HEDL-SA-1795

FFTF STATUS AND TEST RESULTS

B.H. Noordhoff

April 1979

Los Angeles Chapter
American Nuclear Society

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HANFORD ENGINEERING DEVELOPMENT LABORATORY
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Richland, Washington 99352

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For Presentation at the Los Angeles Chapter, American Nuclear Society
Meeting in Los Angeles, California, April 19, 1979

FFTF STATUS AND TEST RESULTS

This SA will provide a general description of the FFTF:

- Construction progress
- Status of startup and selected startup test results
- Planned experiment program during and subsequent to the startup testing program.

The FFTF is a 400 MWt, sodium cooled test reactor plant consisting of a fast-neutron reactor fueled by mixed plutonium oxide-uranium oxide fuel elements, three independent heat transport loops, extensive instrumentation, fuel handling equipment, and auxiliary systems which support the main reactor and cooling systems. The FFTF contains no steam generators, electrical generating equipment, or breeding blankets. Heat generated in the reactor is released to the ambient atmosphere by twelve large sodium-to-air heat exchangers.

The unique features of FFTF and selected plant parameters will be presented (see slides HEDL-7707-218.8 and HEDL-7603-241.5).

After nine years and the involvement of thousands of people and over 200 companies across the nation, the plant's major construction effort was completed by Bechtel in 1978. The remaining construction effort is being completed by the local DOE construction contractor, J. A. Jones, and work is being scheduled to be compatible with startup activities. The estimated cost at completion is within the project budget of $647 million which was established in 1974.

The sodium fill of the secondary heat transport system was initiated on July 2, 1978, two days ahead of the scheduled date. The fill of the primary heat transport system was completed in November 1978. Fuel loading activities are in progress. Initial criticality is scheduled for August 1979, and full power is scheduled for February 1980. This schedule was also established in 1974, and it appears that, although it will be difficult, it is attainable.

Slides showing overall construction status from 1969 through 1977 will be presented.

The startup schedule will be presented and selected results from the following tests will be summarized:

- Integrated leak rate tests of the containment vessel.
- Preheat of the reactor vessel.
- Sodium testing results at 400°F before heatup to maximum isothermal system temperature (MIST).

. Heatup to MIST and MIST testing.

The fuel handling equipment will be discussed and incorporated into a discussion of plans for fuel loading, which is in progress.

Subsequent testing from initial criticality through full power will be described.

The planned experiment program will be discussed covering:

. Absorber assemblies

. Driver fuel assemblies

. Safety experiments

. Characterization assemblies

. Advanced fuel experiments

. Blanket experiments

. Absorber experiments

. Oxide fuel experiments

. Duct experiments

. Advanced pin support concepts

. Clad/duct material experiments

. Miscellaneous experiments

The plans for construction of the supporting Fuel Storage Facility and the Maintenance and Storage Facility will be briefly discussed.

NOTE: The slides forwarded for clearance will be updated, as necessary, to reflect the latest information available at the time the speech is given.

LEFT		RIGHT
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HEDL-SA-1795

Slides

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AGENDA

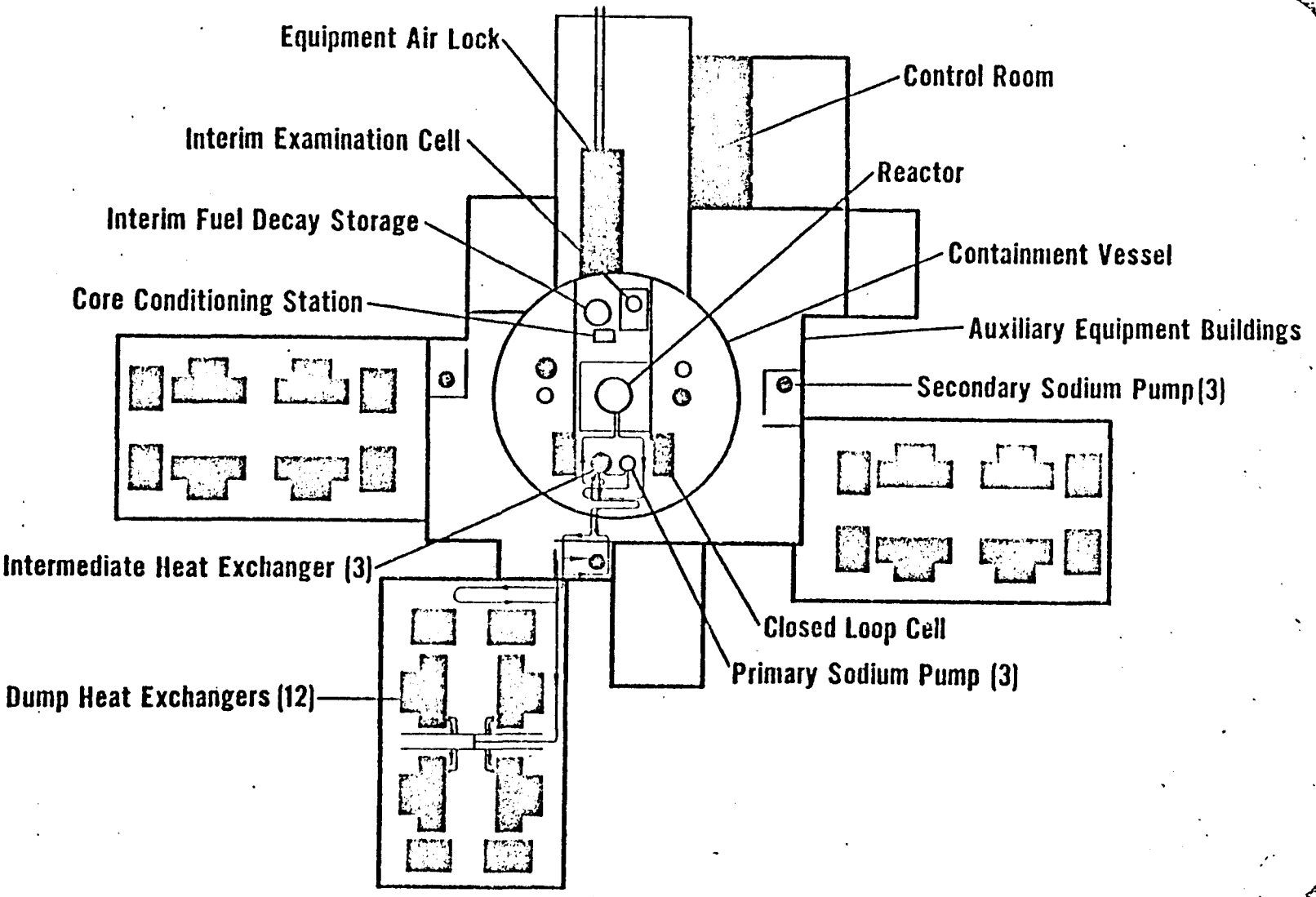
- OBJECTIVES
- DESCRIPTION
- STATUS
- START-UP
- UTILIZATION

KEY MILESTONES COMPLETED

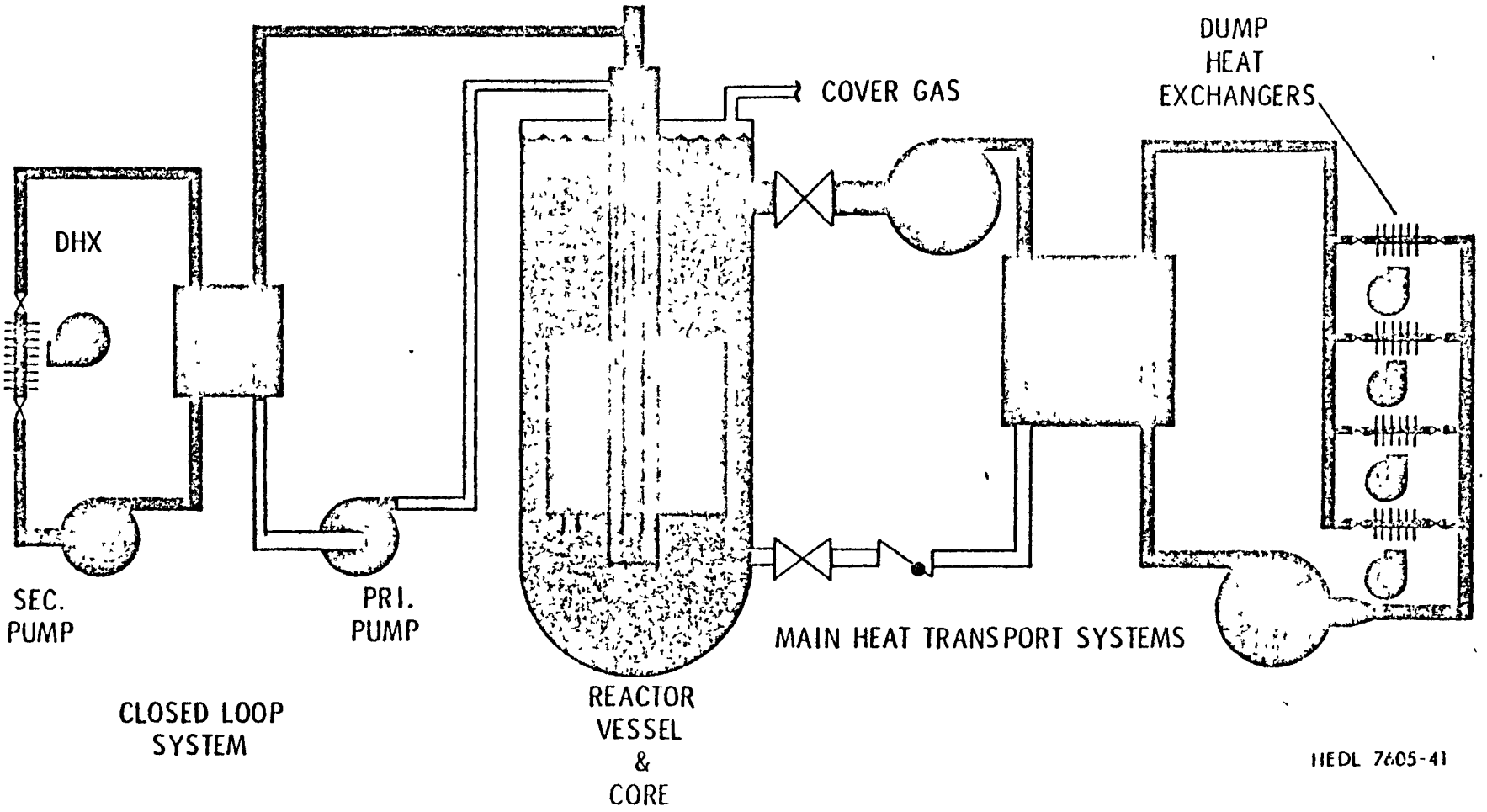
- 90% CONSTRUCTION COMPLETION..... NOVEMBER 1977
- SODIUM FILL OF FIRST LOOP..... JULY 1978
- BECHTEL CONSTRUCTION COMPLETE ... SEPTEMBER 1978
- SODIUM FILL OF PRIMARY SYSTEM..... DECEMBER 1978

