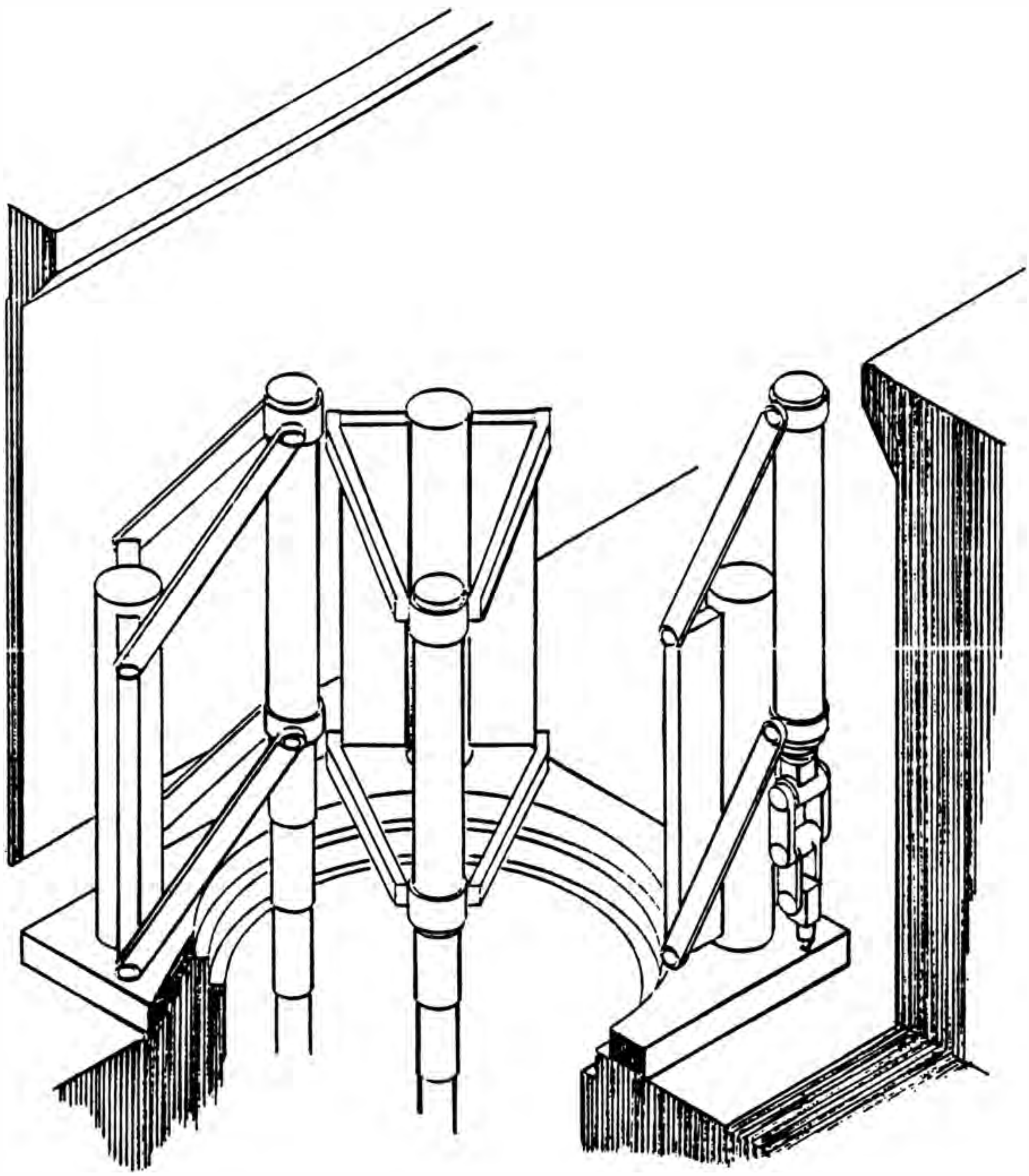
- Development of fuel canisters to contain the fuel and core components before removal from the reactor vessel area
- Development and installation of handling equipment for fuel and fuel canisters
- Removal of fuel debris
- Separation of fused core materials
- Removal of complete or partial fuel assemblies
- Removal of incore instrumentation

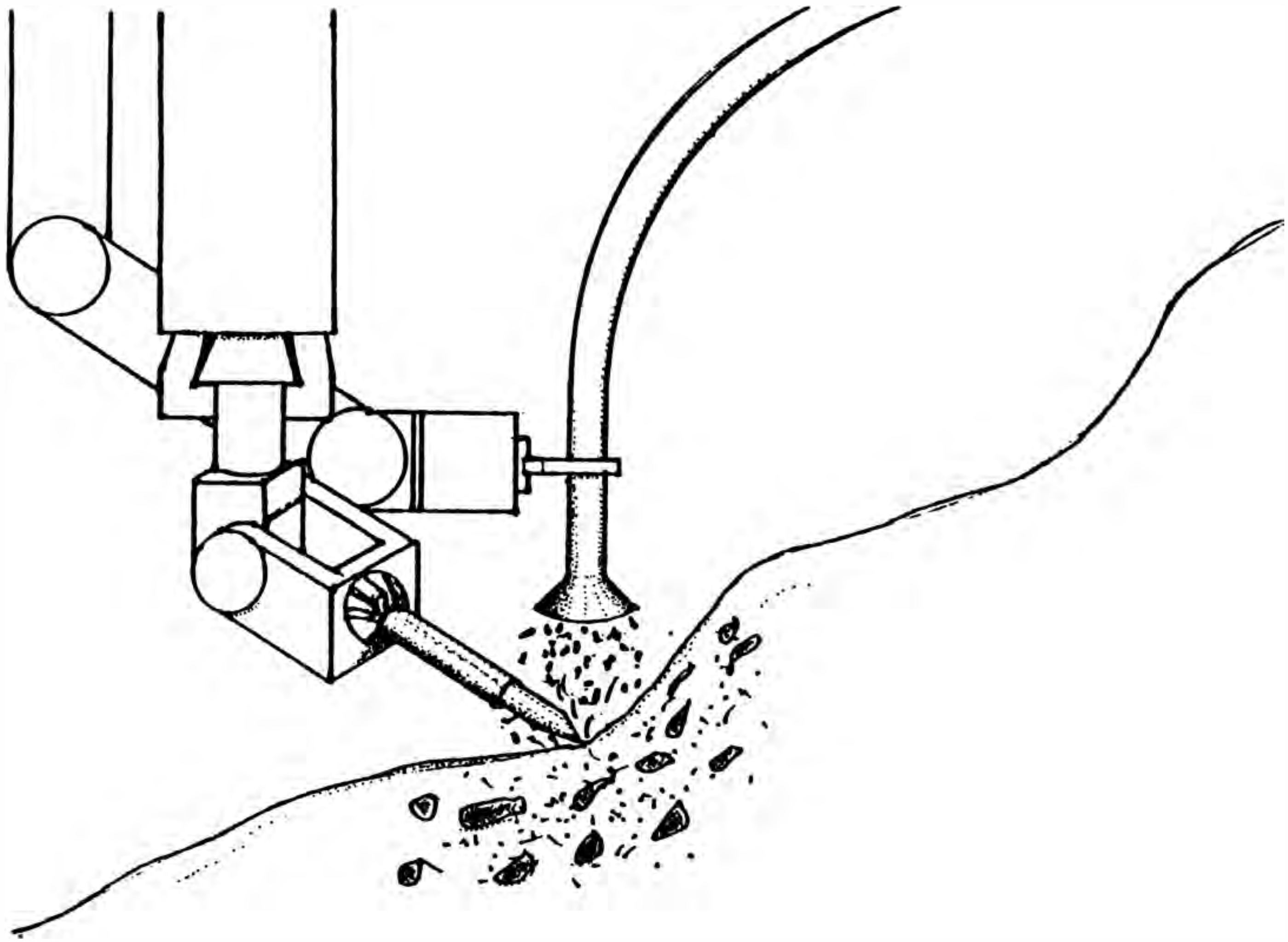
EXAMPLE OF POSSIBLE CANISTER DESIGN

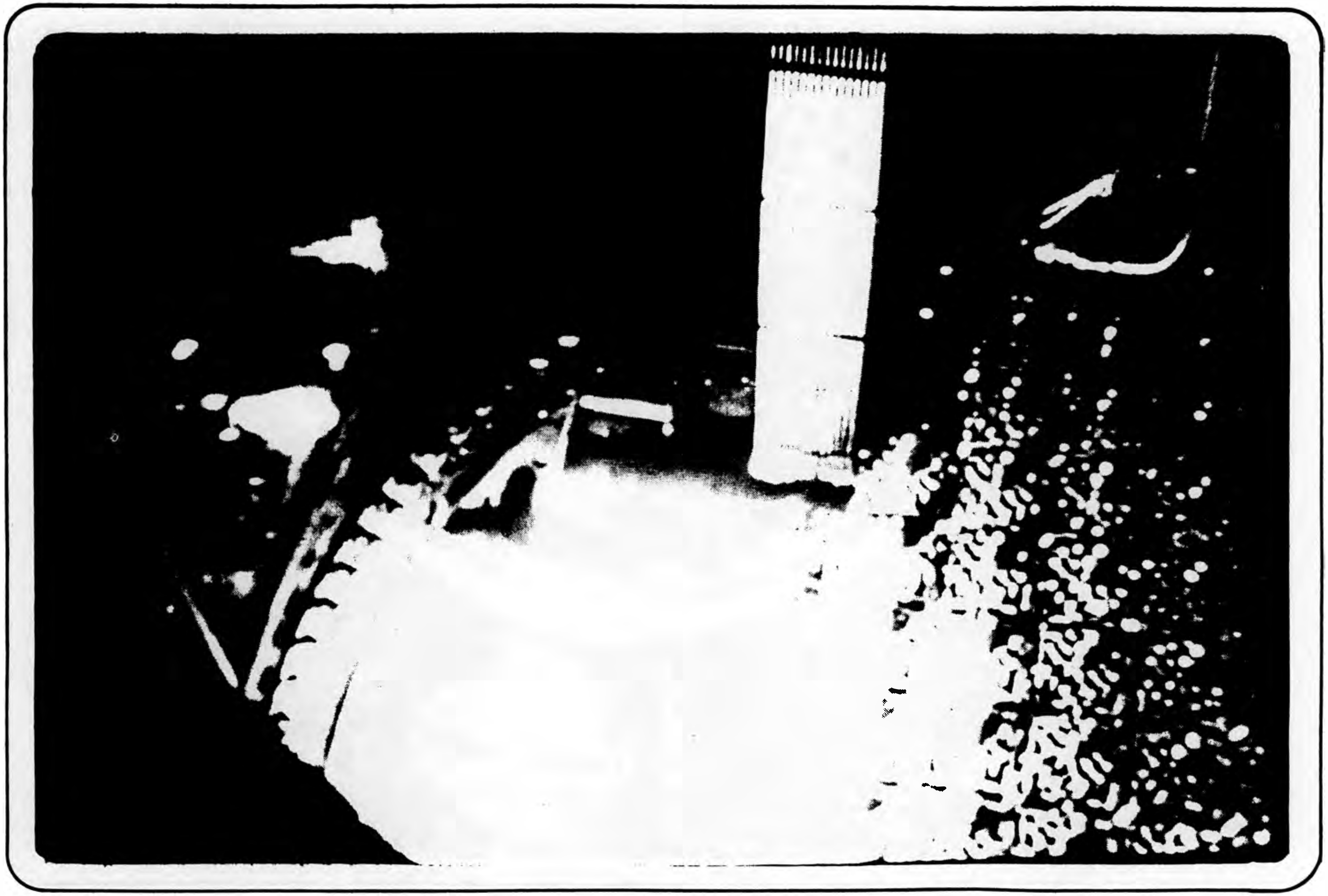


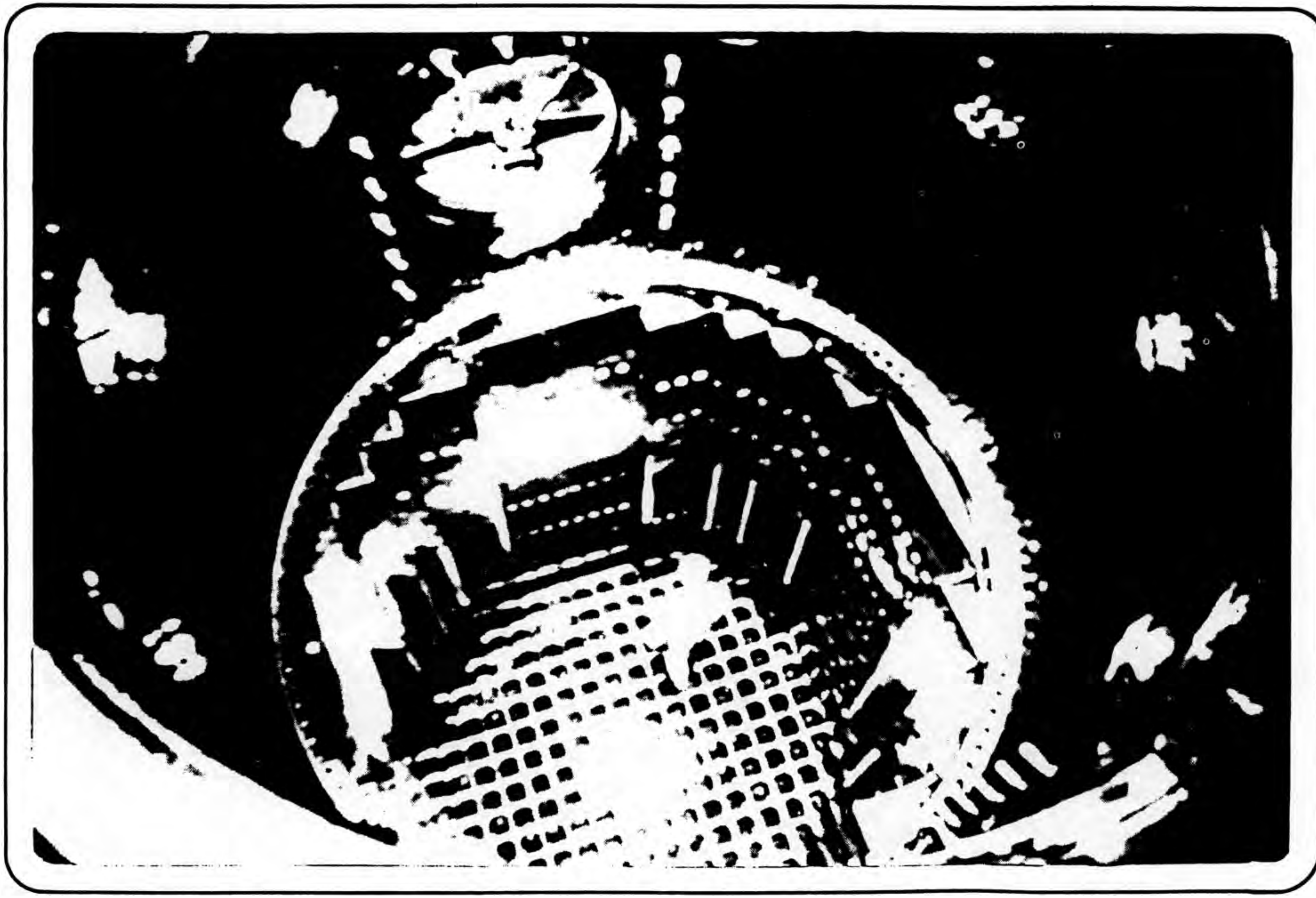

HEAD STORAGE STAND
(WITH HEAD SHOWN IN
STORAGE POSITION)
PENDANT
EL. 351'6"
FL. EL. 347'6"
TOOL MAST
ON AUXILIARY
BRIDGE
MANIPULATOR
(RETRACTED)
VACUUM
SYSTEM
MANIPULATOR
ALTERNATE
CAN STORAGE
CAN
STAGING