FFTF PURPOSE

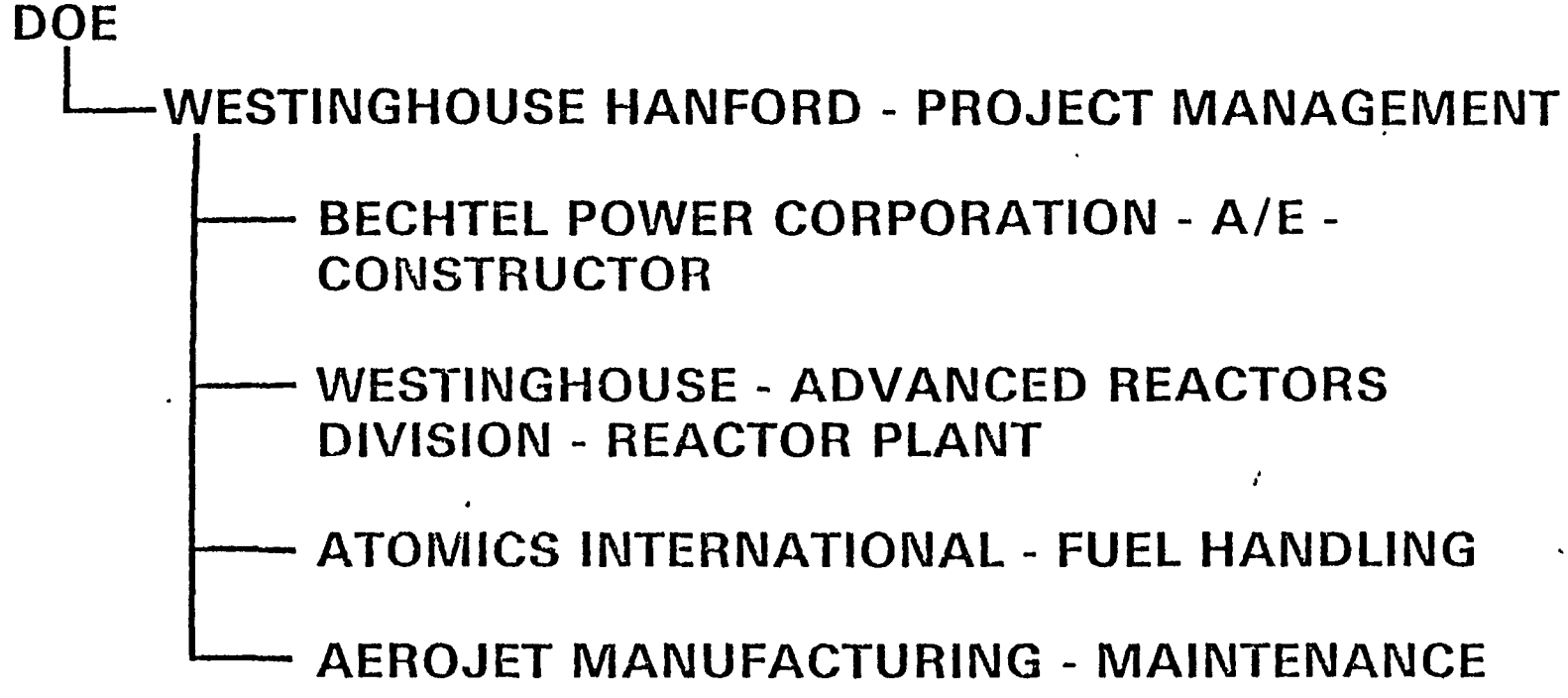
FFTF PLANT ARRANGEMENT



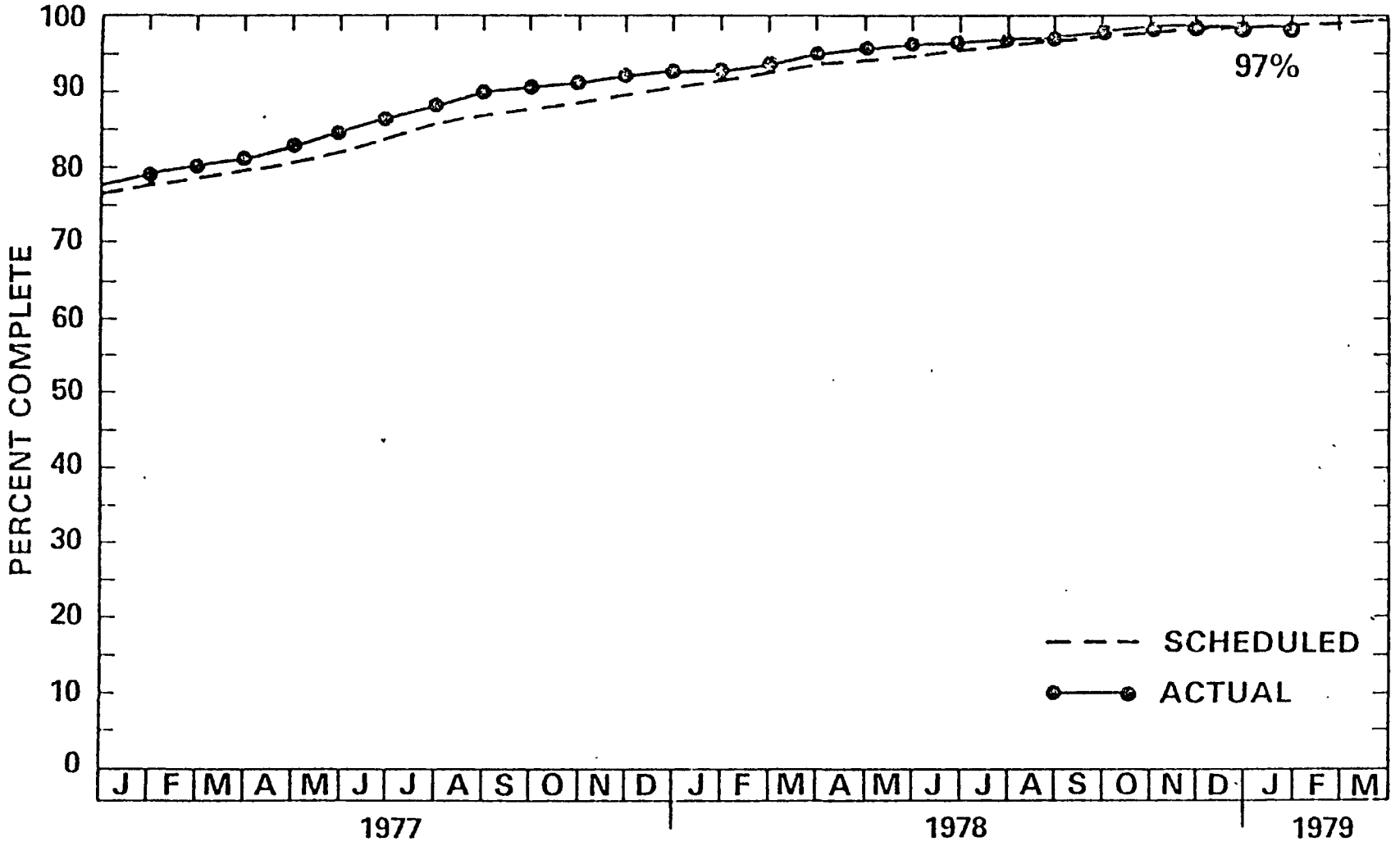
FFTF SODIUM SYSTEMS

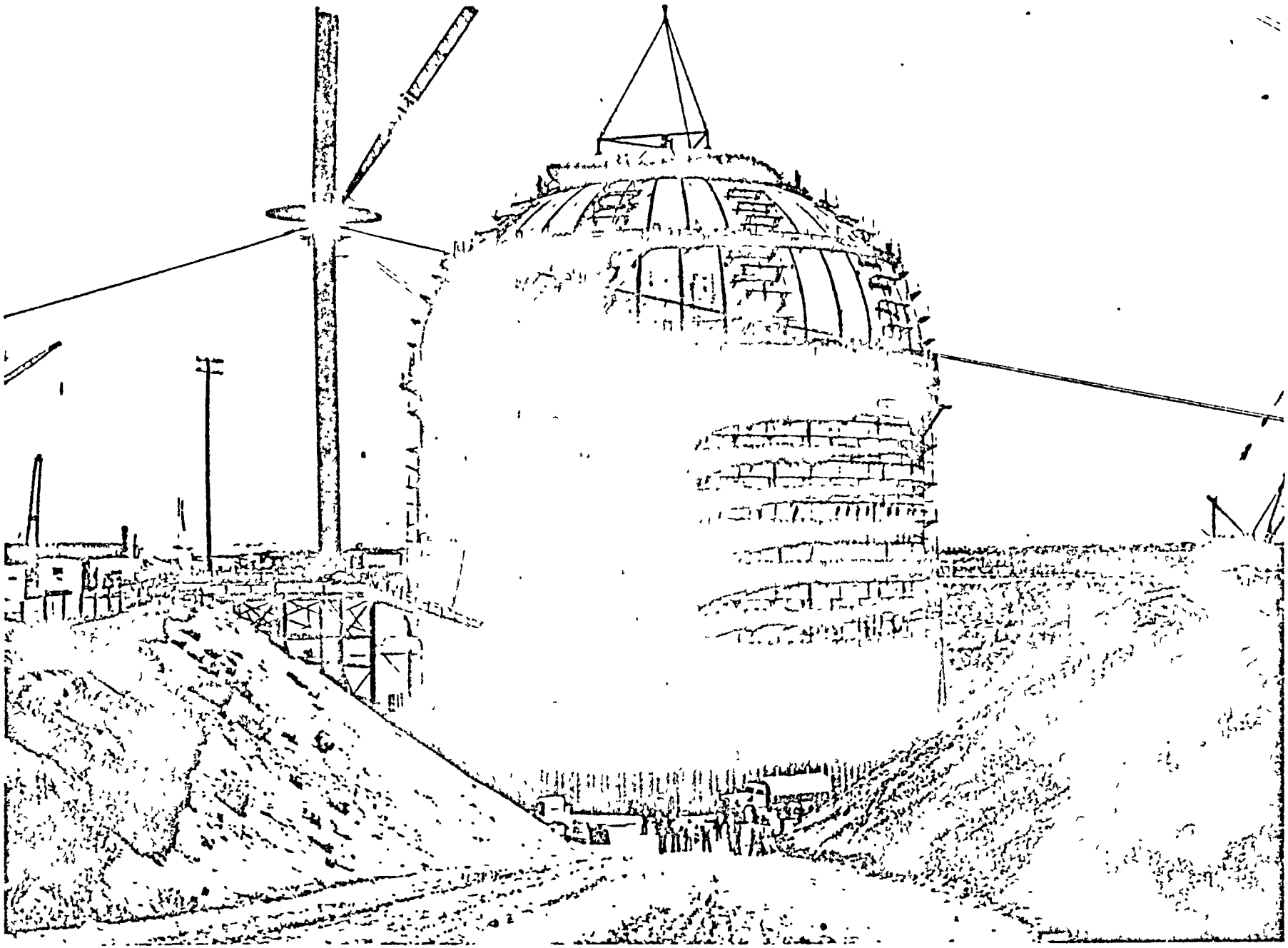


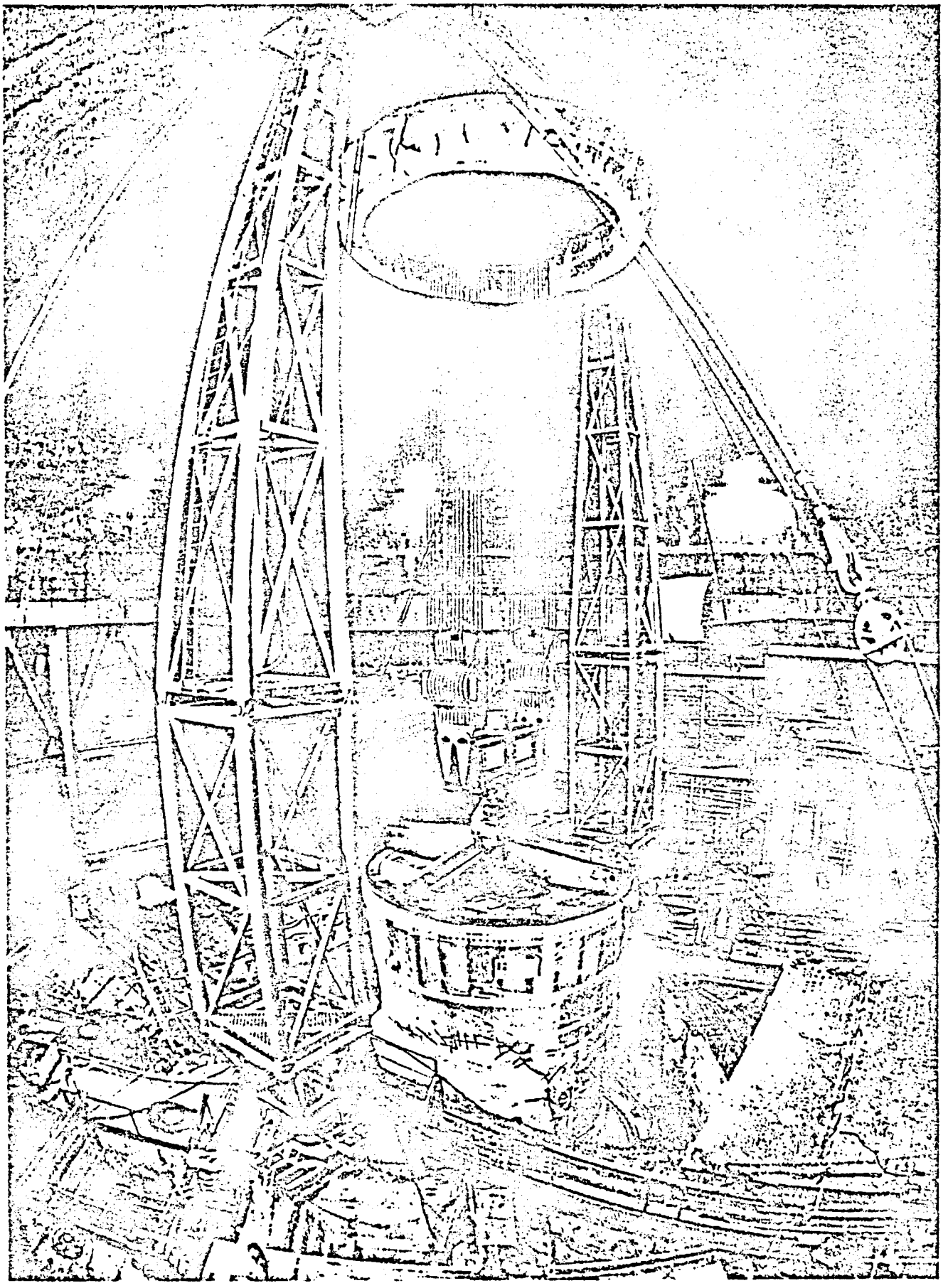
PRINCIPAL CONTRACTORS

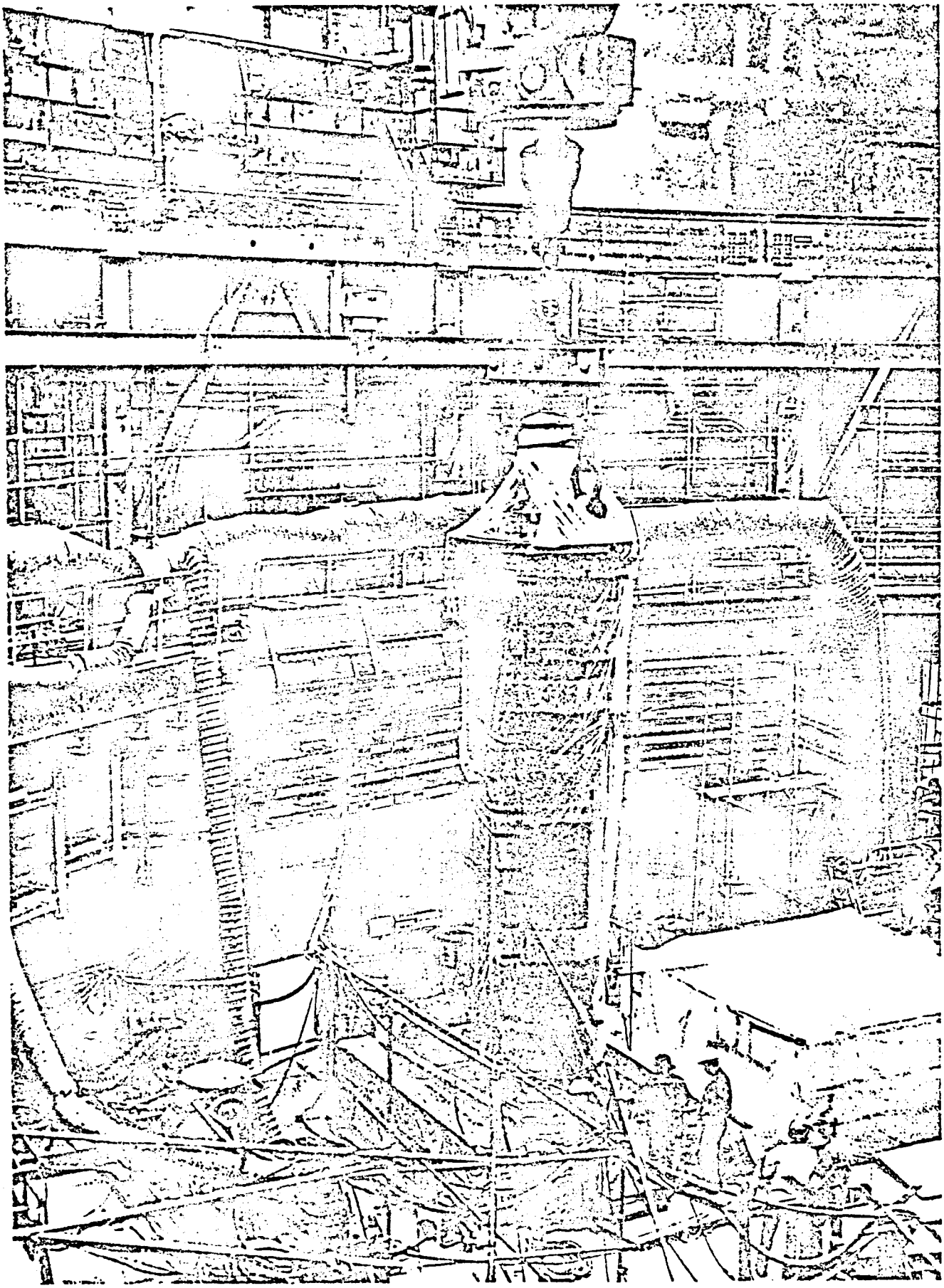


PROJECT PERCENT COMPLETE