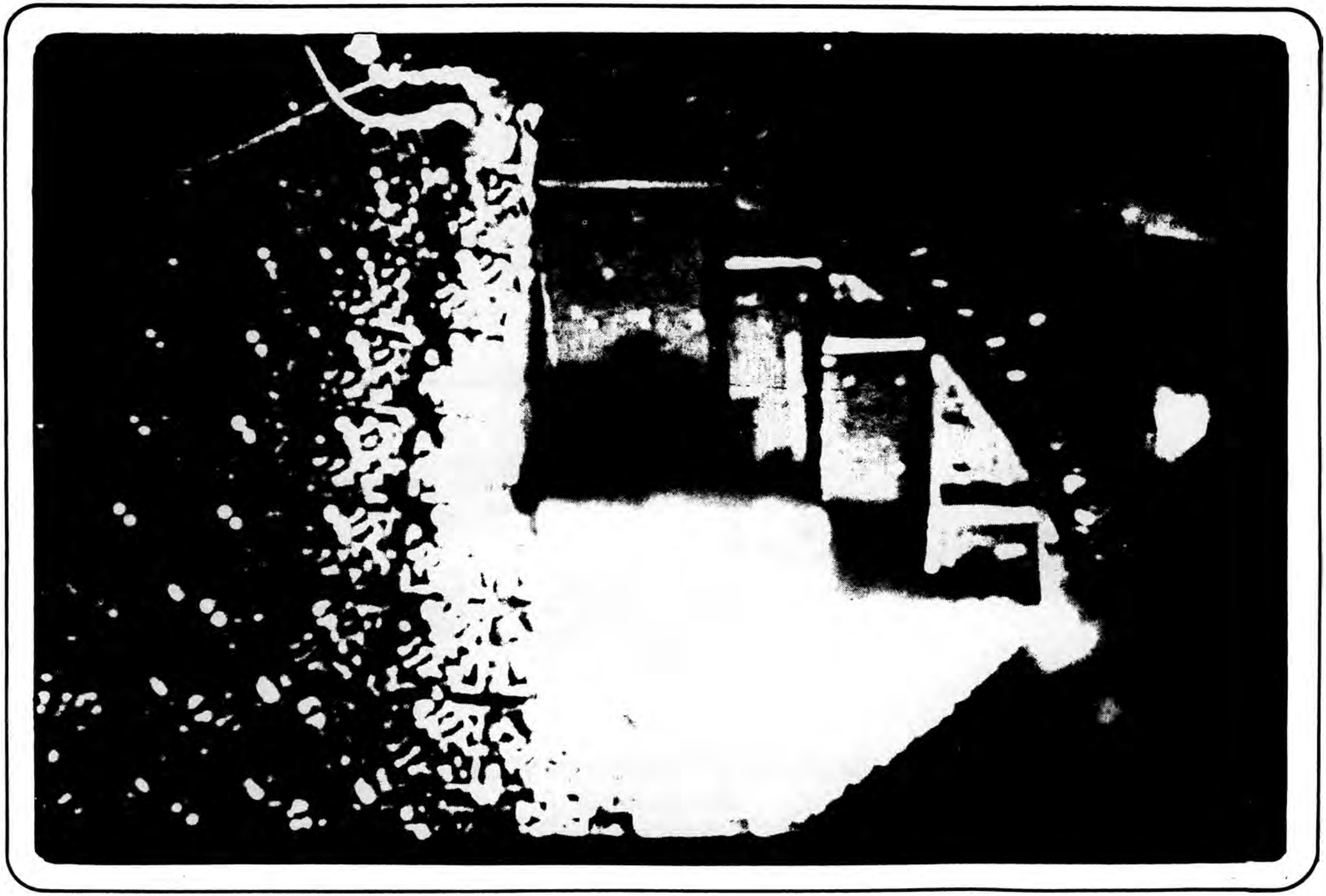
CONCEPT FOR MANIPULATOR PLACEMENT



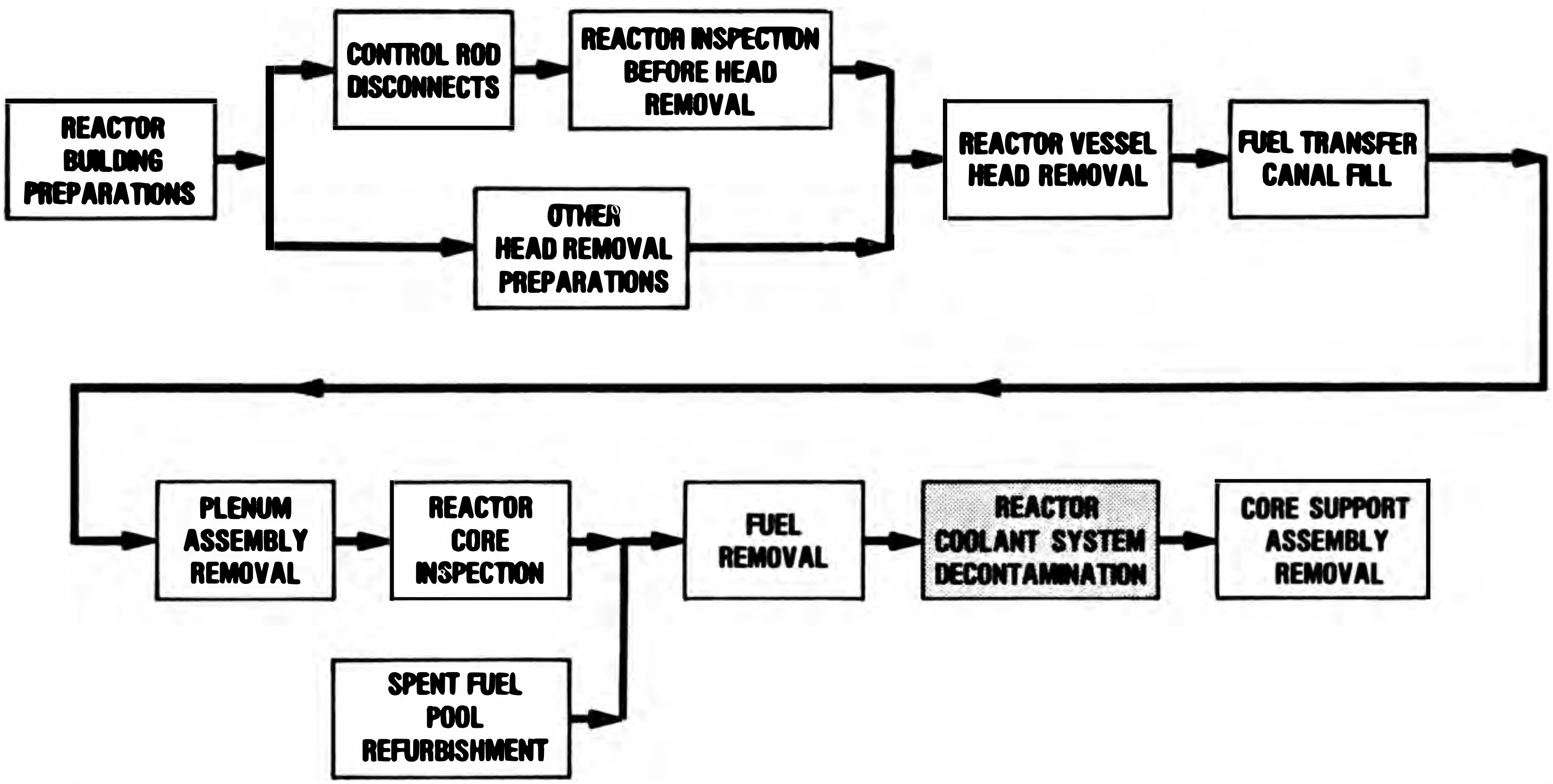




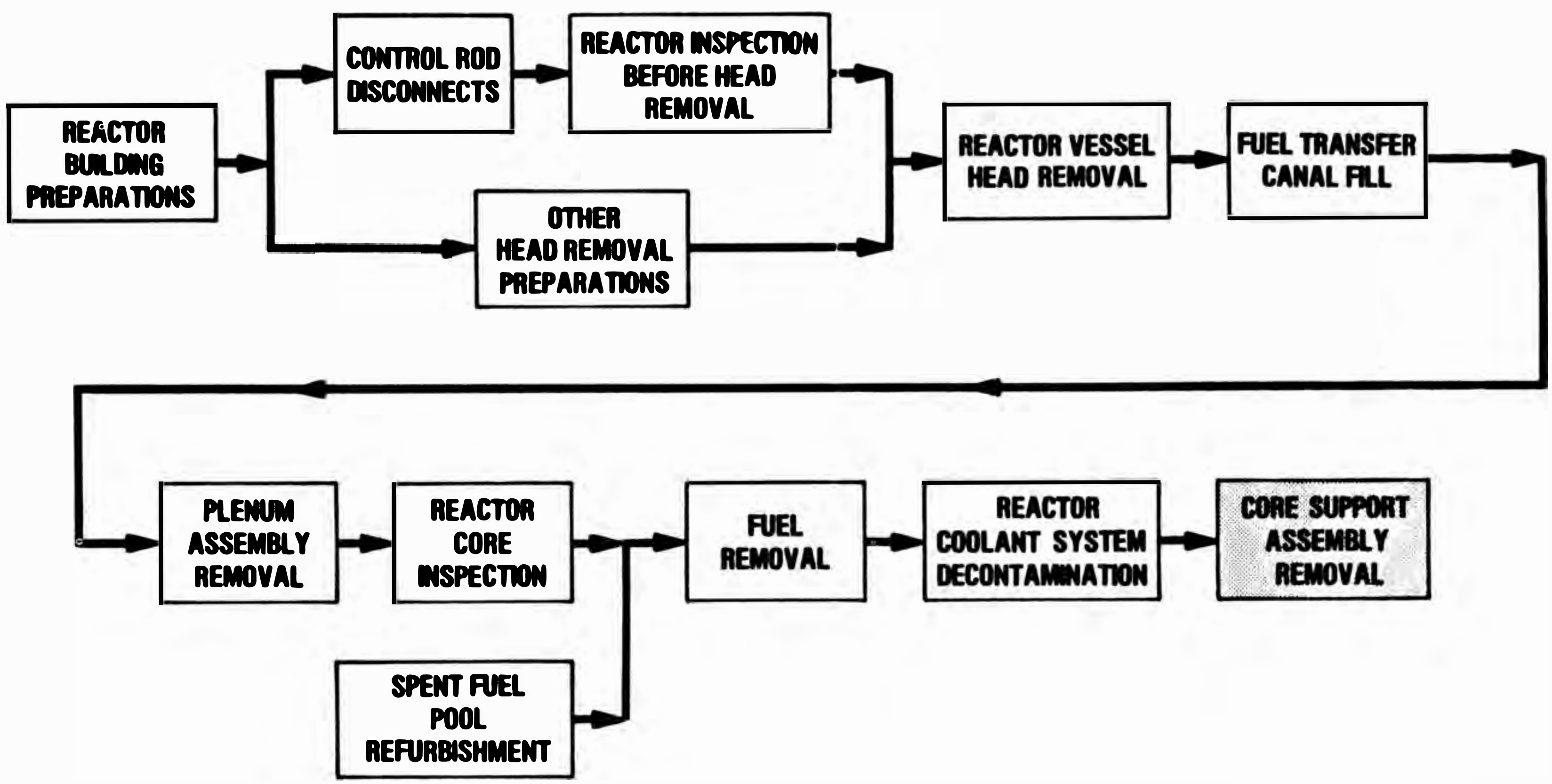


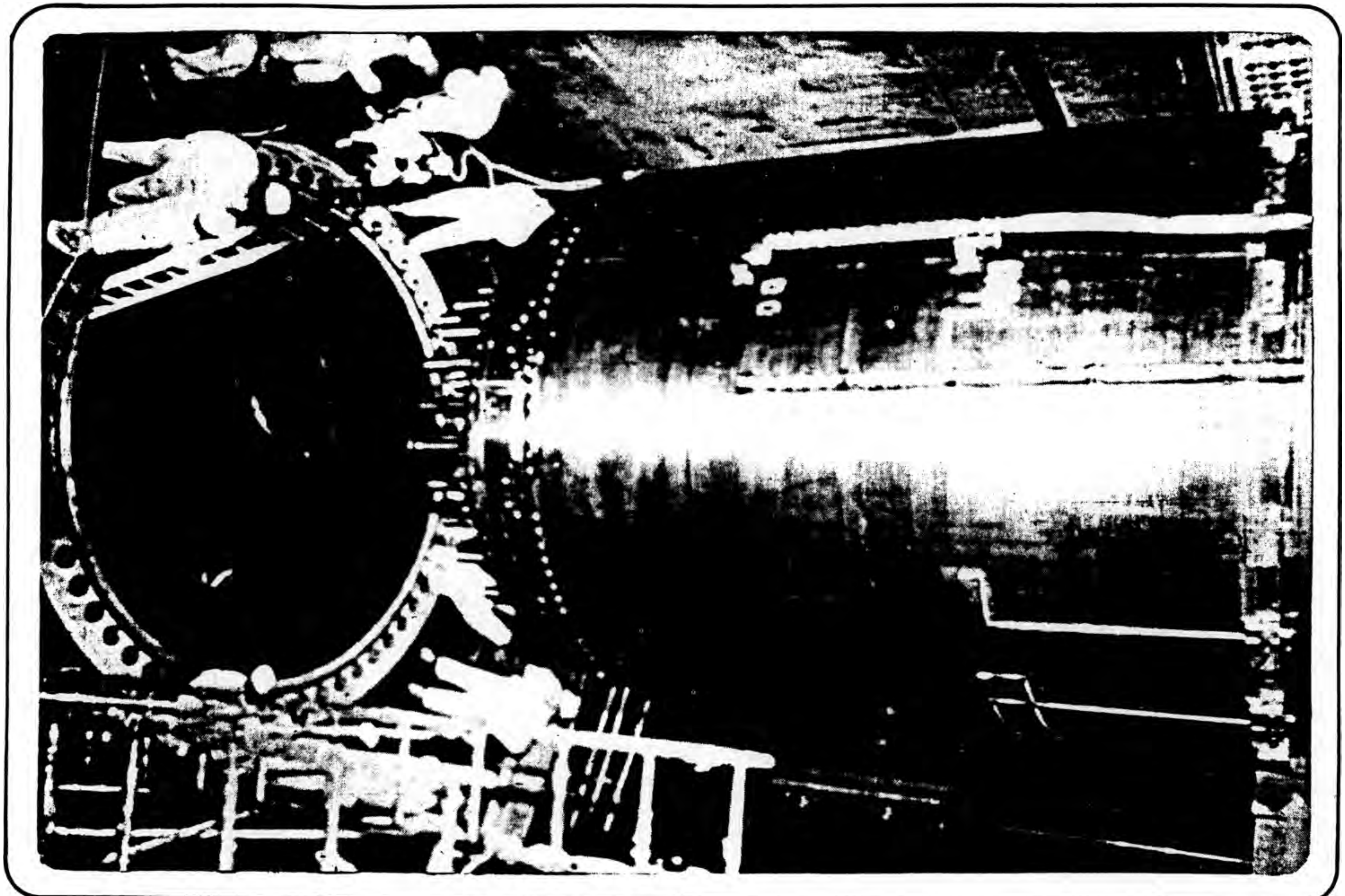


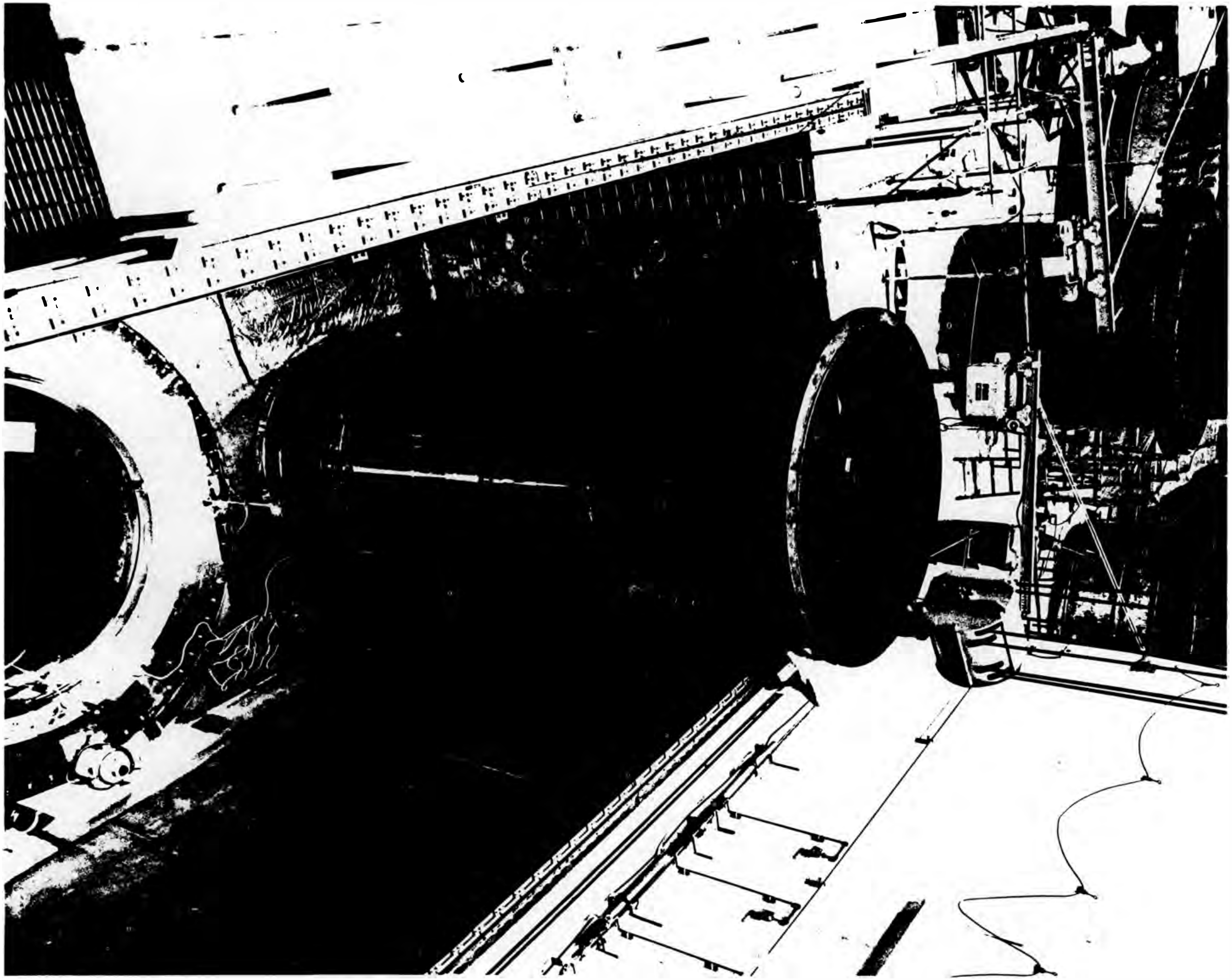
SEQUENCE FOR REACTOR DISASSEMBLY AND DEFUELING



SEQUENCE FOR
REACTOR DISASSEMBLY AND DEFUELING







TMI-2 REACTOR EVALUATION PROGRAM

H. M. Burton

EG&G Idaho, Inc.

TMI-2
Domestic
Seminar

TMI-2 Reactor Evaluation Program

H.M. Burton
EG&G Idaho, Inc.
Technical Integration Office

December 1981

TMI REP-1

The Reactor Evaluation Program

Will Contribute to the Development of Nuclear Power

- Provides
  - Technology for post-accident recovery
  - Data on accident effects
  - Technology for TMI-2 core and internals removal

TMI REP-2

The Reactor Evaluation Program

Provides Technology for Post-Accident Recovery

TMI REP-3

Post-Accident Recovery Technology

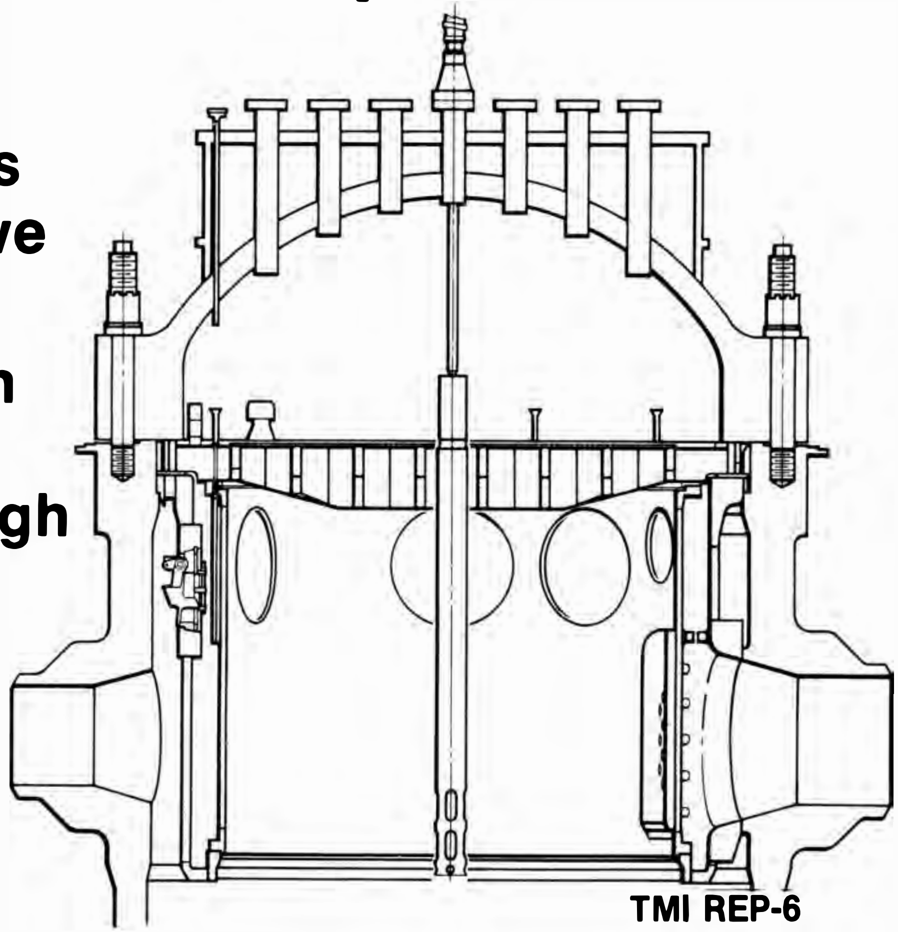
- Contingency CRDM removal equipment and techniques
- Through-head inspection and sampling techniques
- Head removal techniques
- Plenum removal techniques
- Fuel removal techniques
- Canning and accountability technology

CRDM and Through-Head Work Require Special Techniques

- Possible condition
  - CRDM leadscrews may be fused to spiders
  - Radiation levels may be higher than normal defueling levels
  - Plenum internals condition unknown
- Status
  - B&W equipment developed
  - Inspection scheduled for last quarter 1982