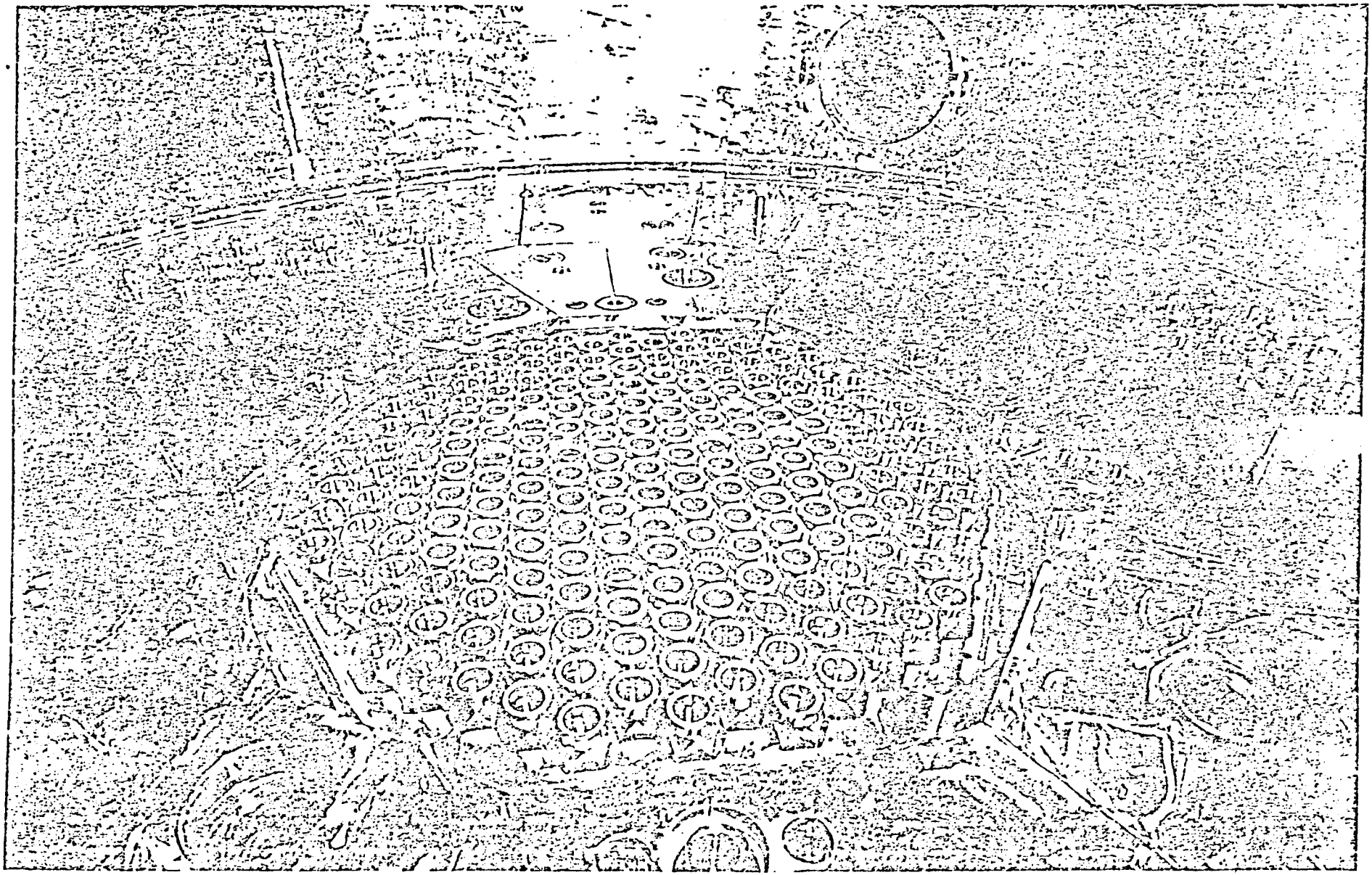


Figure 11

~~HH-H~~

RCB meeting

Open house clean up

- Meeting CLEM

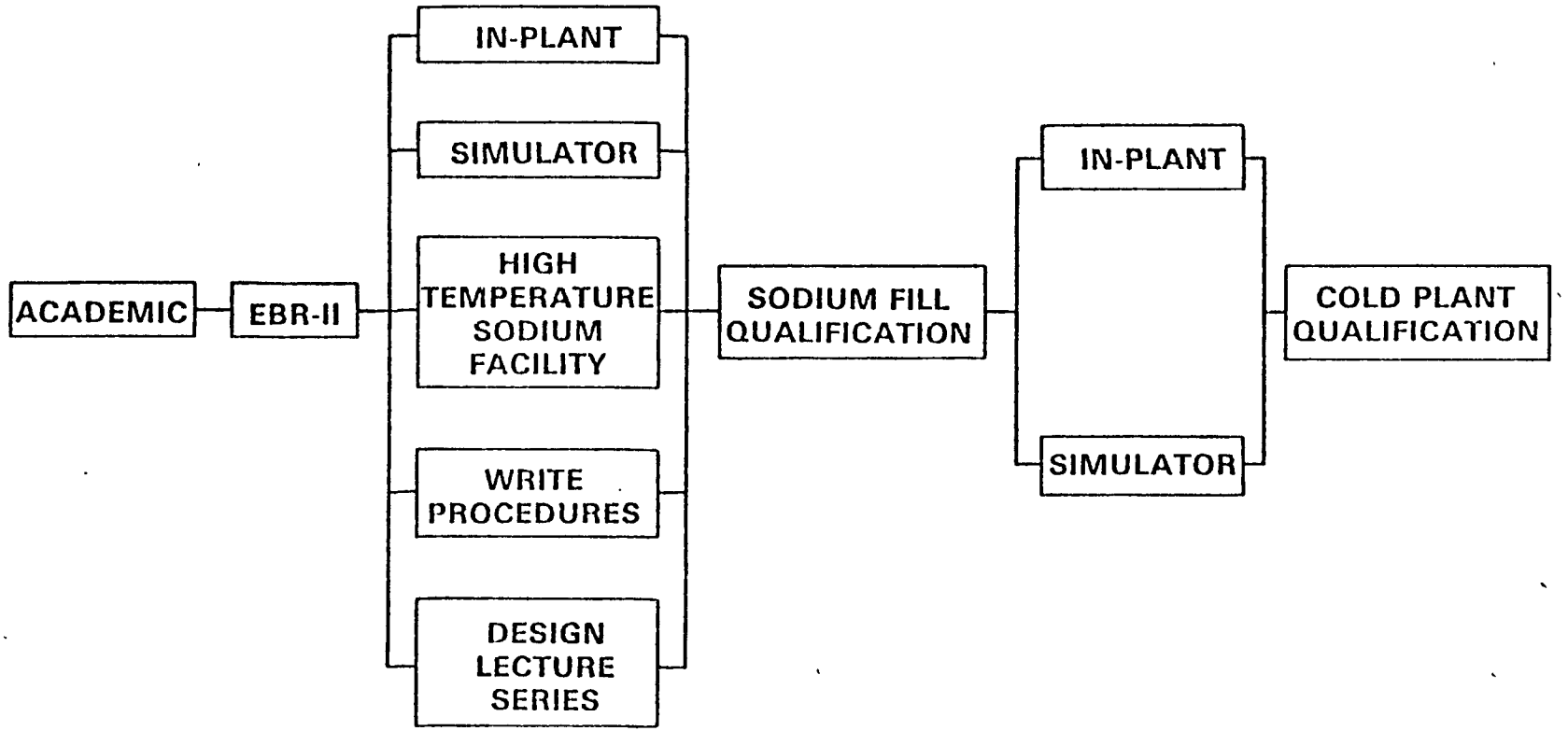
FUELS & MATERIALS

- ALL CORE 1 AND CORE 2 FUEL ASSEMBLIES COMPLETE
- ALL CORE 1 AND CORE 2 CONTROL RODS COMPLETE
- FUEL PINS FOR CORE 3 AND CORE 4 IN FABRICATION

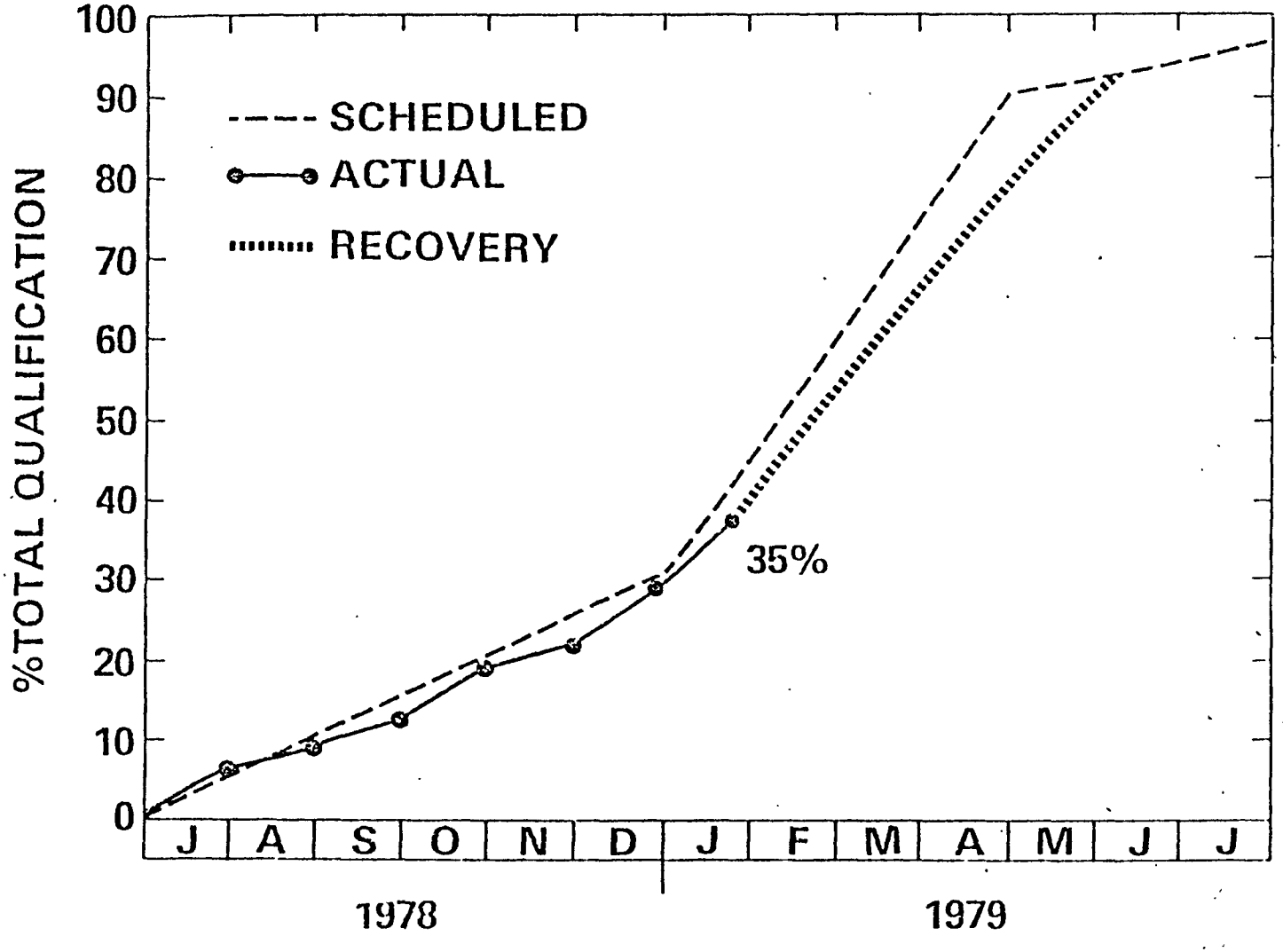
FFTF NRC REVIEW STATUS

- REPLIES TO DETAILED QUESTIONS COMPLETE
- NRC SAFETY EVALUATION REPORT ISSUED
- ACRS MEETING WAS HELD IN DECEMBER /1978 ? ° AMS
- ACRS/NRC FORMAL ADVICE RECEIVED

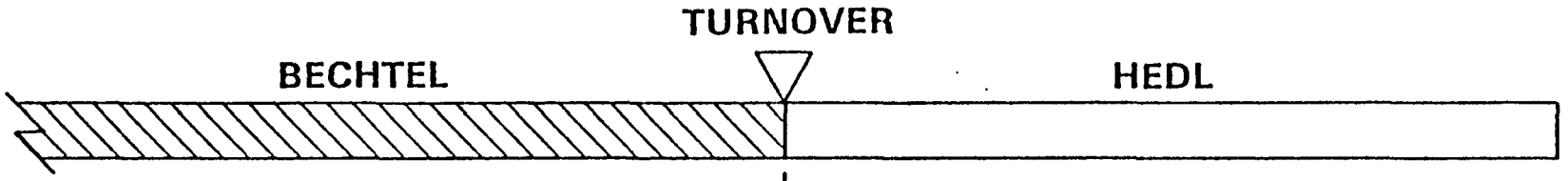
FFTF OPERATIONS TRAINING



COLD PLANT QUALIFICATION PROGRESS



PRE AND POST TURNOVER ACTIVITIES



- CONSTRUCTION
- CONSTRUCTION TESTS
- PRE-TURNOVER ENGR TESTS
- CODE PRESSURE TESTS

- FLUSHING
- PLANNED MODIFICATIONS
- CALIBRATION, GROOMING AND ALIGNMENT
- ACCEPTANCE TESTING
- OPERATION

19 L

DISCIPLINED TESTING PROGRAM

- PHASE I - COMPONENT TESTS
- PHASE II - SYSTEM TESTS
- PHASE III - HOT FUNCTIONAL TESTS
- PHASE IV - FUEL LOAD AND ZERO POWER TESTS
- PHASE V - PARTIAL AND FULL POWER TESTS

  NATURAL CIRCULATION TESTS

Component and System

~~FFTF ACCEPTANCE~~ TEST STARTUP SCHEDULE

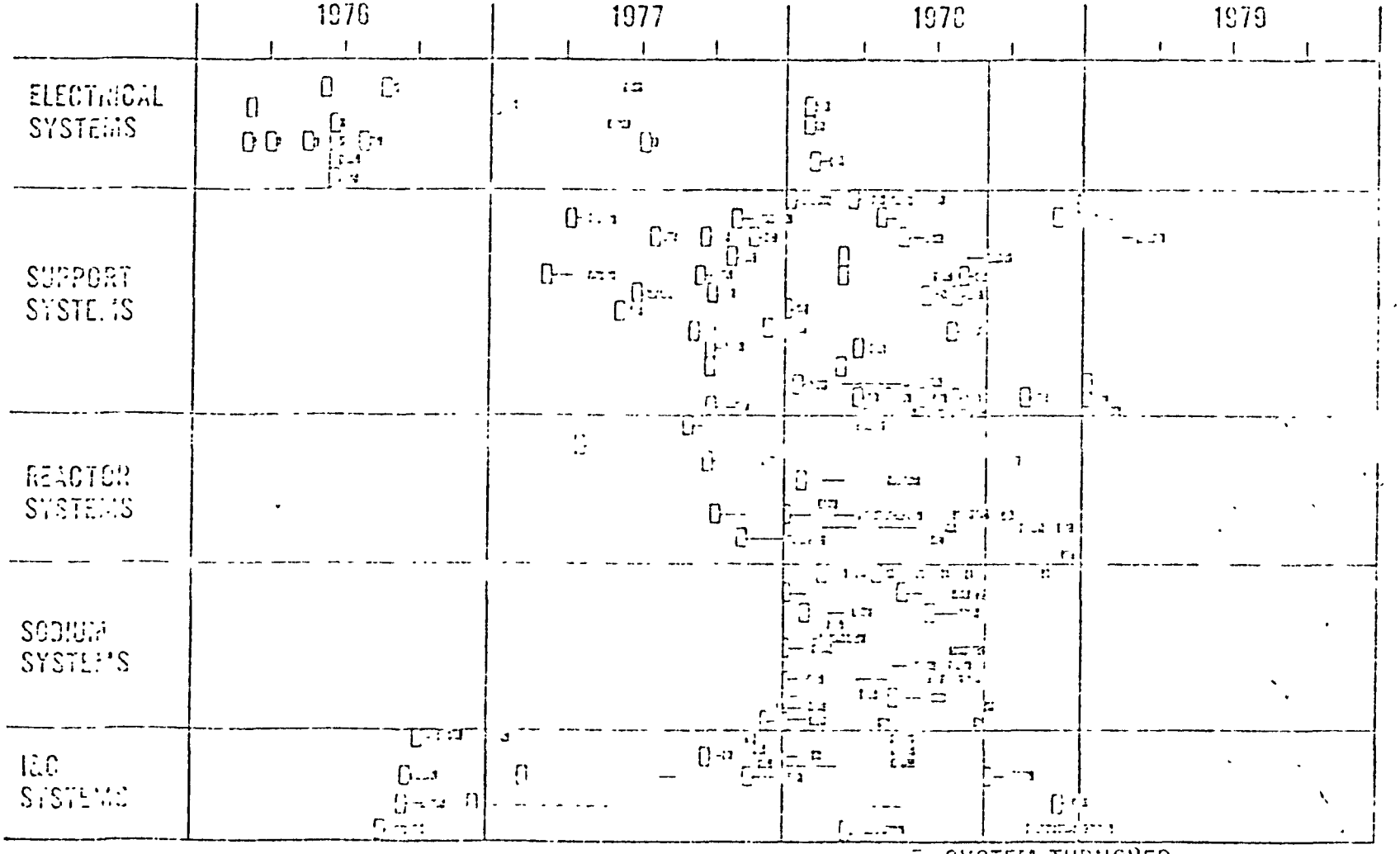


Figure 20

Stick Repeated RLD

214

FFTF ILRT INSTRUMENTATION

ITEM	MANUFACTURER	NUMBER	REPEATABILITY
RTD'S	RDF	66	.036°F
DEWCELLS	PHYS-CHEMICAL RESEARCH HUMETER	10	1.25% FS
PRESSURE GAGES	MENSOR (QUARTZ MANOMETER)	2	.00201 PSIA