Head Removal Techniques

- Possible condition
  - Remaining leadscrews may require destructive separation
  - Underhead spraydown may be required if radiation levels are high
- Status
  - Techniques being developed in 1982



TMI REP-6

Plenum Removal Techniques

- Possible conditions
  - Plenum assembly may be distorted
  - Metallurgical bonding may be present in plenum assembly
  - Fuel or control materials may be bonded to upper grid
- Status
  - Review of destructive removal techniques completed
  - Equipment functional requirements under development

Fuel Removal Techniques

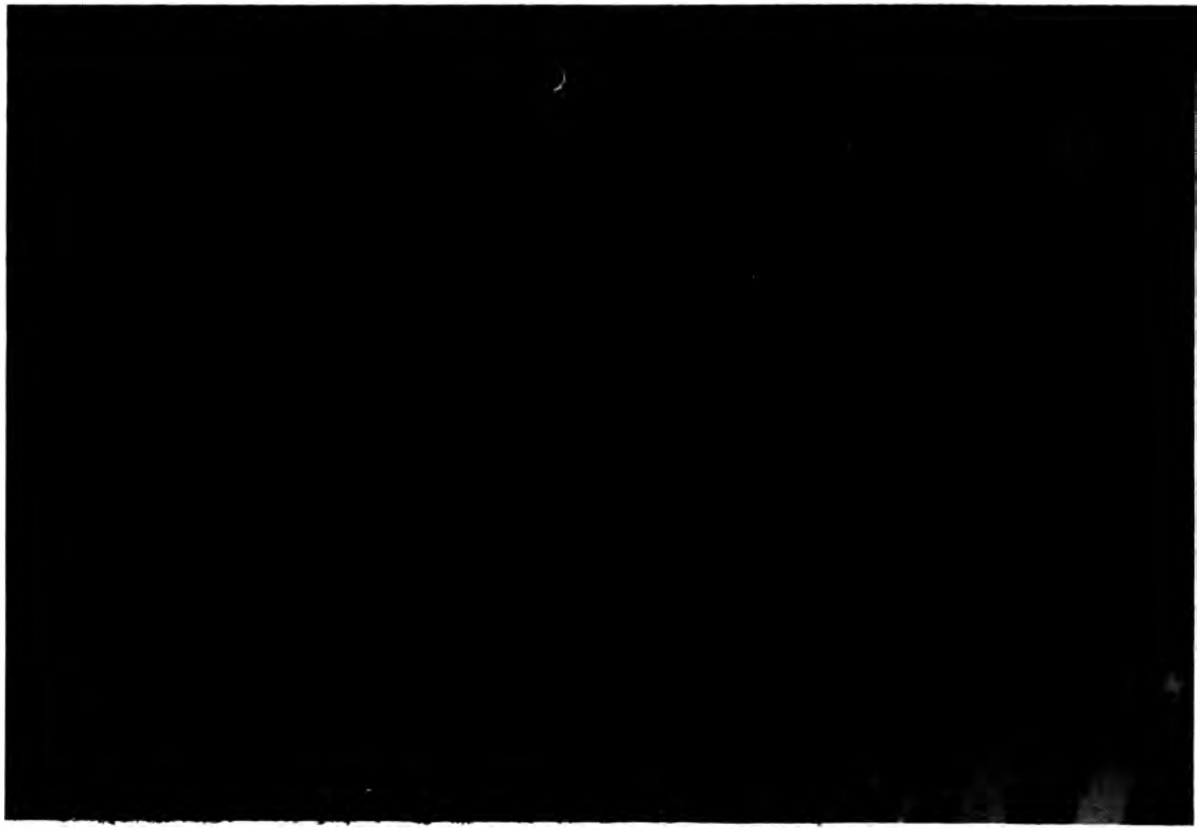
- **Possible condition**
  - Core condition unknown: estimates vary widely
- **Status**
  - Review of tooling requirements and contingencies complete
  - Definition of functional requirements under development prior to initiation of design

Canning and Accountability Technology

- Possible condition
  - Fuel failure condition will require fission product barrier for storage
  - Conventional SNM accountability techniques difficult if fuel is severely damaged
- Status
  - Accountability study for TMI-2 fuel, GEND 016
  - Canister design considerations, GEND 011

The Reactor Evaluation Program

Provides Data on Accident Effects



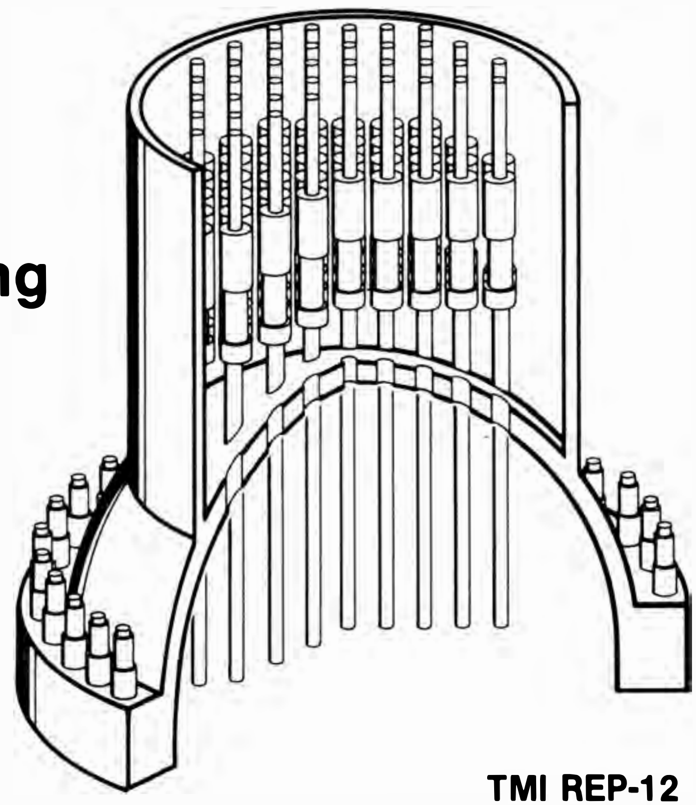
TMI REP-10

Accident Effects

- Provides data on core and reactor internals through
  - Pre-head removal core damage assessment
  - In situ data acquisition