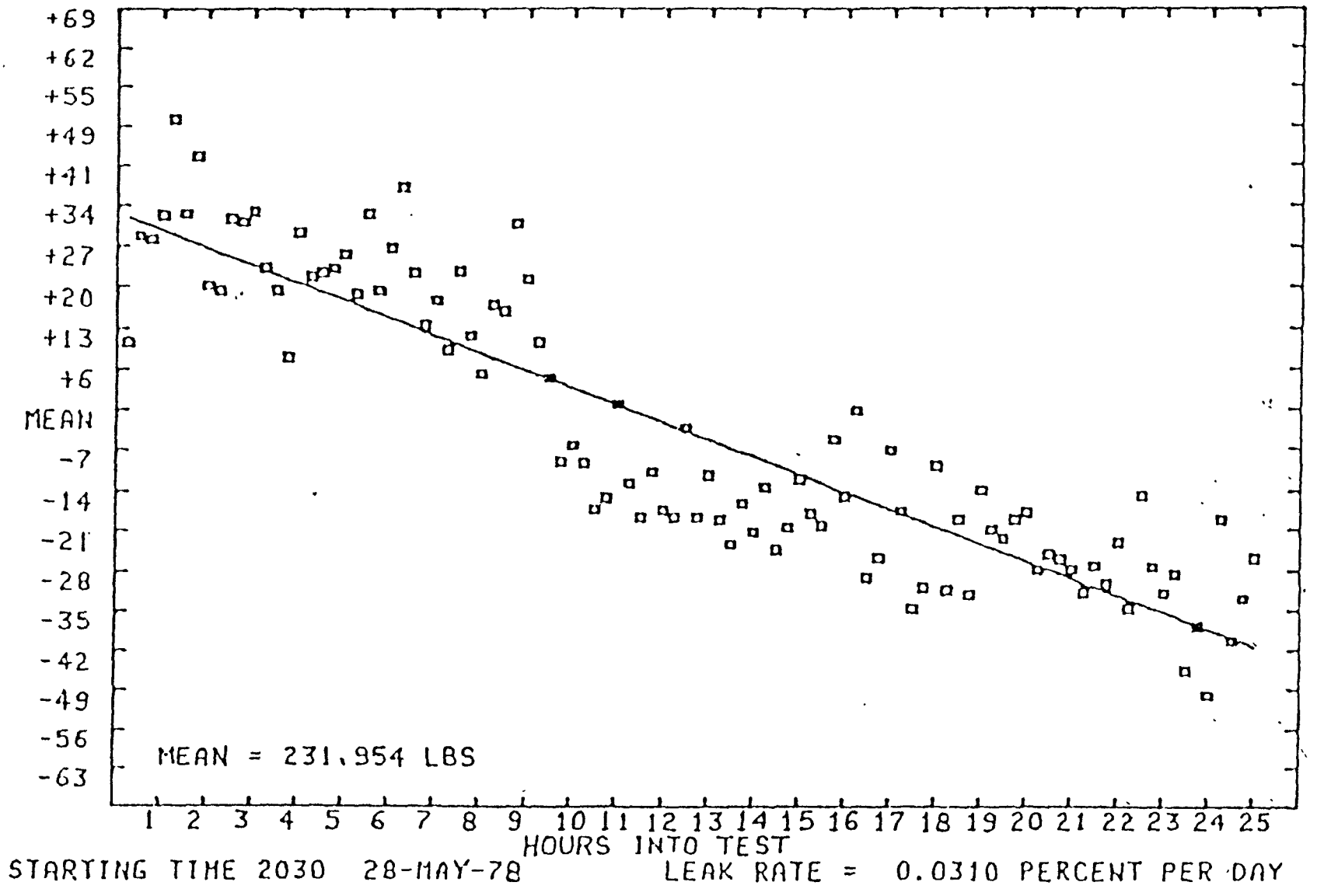
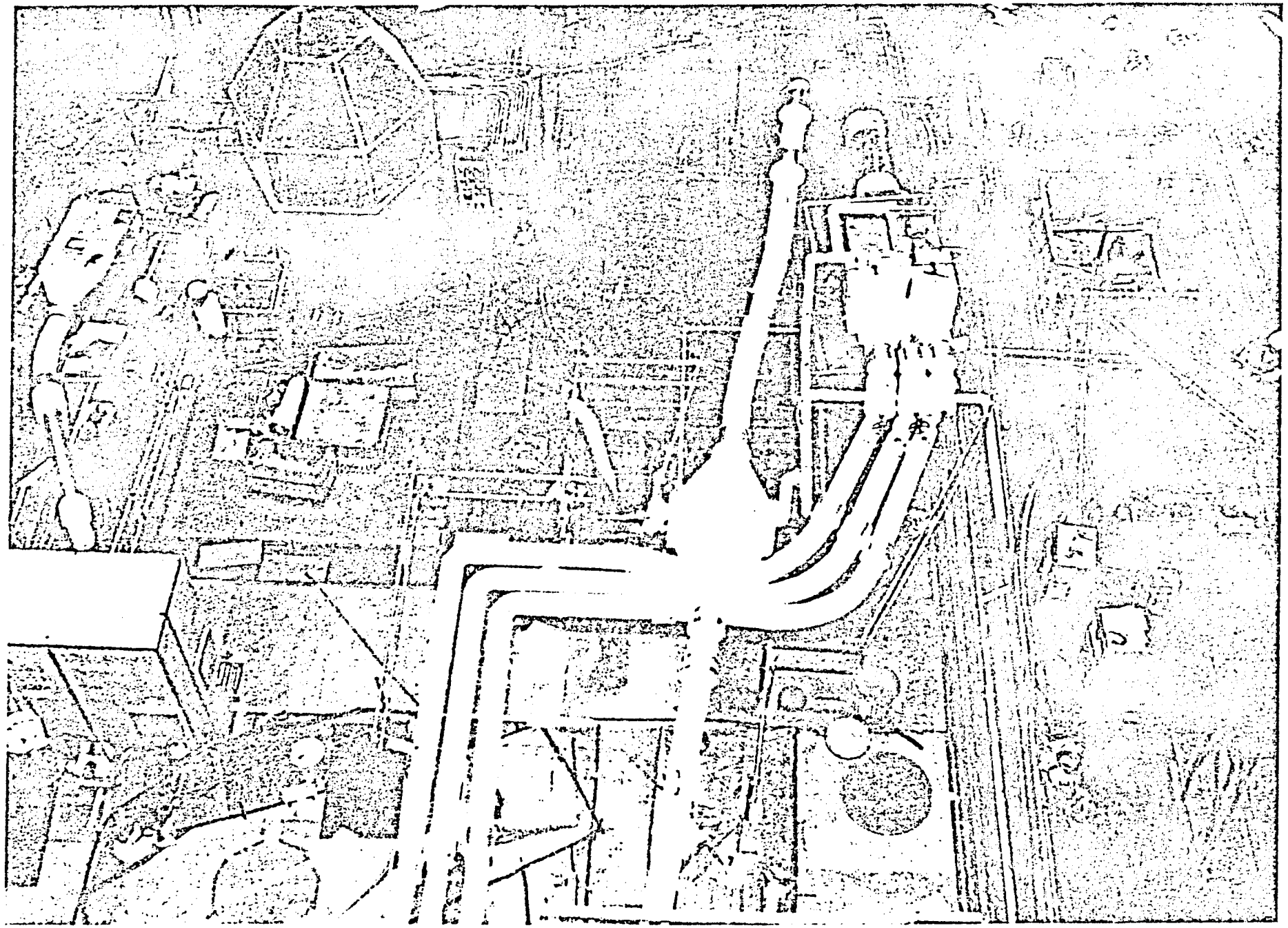

FFTF INTEGRATED LEAK RATE TEST
MASS POINT ANALYSIS
+69
+62
+55
+49
+41
+34
+27
+20
+13
+6
MEAN
-7
-14
-21
-28
-35
-42
-49
-56
-63
MEAN = 231.954 LBS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
HOURS INTO TEST
STARTING TIME 2030 28-MAY-78
LEAK RATE = 0.0310 PERCENT PER DAY

Figure 10

Primary and Secondary System

Elevation View

in Sodium Fill



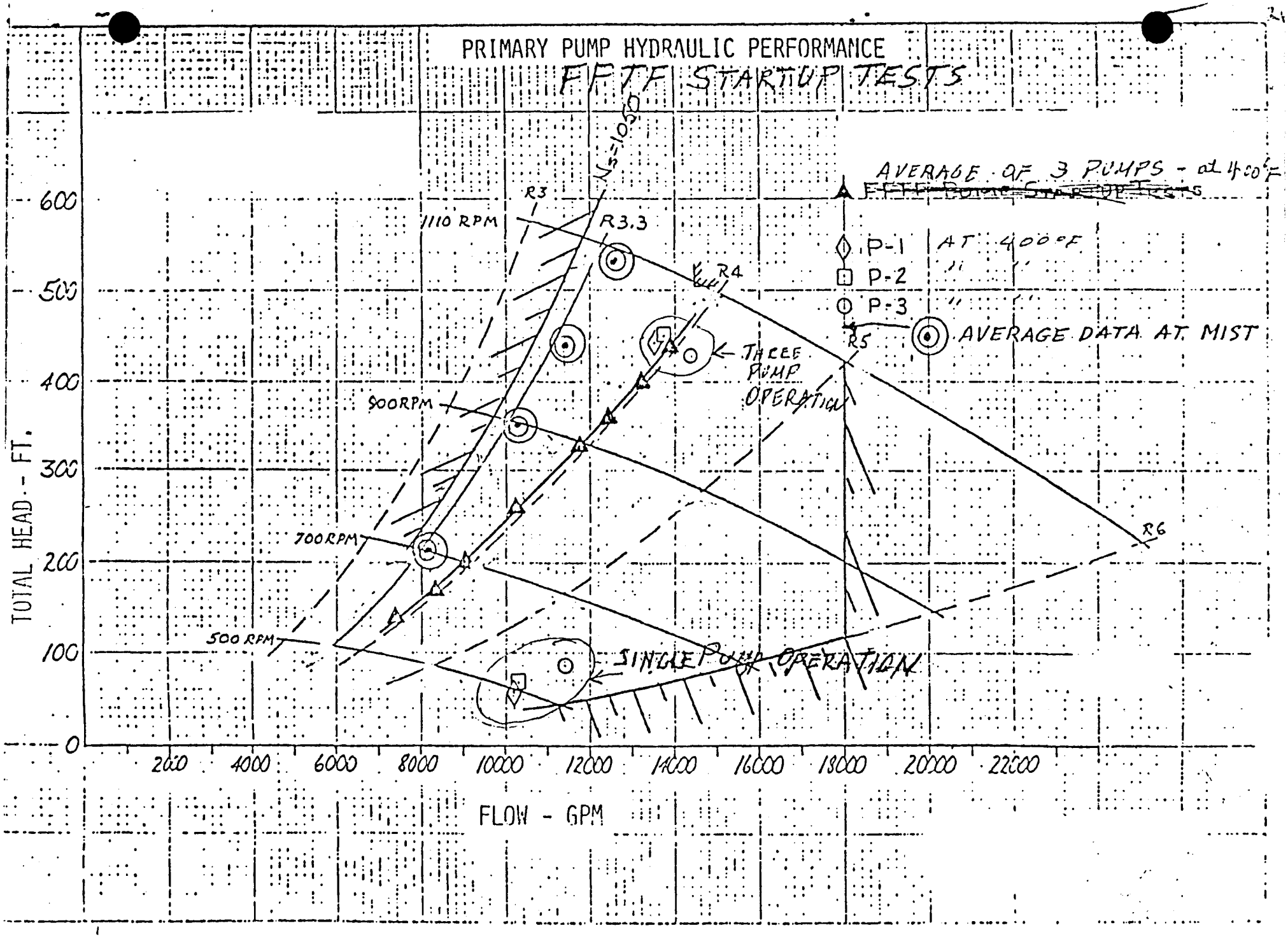
HTS PUMP PERFORMANCE SUMMARY

CONCLUSIONS

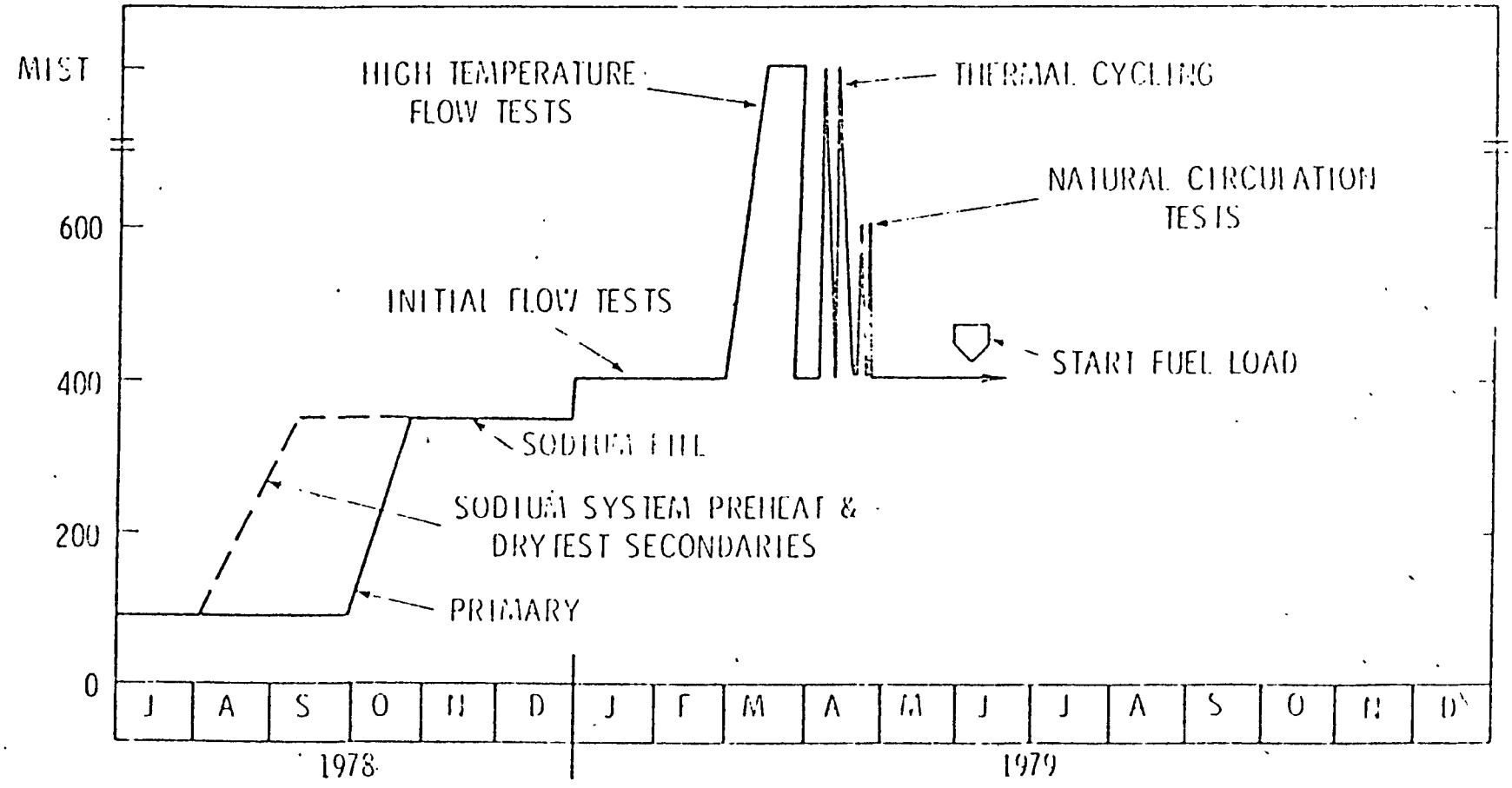
- HYDRAULIC PERFORMANCE ACCEPTABLE
- MECHANICAL PERFORMANCE ACCEPTABLE
- VIBRATION RESPONSE EXCEEDS SPEC VALUE BUT ACCEPTABLE TO PUMP AND PIPING

RECOMMENDATIONS

- PROCEED TO MIST 800°F TESTING


PRIMARY PUMP HYDRAULIC PERFORMANCE
FFTF STARTUP TESTS
AVERAGE OF 3 PUMPS - at 400°F
FFTF Pump Startup Tests
P-1 AT 400°F
P-2 "
P-3 "
AVERAGE DATA AT MIST
THREE PUMP OPERATION
SINGLE PUMP OPERATION
R3
R3.3
R4
R5
R6
1110 RPM
900RPM
700RPM
500 RPM
TOTAL HEAD - FT.
FLOW - GPM
0
100
200
300
400
500
600
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
22000