Approach to Core Damage Assessment

- Normal CRDM uncoupling
  - First lowering & venting of reactor coolant system
  - Each successful uncoupling provides core access and later head removal
  - Each unsuccessful uncoupling provides data on conditions



Approach to Core Damage Assessment

- Abnormal CRDM uncoupling
  - Apply B&W supplied equipment to through-head examinations
  - Perform video inspection of plenum and top of core
  - Sample debris on plenum cover
  - Perform underhead radiation survey
  - Remove required CRDMs using contingency tooling

Approach to In-Vessel Data Acquisition

- Identify techniques & develop equipment to document in-vessel conditions for
  - Subsequent analyses
  - Analytical sample selection
  - Defueling process decisions

Approach to In-Vessel Data Acquisition

Identify techniques & develop equipment to

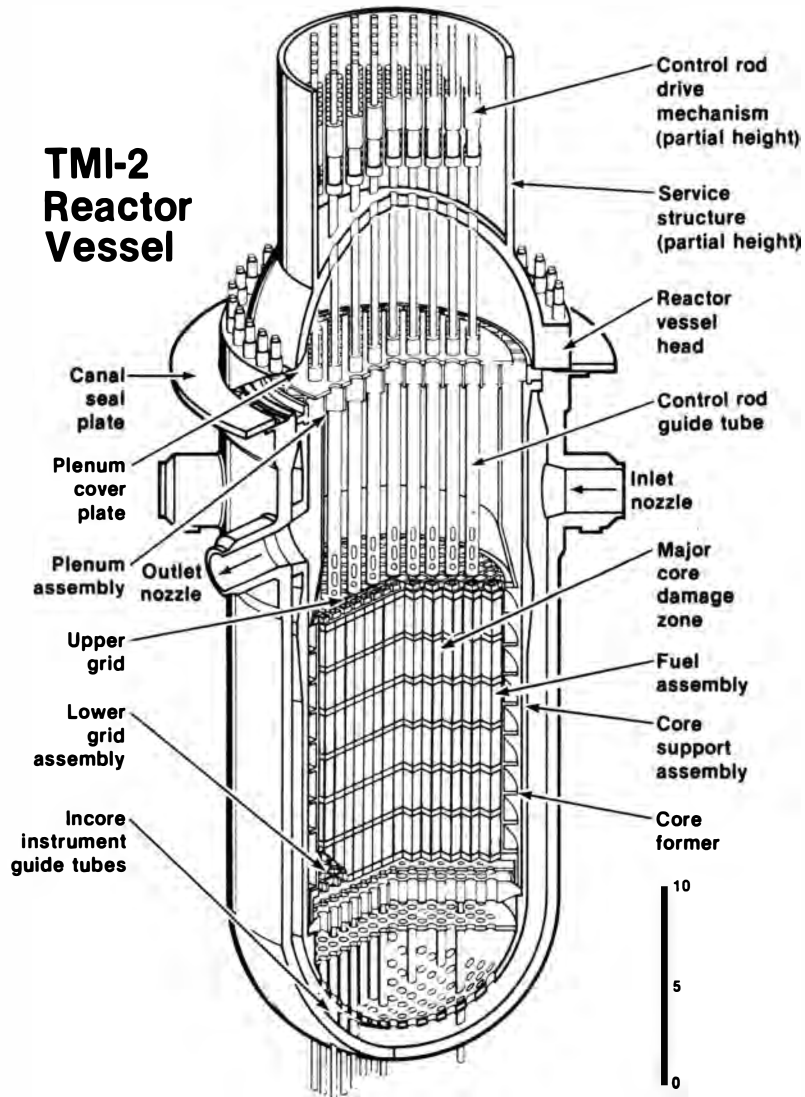
- Provide data in support of specific in situ data needs
- Extract specific sample materials in support of analytical requirements

Phases of In Situ Data Acquisition

- Head inspection
- Post-head removal core damage assessment
- Plenum inspection
- Core examination: prior to and during fuel removal
- Internals inspection after fuel removal

The Reactor Evaluation Program

Provides Technology for TMI-2 Core and Internals Removal



TMI REP-17

Supports Core and Internals Removal

- Upper plenum assembly removal and interim storage
- Core debris removal, canning, and interim storage
- Partial and intact fuel assemblies removal, canning, and interim storage
- TMI-2 core removal for off-site examination

Contributions of the TMI-2 Reactor Evaluation Program

- Provides generic technology for post-accident recovery

- Develops data for improved accident assessment codes, rulemaking bases, and operational safety

- Removes a major obstacle to recovery at TMI-2

CORE EXAMINATION PROGRAM PLAN

J. E. Hanson

EG&G Idaho, Inc.

TMI-2
Domestic
Seminar

Core Examination Program Plan

Presented by

J.E. Hanson
EG&G Idaho. Inc.
December 1981

TMI CEPP-1

Acknowledgements

- Planning Group 7.4
- GEND 001, 7.4, TMI-2 fuel and core component examinations
- Technical Evaluation Group - reactor assessment
- Reactor Evaluation Program
- Data Evaluation Program

Planning Objectives

- Develop rationale and basis for examination program
- Develop recommendations for fuel and component examinations
- Identify required support activities

Planning Basis

- Provide data for
  - Enhanced understanding of accident
  - Assessing accident analysis methods
  - Technical bases for future licensing criteria
  - Accident consequence mitigation
  - Improved operations & maintenance procedures

Data for Assessing Accident Analysis Methods

Data needed	Data obtainable
1. Coplanar flow blockage	1. Radial and axial extent of core blockages and areas of reduced coolability
2. UO_2 dissolution by molten zircaloy	2. Extent of UO_2 dissolution by molten zircaloy
3. Liquid zircaloy relocation and freezing and slag formation	3. Radial and axial extent of liquid zircaloy relocation and freezing and slag formation

Data for Assessing Accident Analysis Methods (cont'd)

Data needed	Data obtainable
4. Debris bed formation and coolability	4. Radial and axial extent of formation and physical, chemical, and hydraulic characteristics of debris
5. High temperature oxidation kinetics of solid and liquid zircaloy	5. Extent of oxidation of UO_2
6. Rod fragmentation upon quenching	6. Thermal shock fragmentation of embrittled fuel rods and other core components during reflood

Data for Assessing Accident Analysis Methods (cont'd)

Data needed	Data obtainable
7. Peak temperature in the core	7. Peak core component temperatures
8. Fission product release, transport, and deposition	8. Fission product retention in fuel and deposition on core components and within the primary system piping
9. Extent and kinetics of inner surface cladding oxidation	9. Extent and thickness of inner surface cladding oxidation
10. Cladding deformation and rupture	10. Bow, ballooning, and rupture of zircaloy cladding

Data for Assessing Accident Analysis Methods (cont'd)

Data needed	Data obtainable
11. High temperature metallurgical interaction between core materials (e.g., eutectics)	11. Interactions between core materials
12. Molten fuel and cladding interaction with coolant and associated energetics	12. Evidence, if any, of rapid deformations and failures of components from pressure pulses, and the formation and dispersal of liquid fuel droplets
13. Neutron absorber material behavior during severe core damage accidents	13. Extent of damage to absorber materials and interaction with other core components

Data for Assessing Accident Analysis Methods (cont'd)

Data needed	Data obtainable
14. Hydrogen evolution	14. Hydrogen evolution can be assessed by measuring extent of UO_2 and zircaloy oxidation
15. Behavior of molten fuel	15. Fuel melting probably did not occur in TMI-2

Data for Future Licensing Criteria

- Definition of coolable geometry
- Criteria for peak cladding temperature and local metal reaction
- Criterion for total hydrogen generation
- Radiological consequences

Data for Accident Mitigation Evaluation

- Inherent mitigators which may have acted
- Potential additional mitigators
- Design features which enhanced or detracted from core coolability
- Material incompatabilities

Data for Reactor Operation and Maintenance

- Potential improved safety instrumentation/survivability
- Replacement of damaged core components
- Assessment of component structural integrity
- Debris removal techniques
- Component decontamination techniques

Supporting Activities

- Encapsulation materials and techniques
- Packaging and shipping
- Archive plan and facility
- Remote examination facilities and equipment
- Surveillance capsule examination

Present Status and Accomplishments

- Initial planning completed 7.4 report
- Recommendations made to technical working group
- Encapsulation feasibility study begun
- Special nuclear material accountability study completed
- Core damage specification study completed

Present Status and Accomplishments (cont'd)

- Archiving, repackaging, and preliminary examination site selected
- Technical Evaluation Group formed
- Detailed in situ data acquisition planning underway
- Detailed core examination planning underway

PRE-HEAD REMOVAL REACTOR EVALUATION

G. E. Kulynych

Babcock & Wilcox

TMI-2
DOMESTIC SEMINAR
PRE-HEAD REMOVAL REACTOR EVALUATION

Presented by
G.E. Kulynych
Babcock & Wilcox

December 1981

TMI-2
Pre-Head Removal Reactor Evaluation

Objectives

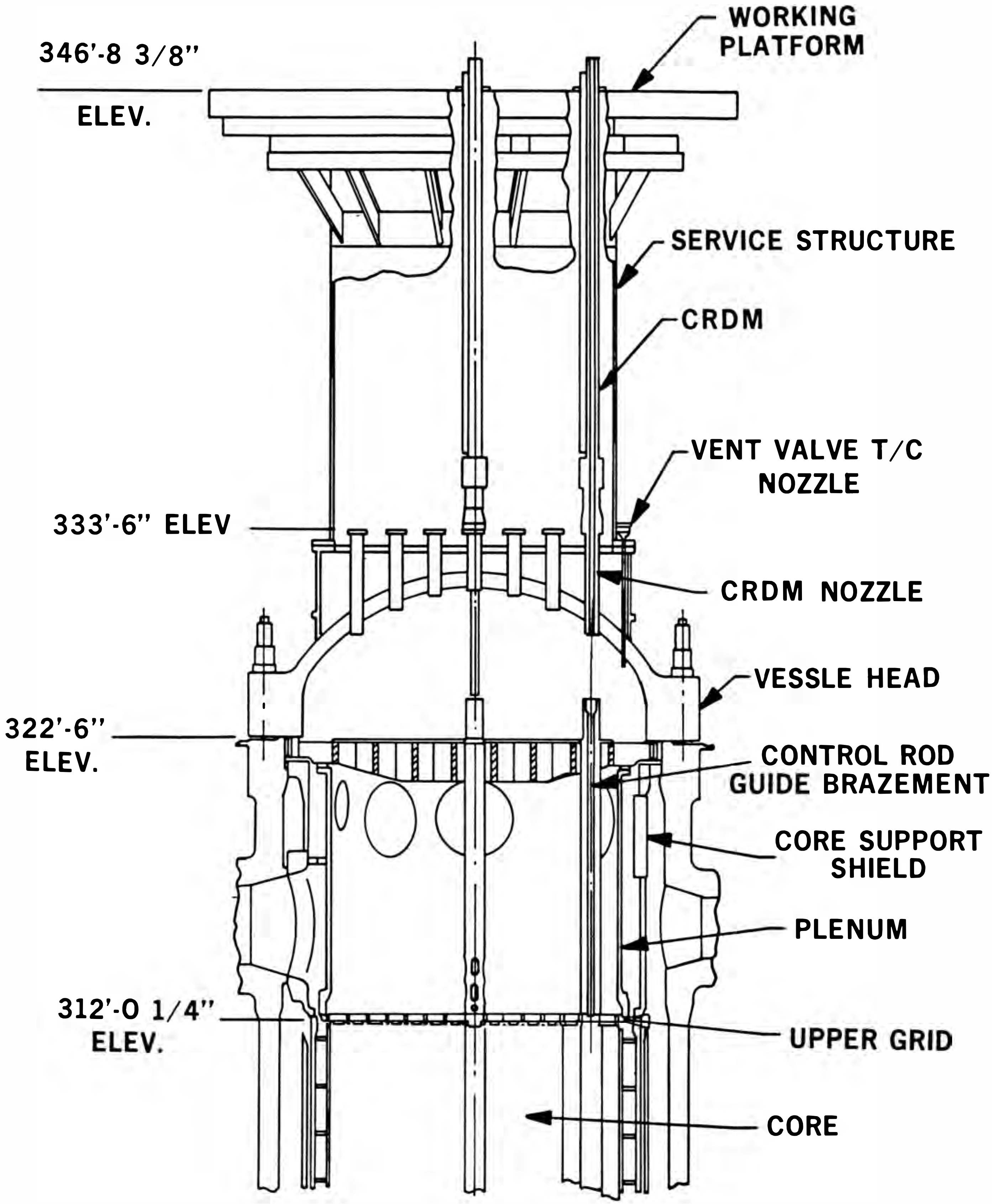
- Conditions Inside Reactor Vessel
- Benchmark Range of Core Damage Estimates
- Develop Tooling for CRDM Separation

TMI-2
Pre-Head Removal Reactor Evaluation

Key Elements of Program

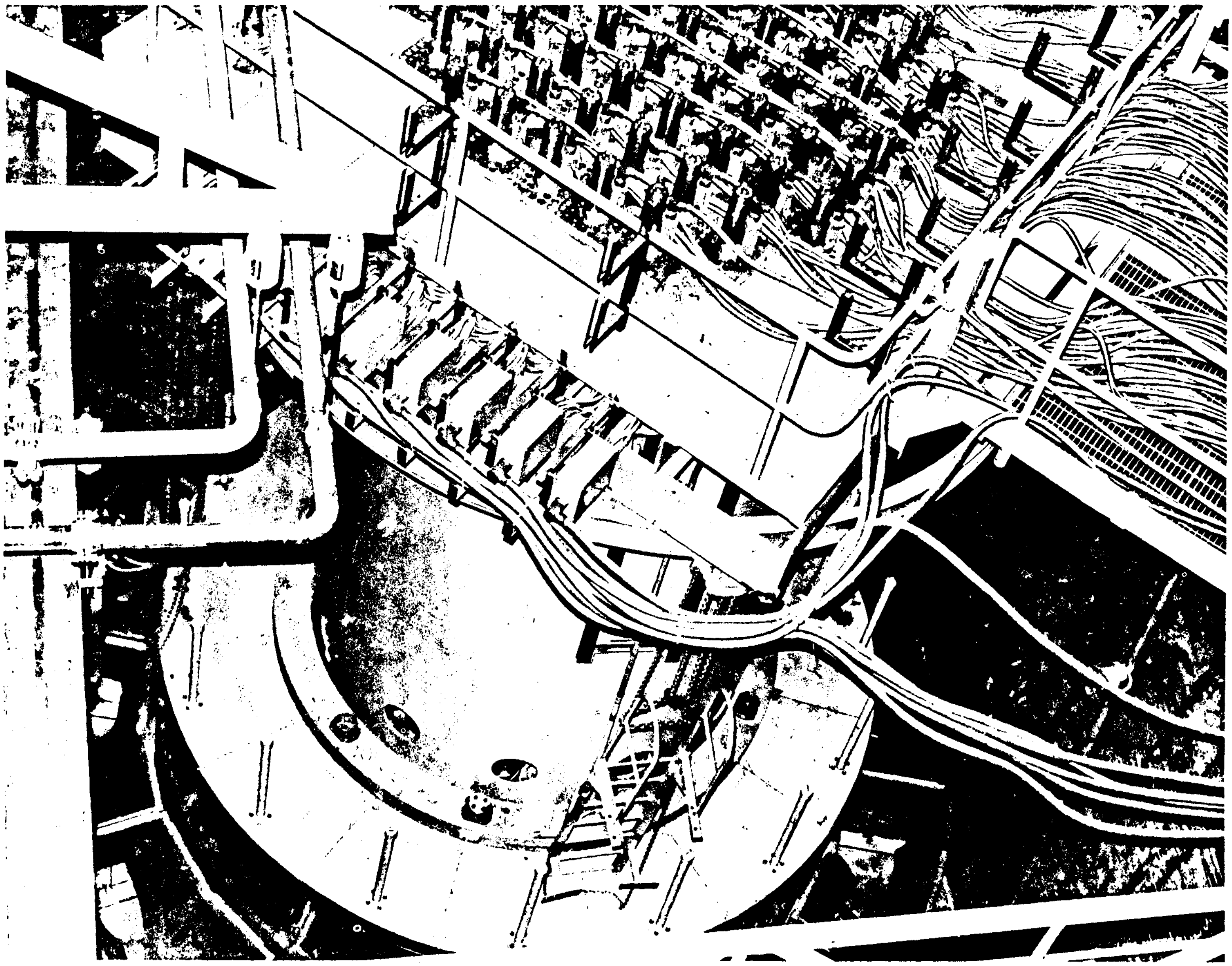
- Selection of Access Path
- Radiological Control System
- Water Level Monitoring System
- Contingency Tooling for Creating Abnormal Access
- Develop Manipulators and Select Inspection Equipment
- Sample Tool