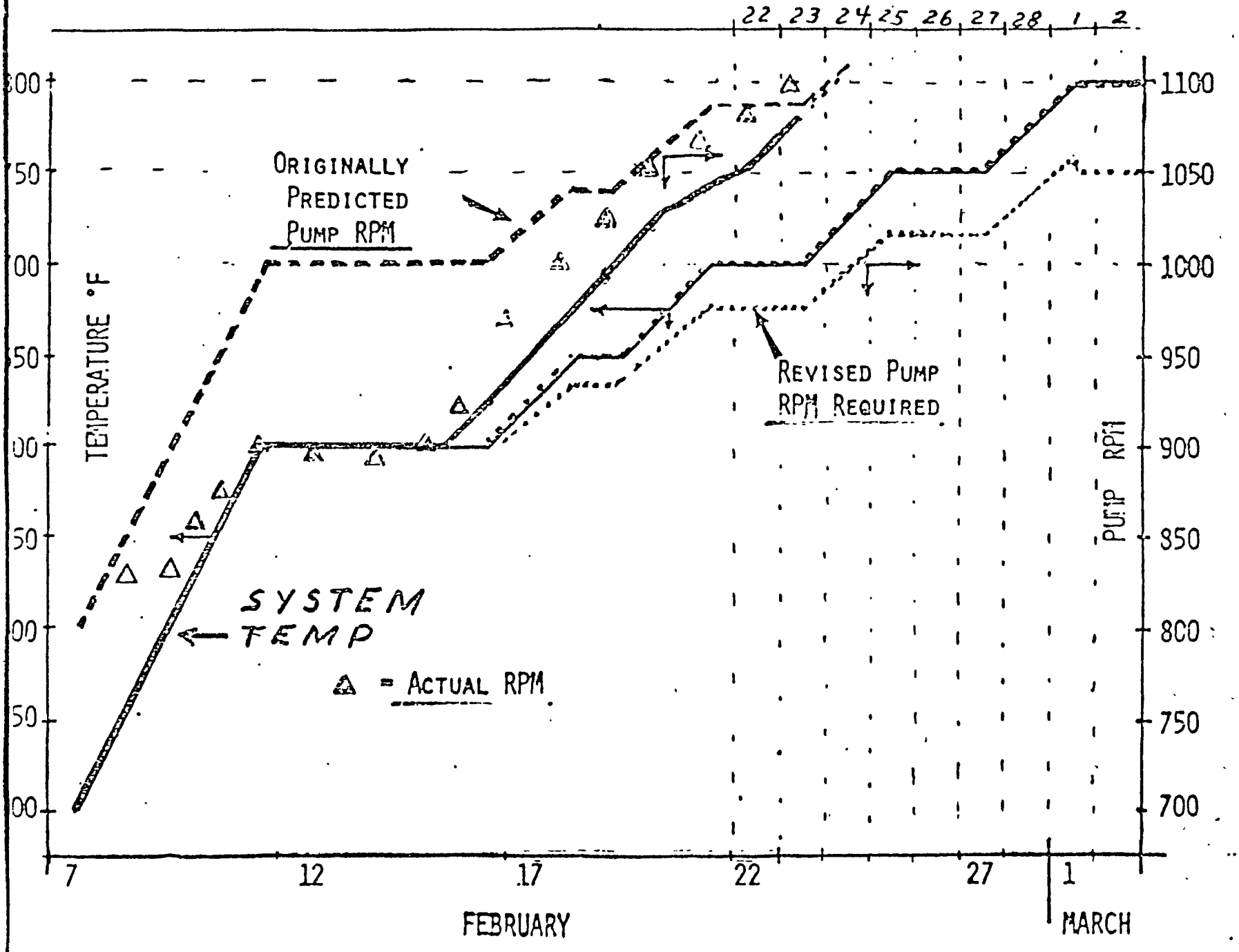
FFTF TEMPERATURE PROFILE - PHASE 3



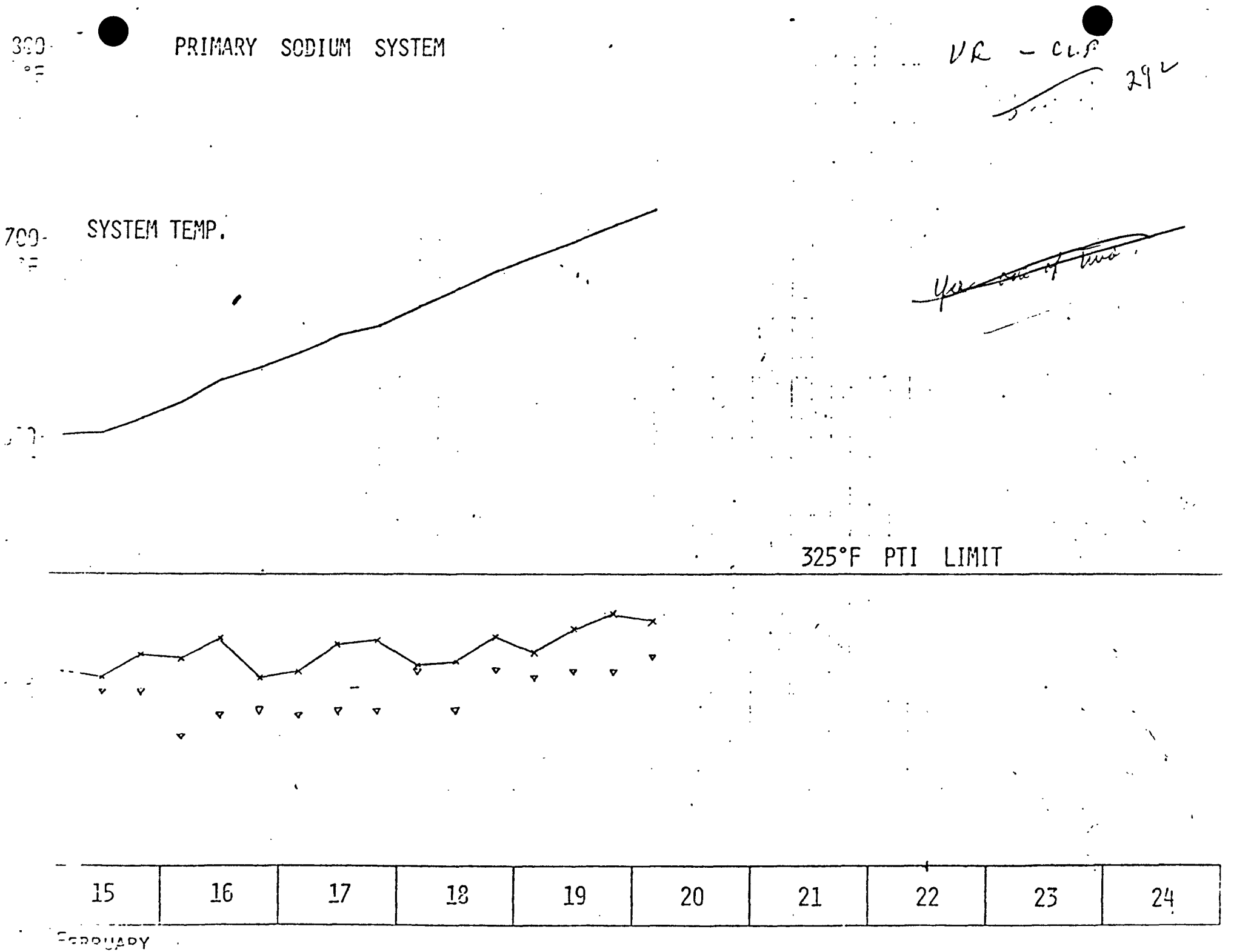
HEDL 7707-218.13

Figure 23

PUMP SPEED VS MIST HEATUP



PRIMARY SODIUM SYSTEM



15	16	17	18	19	20	21	22	23	24

FEBRUARY

DHX NATURAL CIRCULATION TEST

INITIAL CONDITIONS

- ALL PUMPS (3 PRIM & 3 SEC) CIRCULATING WITH MAIN MOTOR
- SYSTEM TEMPERATURE NOMINALLY 700°F

TEST ACTION

- TRIP SEC LOOP 3 PUMP AND COASTDOWN WITH PONY MOTOR OFF
- MAINTAIN FLOW ON REMAINING 5 PUMPS
- MONITOR DHX OUTLET TEMPERATURES ON LOOP 3
- RESTORE SEC LOOP 3 FLOW IF TEMPERATURE FALLS BELOW ACCEPTANCE CRITERION OR AT END OF 3 HOURS