Reactor & Service Structure

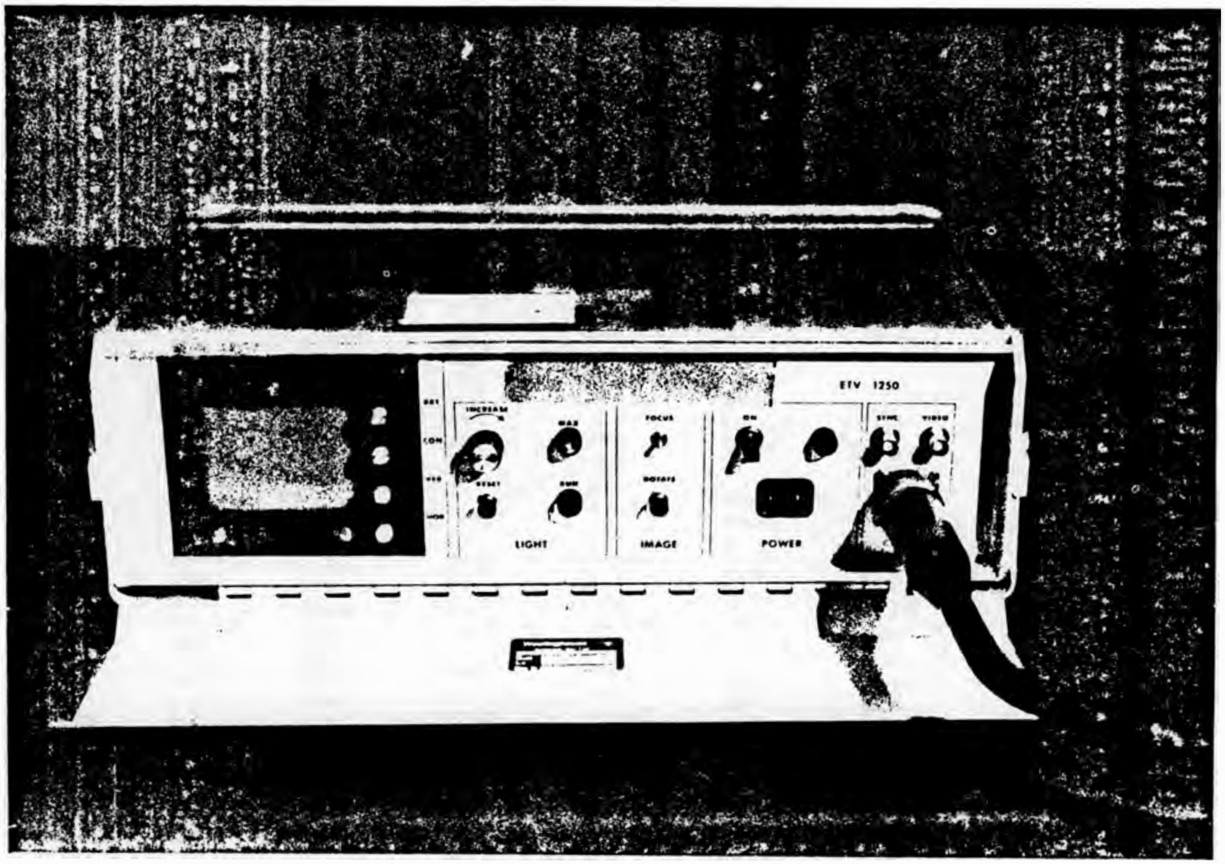


Reactor Internals -- Plenum Assembly

Reactor Head and Service Structure



Camera Control Unit

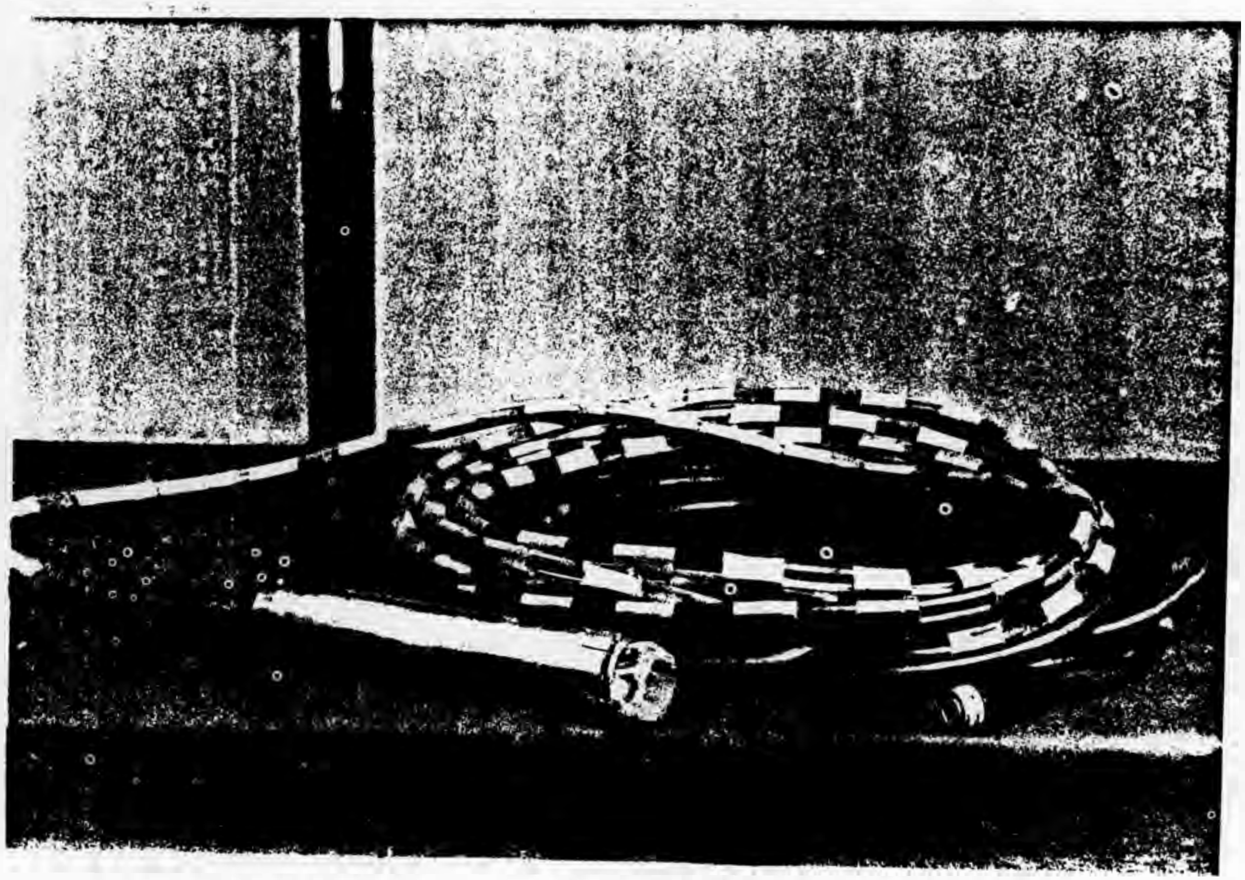


TMI-2
Pre-Head Removal Reactor Evaluation

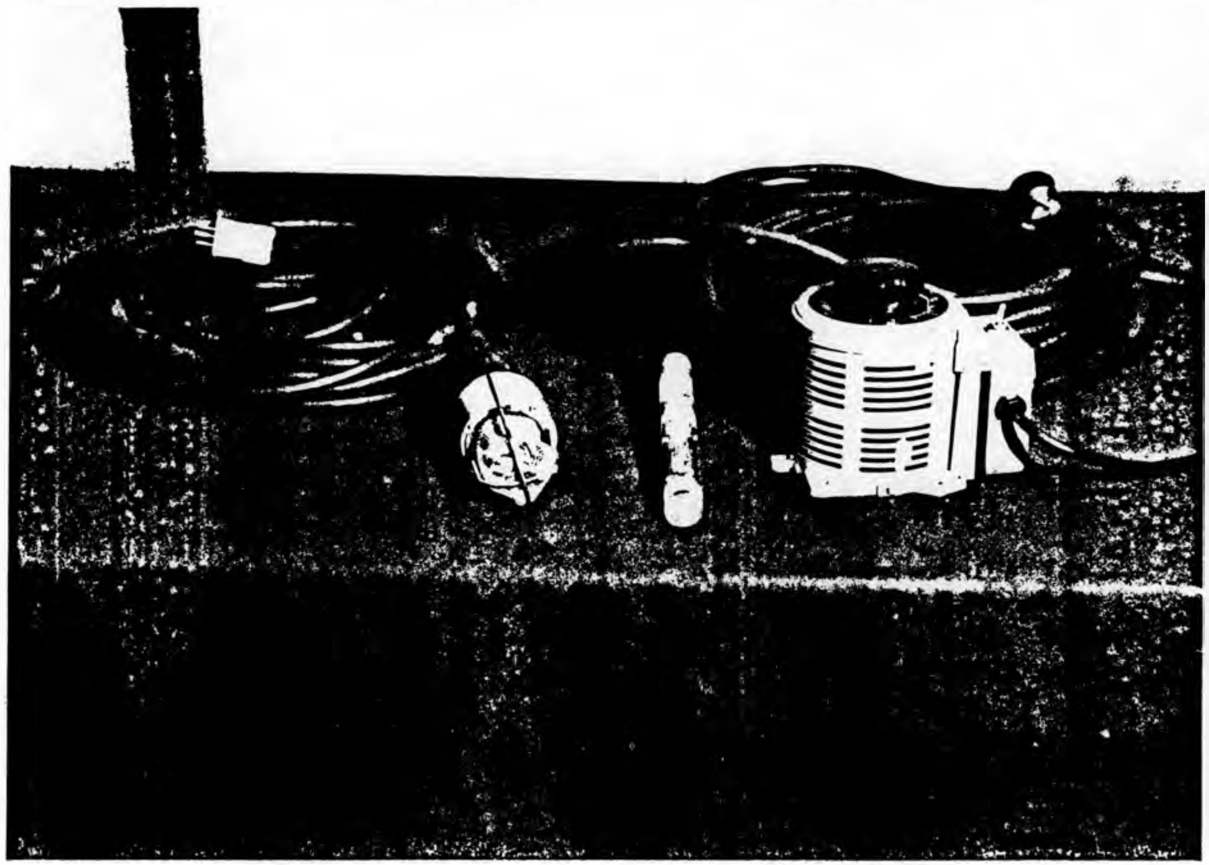
Typical Equipment Under Development

- Camera Control Unit
- Camera with Shield
- Underhead Special Lighting
- Underhead Camera Manipulator
- Manipulator Guide Tube
- Mechanical Leadscrew Separator
- Underhead Leadscrew Cutting Tools
- Underhead Plasma Cutter and Clamp
- Plenum Cover Sample Tool

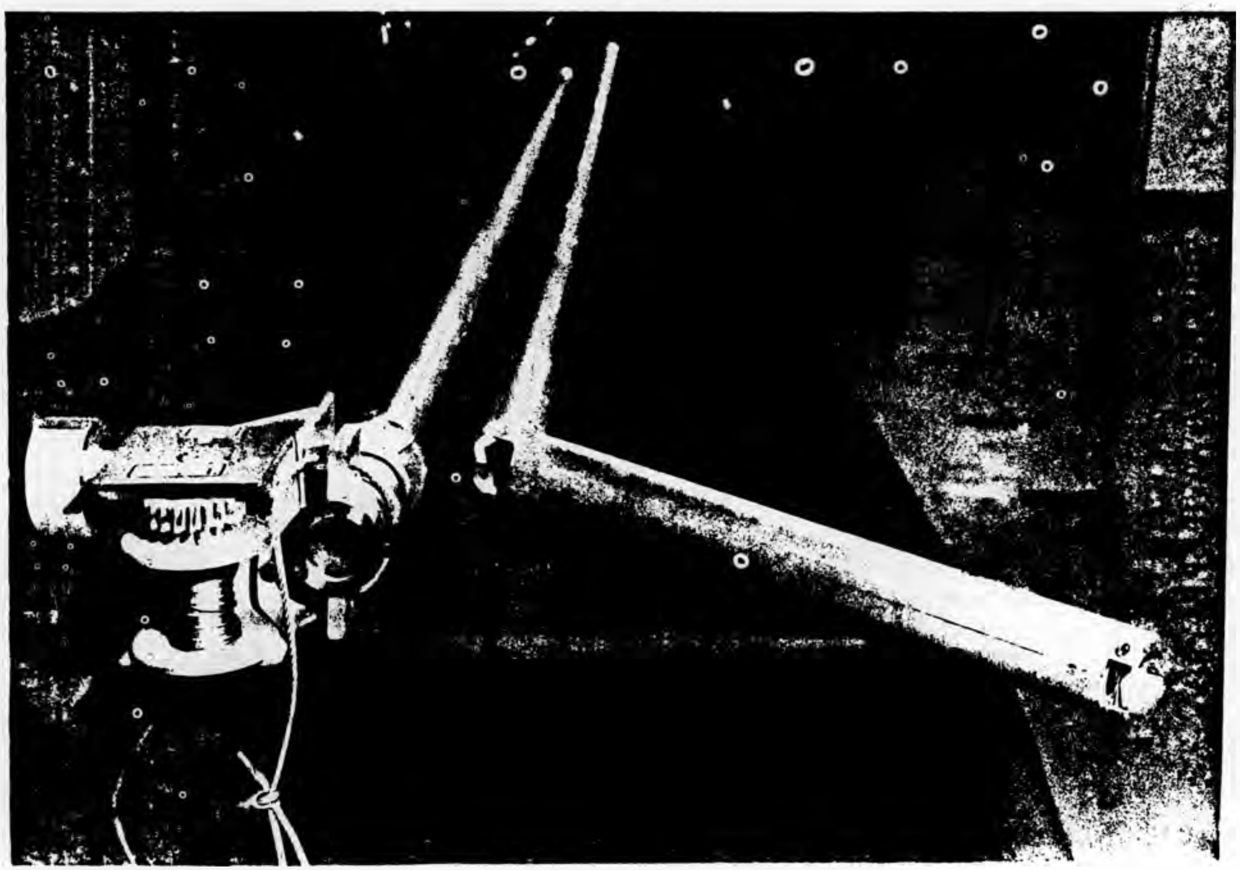
Camera With Shield



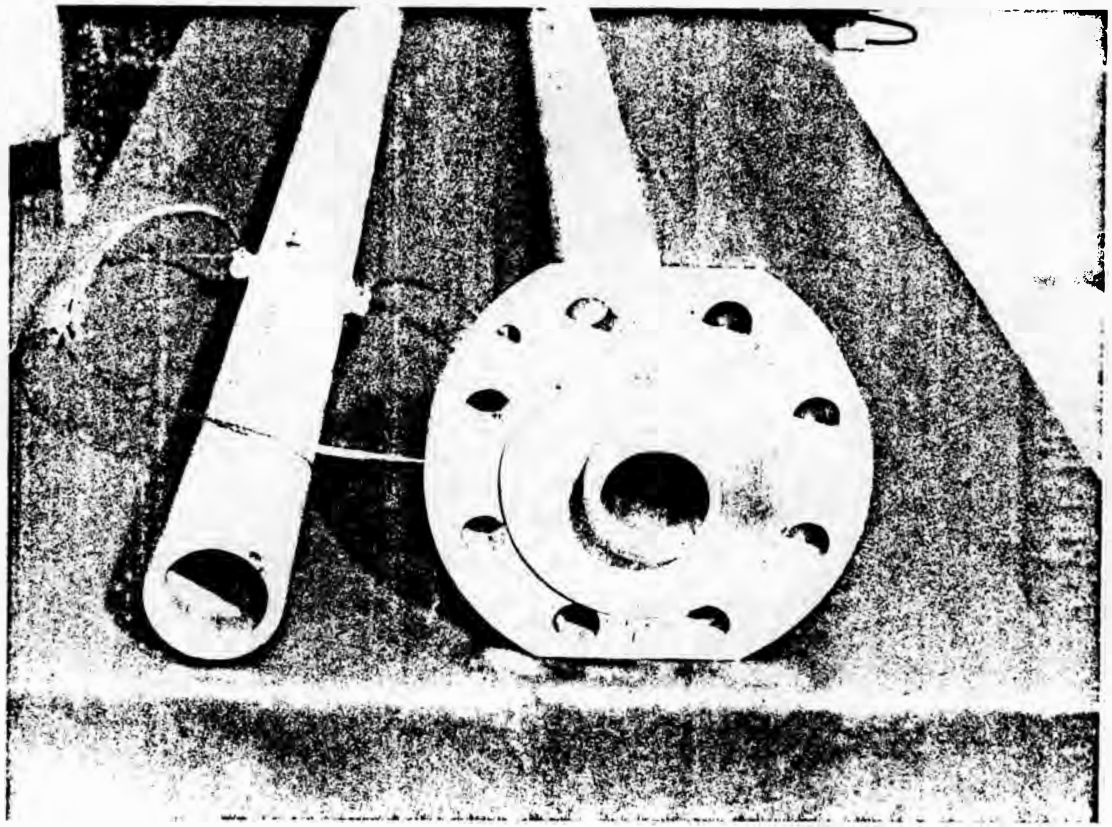
Underhead Special Lighting



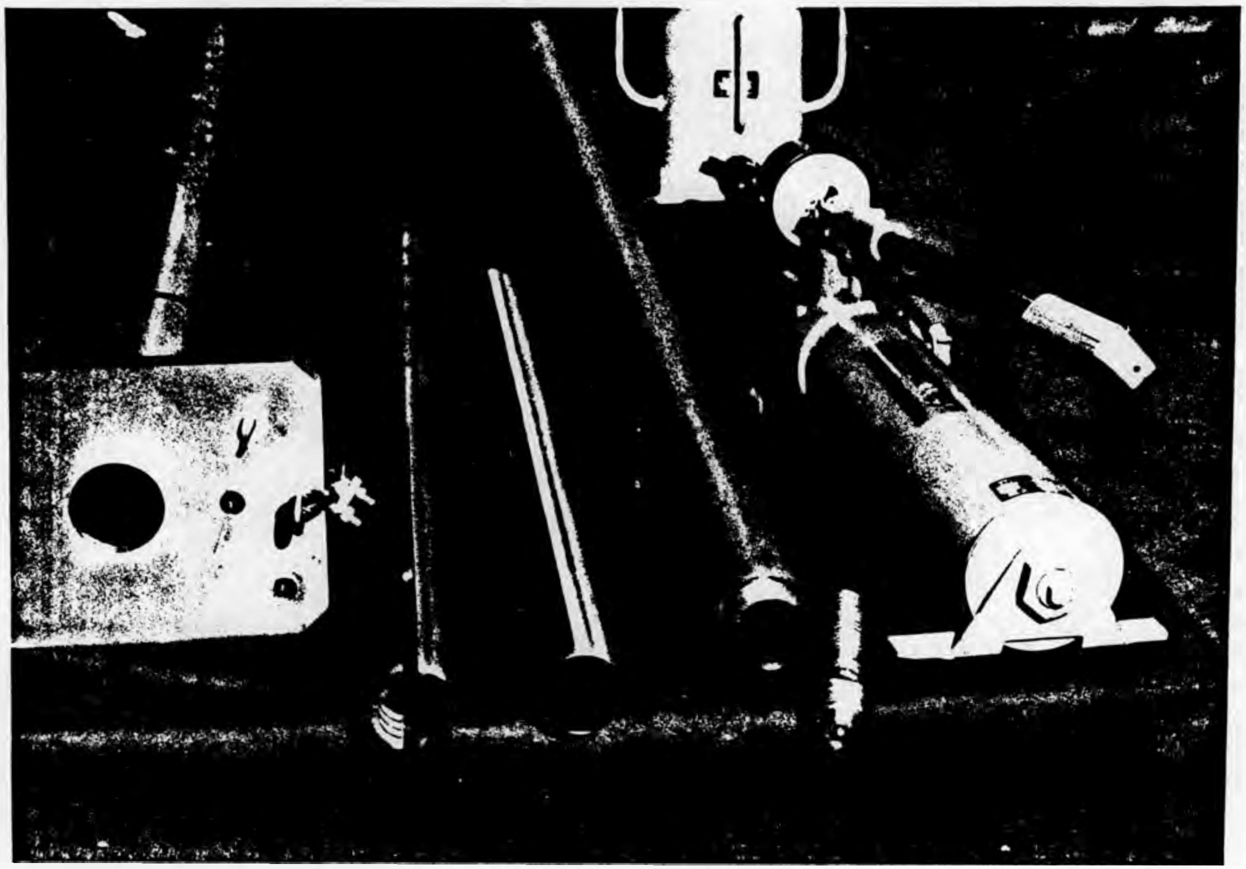
Underhead Camera Manipulator



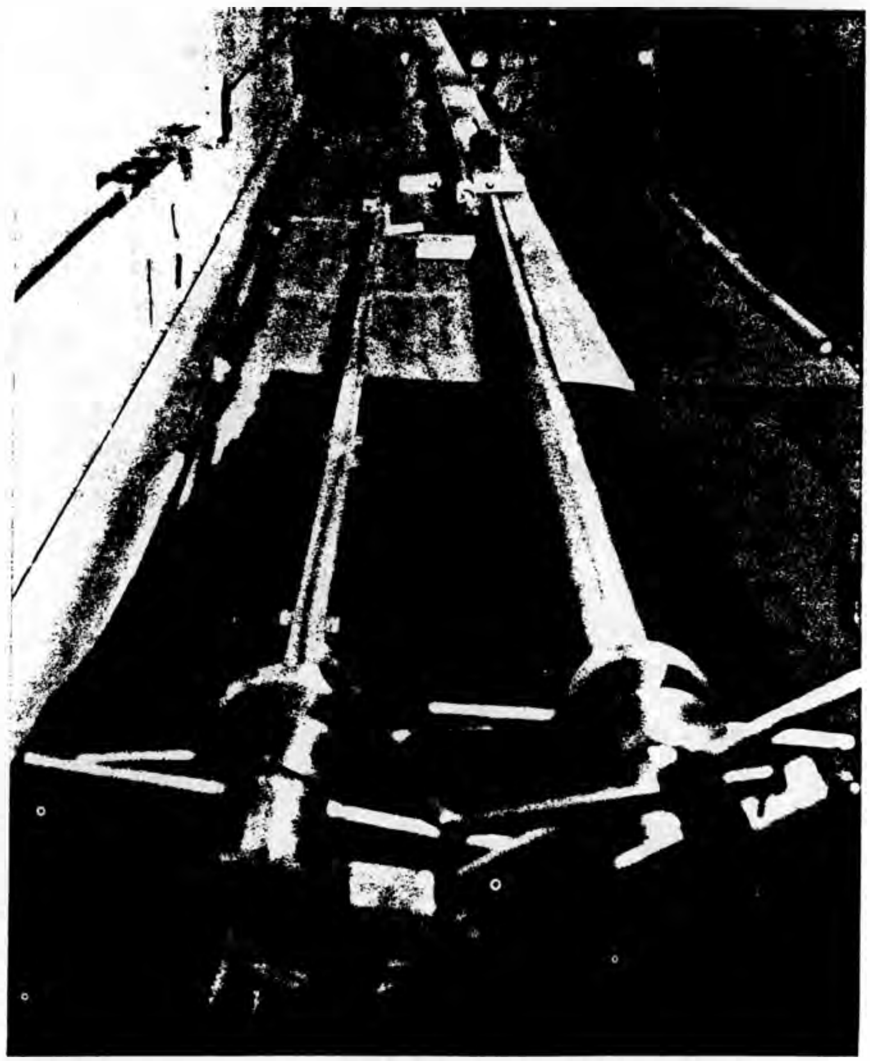
Manipulator Guide Tube



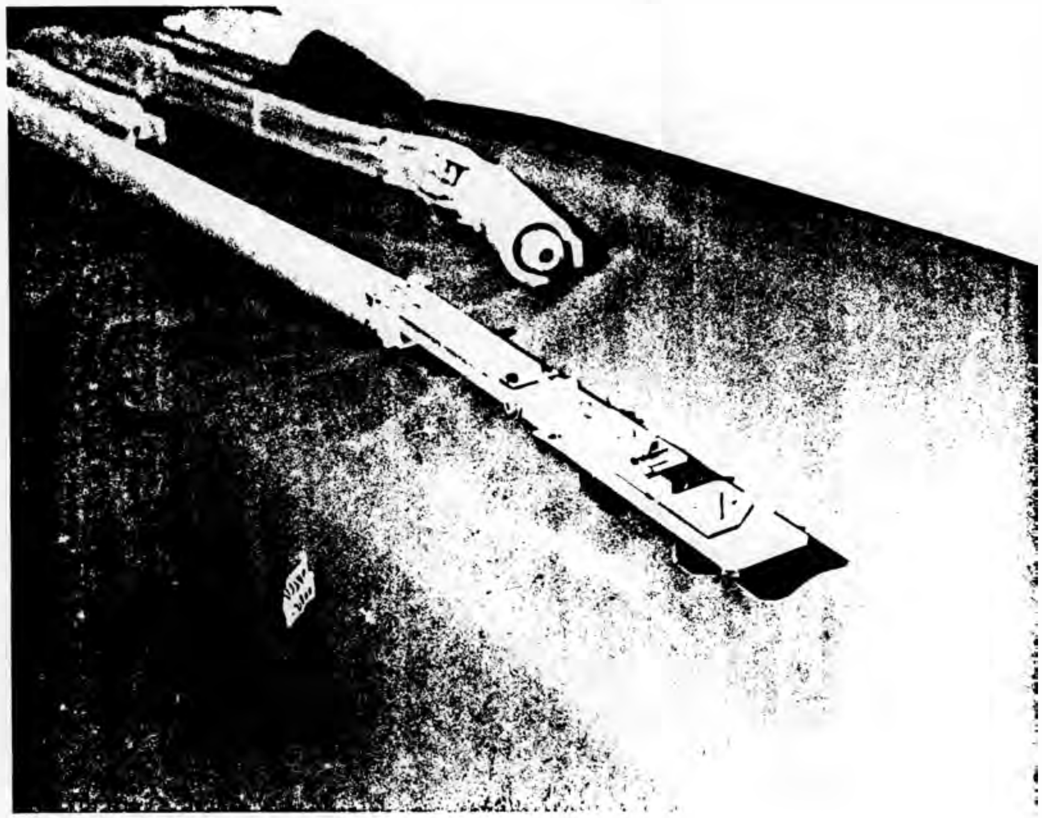
Mechanical Leadscrew Separator



Underhead Leadscrew Cutting Tools



Underhead Plasma Cutter and Clamp



Plenum Cover Sample Tool