FFTF ACCEPTANCE TEST PROGRAM

PHASES III, IV, AND V BASE PLAN

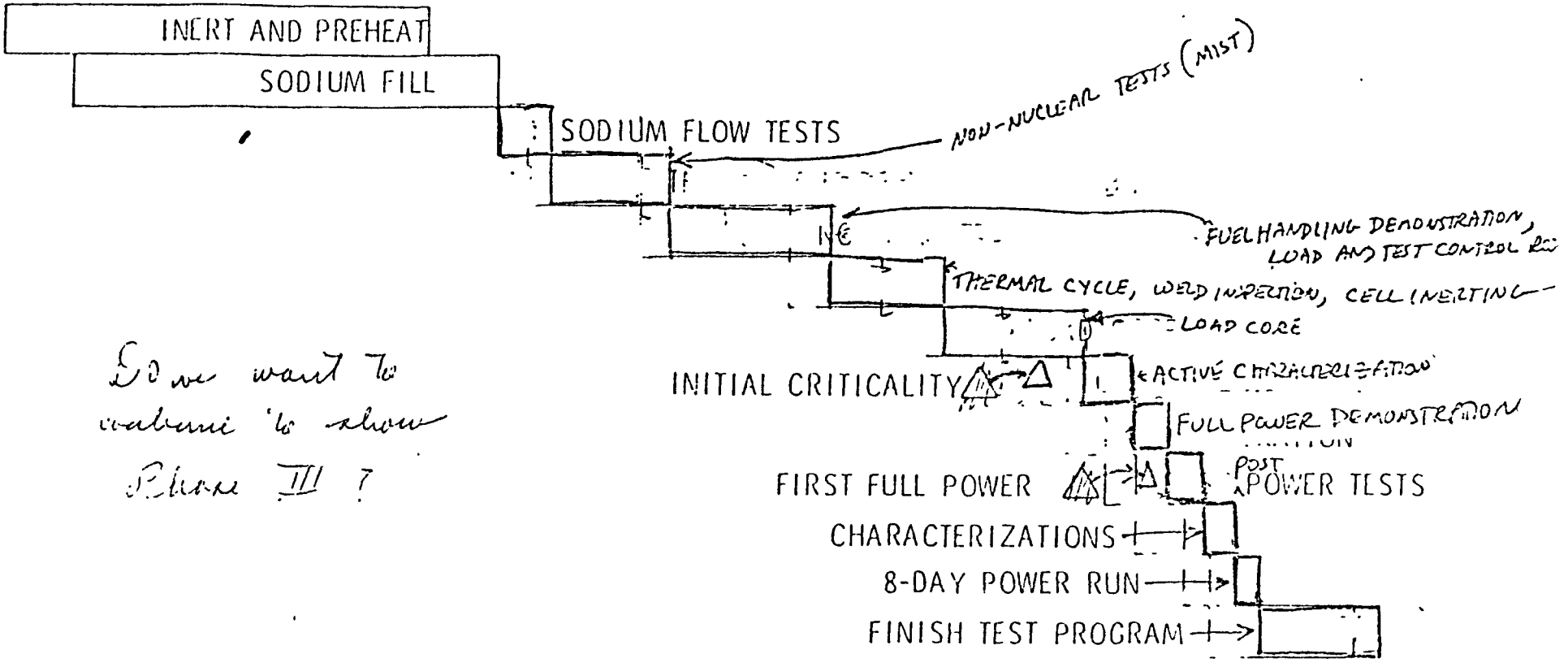
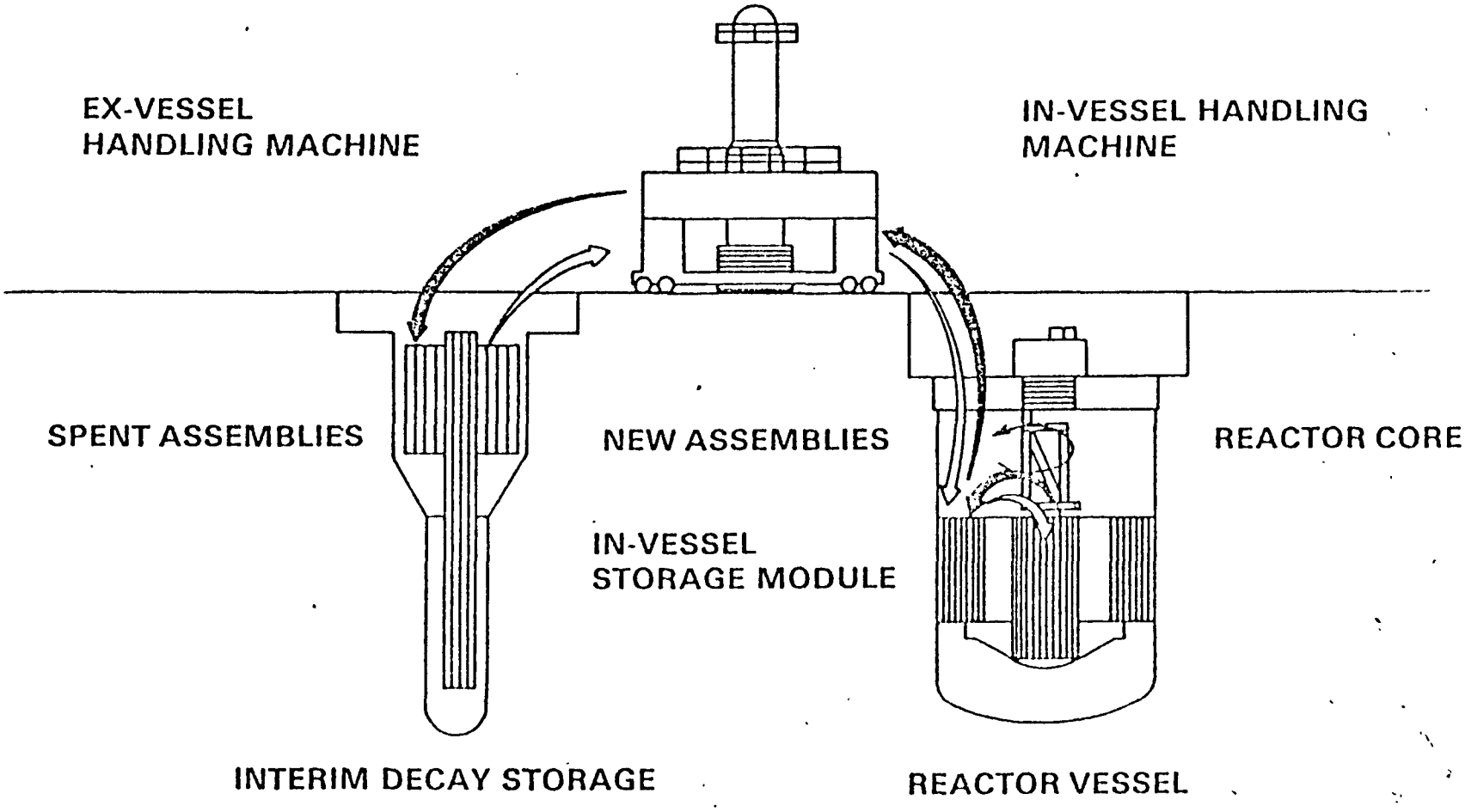
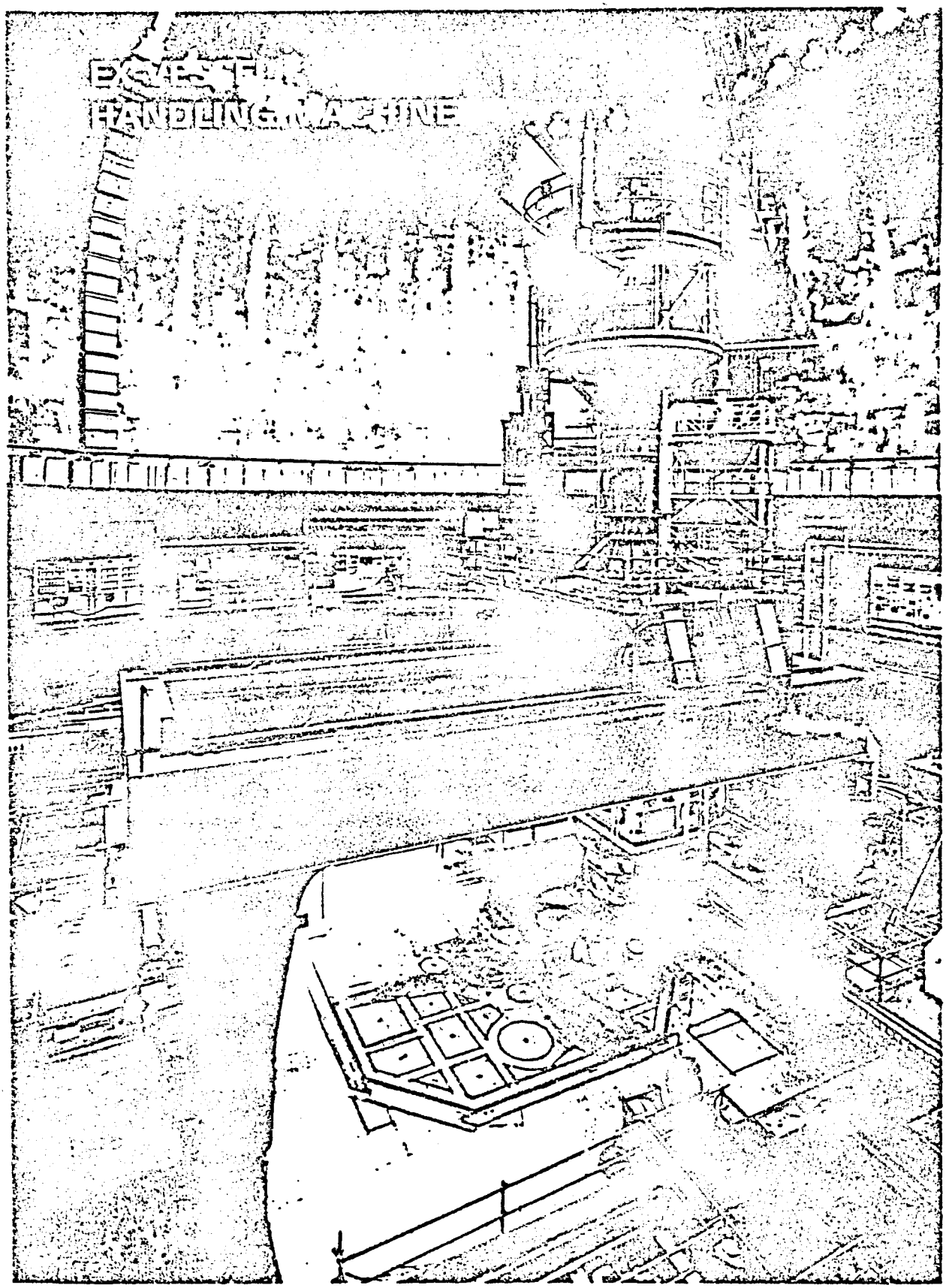


Figure 3

HEDL 7807-172.3

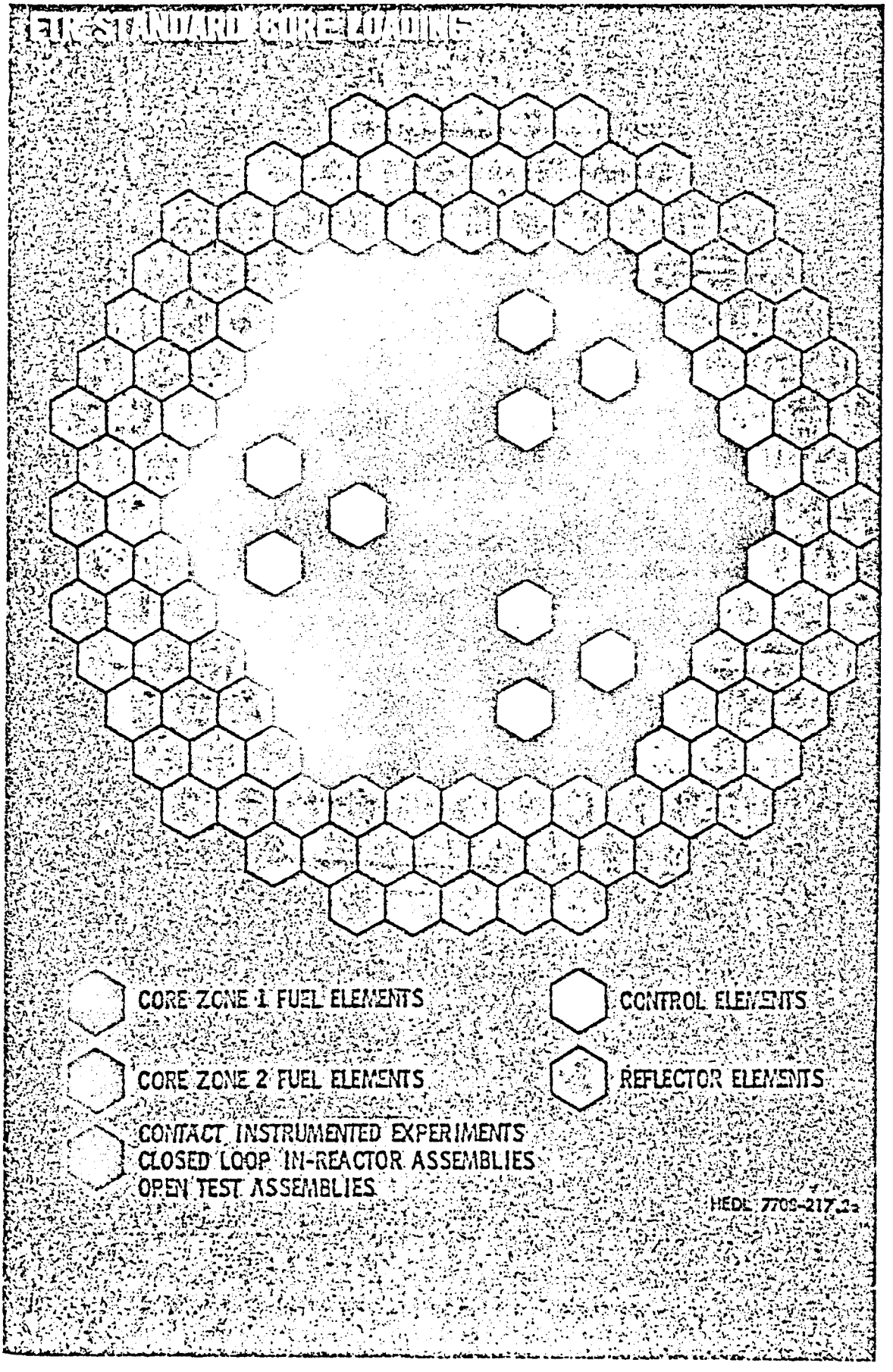
REFUELING TRANSFERS




PARCEL
HANDLING MACHINE

INTERIM EXAMINATION AND MAINTENANCE CELL CAPABILITY

- RETRIEVE DATA FROM IRRADIATED FUELS AND MATERIALS
- PROCESS THE ABOVE FOR SHIPMENT TO OTHER EXAMINATION FACILITIES OR DISPOSAL SITES
- SUPPORT LIMITED MAINTENANCE OF PLANT EQUIPMENT OR SERVE AS A TRANSFER POINT FOR OFF-SITE SHIPMENT OF LARGE PLANT EQUIPMENT
- REASSEMBLE AND REQUALIFY SELECTED ASSEMBLIES FOR RETURN TO THE REACTOR


FFTF STANDARD CORE LOADING
CORE ZONE 1 FUEL ELEMENTS
CORE ZONE 2 FUEL ELEMENTS
CONTACT INSTRUMENTED EXPERIMENTS
CLOSED LOOP IN-REACTOR ASSEMBLIES
OPEN TEST ASSEMBLIES
CONTROL ELEMENTS
REFLECTOR ELEMENTS
HEDL 7709-217.2a

TESTING CATEGORIES

- FFTF COMPONENT EVALUATIONS

- DEVELOPMENT EXPERIMENTS

FFTF COMPONENT EVALUATIONS

ABSORBER ASSEMBLIES

- REFERENCE DESIGN
- REFERENCE MATERIALS
- FABRICATION METHODS

FUEL COMPONENT EVALUATIONS

DRIVER FUEL ASSEMBLIES

- CONFIRM DESIGN BASIS
- CORE DESIGN METHODS
- MATERIALS PERFORMANCE
- VARYING BURNUP METHODS

FFTF COMPONENT EVALUATIONS

SAFETY EXPERIMENTS

- PRE-IRRADIATE FUEL FOR NATIONAL SAFETY PROGRAMS

FFTF COMPONENT EVALUATIONS

FFTF CHARACTERIZATION ASSEMBLIES

- STRUCTURAL MATERIAL SURVEILLANCE
- NEUTRONICS
- CORE VIBRATIONAL STABILITY
- OPERATIONAL TRANSIENTS

DEVELOPMENT EXPERIMENTS

ADVANCED FUEL EXPERIMENTS

- CARBIDES
- THORIA BASE
- RUN TO FAILURE
- IMPROVED LIFETIME

DEVELOPMENT EXPERIMENTS

BLANKET EXPERIMENTS

- CARBIDES & OXIDES
- DOUBLING TIME
- LOCATION IN CORE
- PERFORMANCE IN CORE

DEVELOPMENT EXPERIMENTS

ABSORBER EXPERIMENTS

- VENTED PINS
- INCREASED LIFETIME
- ADVANCED DESIGN

DEVELOPMENT EXPERIMENTS

OXIDE FUEL EXPERIMENTS

- HIGH BURNUP
- REDUCED DOUBLING TIME
- IMPROVED LIFETIME

DEVELOPMENT EXPERIMENTS

DUCT EXPERIMENTS

- ADVANCED ALLOY MATERIALS
- IMPROVED LIFETIME
- CURRENT DESIGN

DEVELOPMENT EXPERIMENTS

ADVANCED PIN SUPPORT CONCEPTS

- BACKUP SUPPORT METHODS

- DESIGN ADVANCEMENTS

DEVELOPMENT EXPERIMENTS

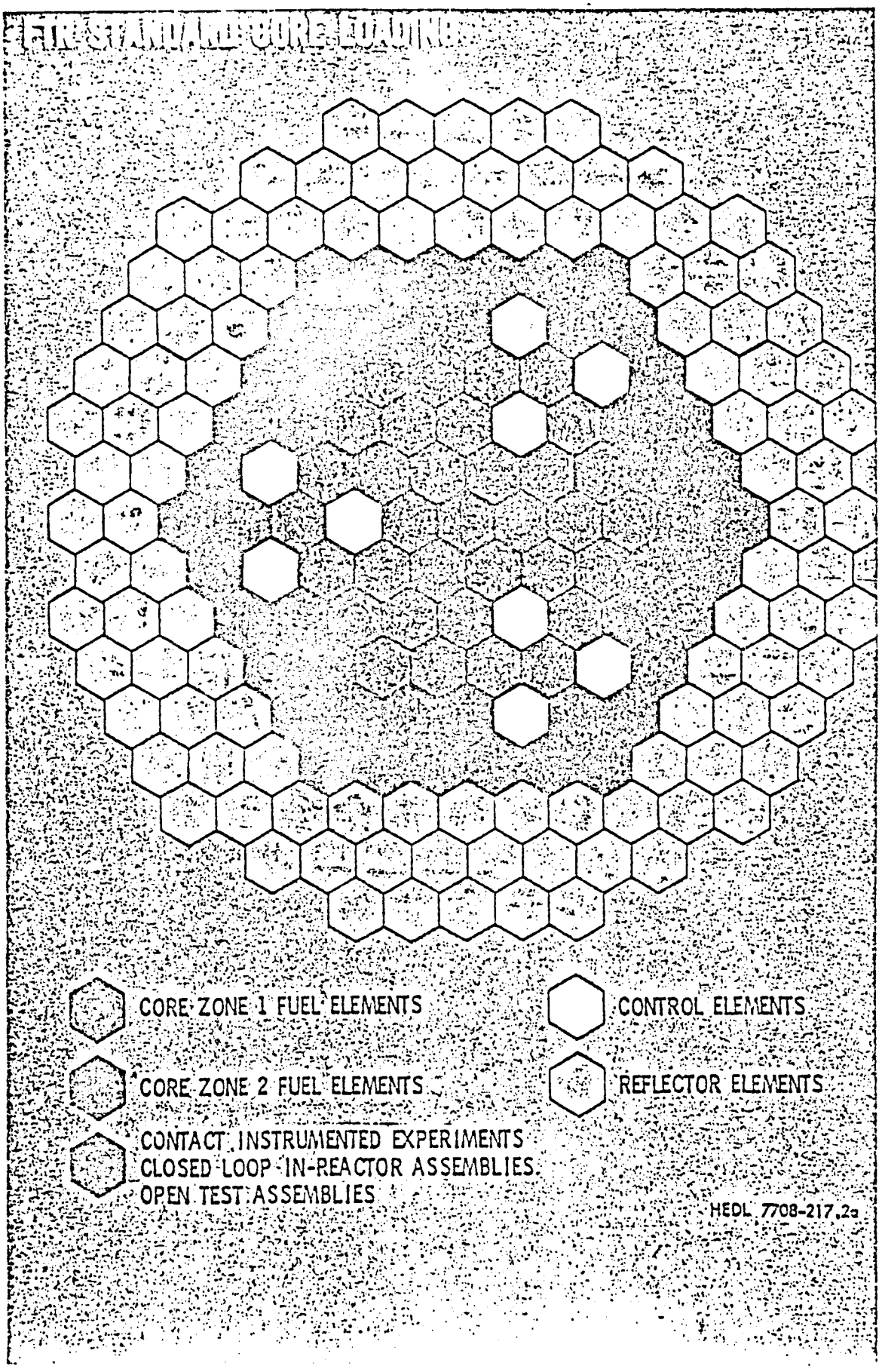
CLAD/DUCT MATERIALS EXPERIMENTS

- ADVANCED MATERIALS
- MATERIALS NOW IN USE
- EXTEND KNOWLEDGE OF IRRADIATION EFFECTS
  - ON PERFORMANCE
  - ON BASIC PROPERTIES

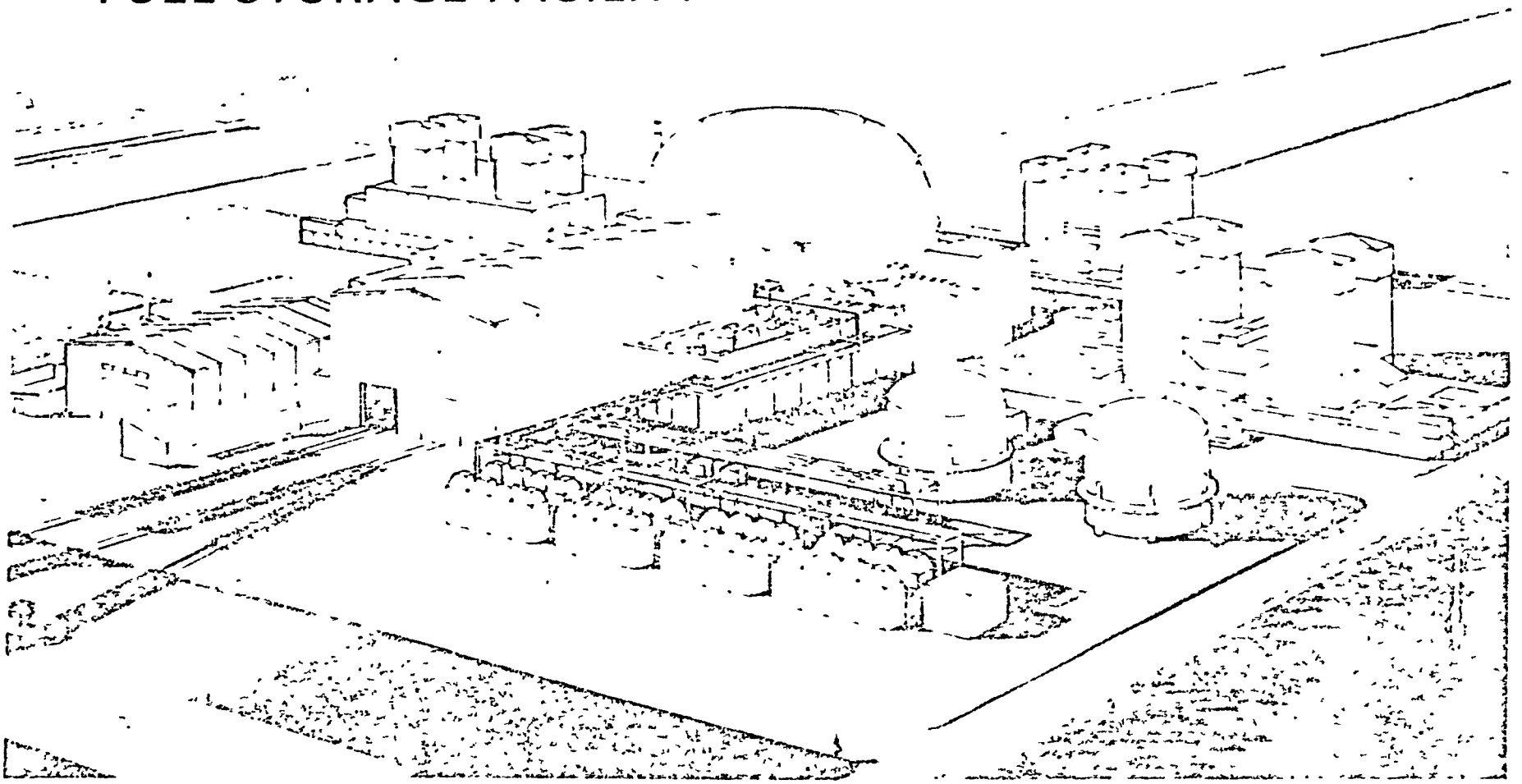
DEVELOPMENT EXPERIMENTS

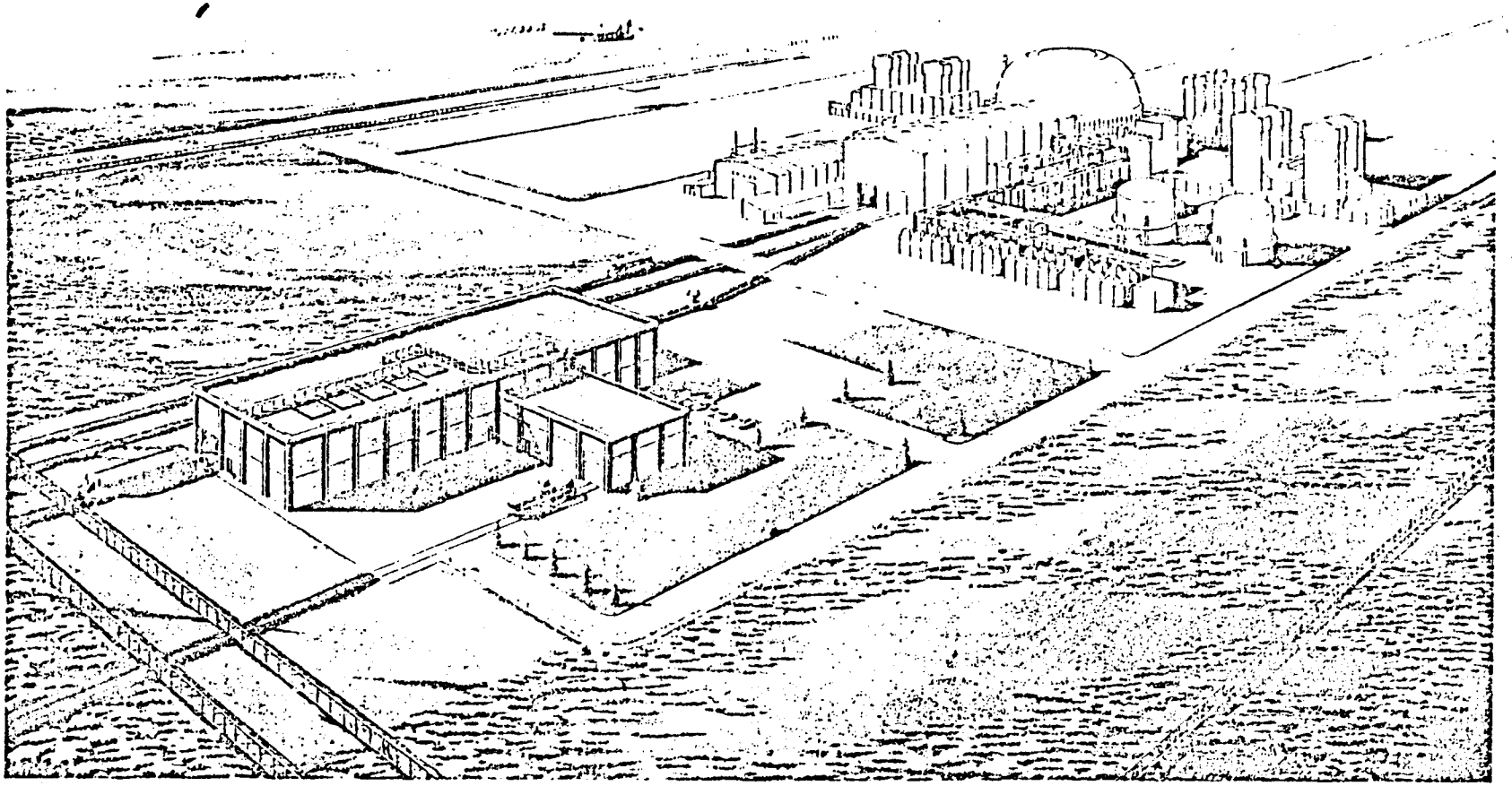
MISCELLANEOUS EXPERIMENTS

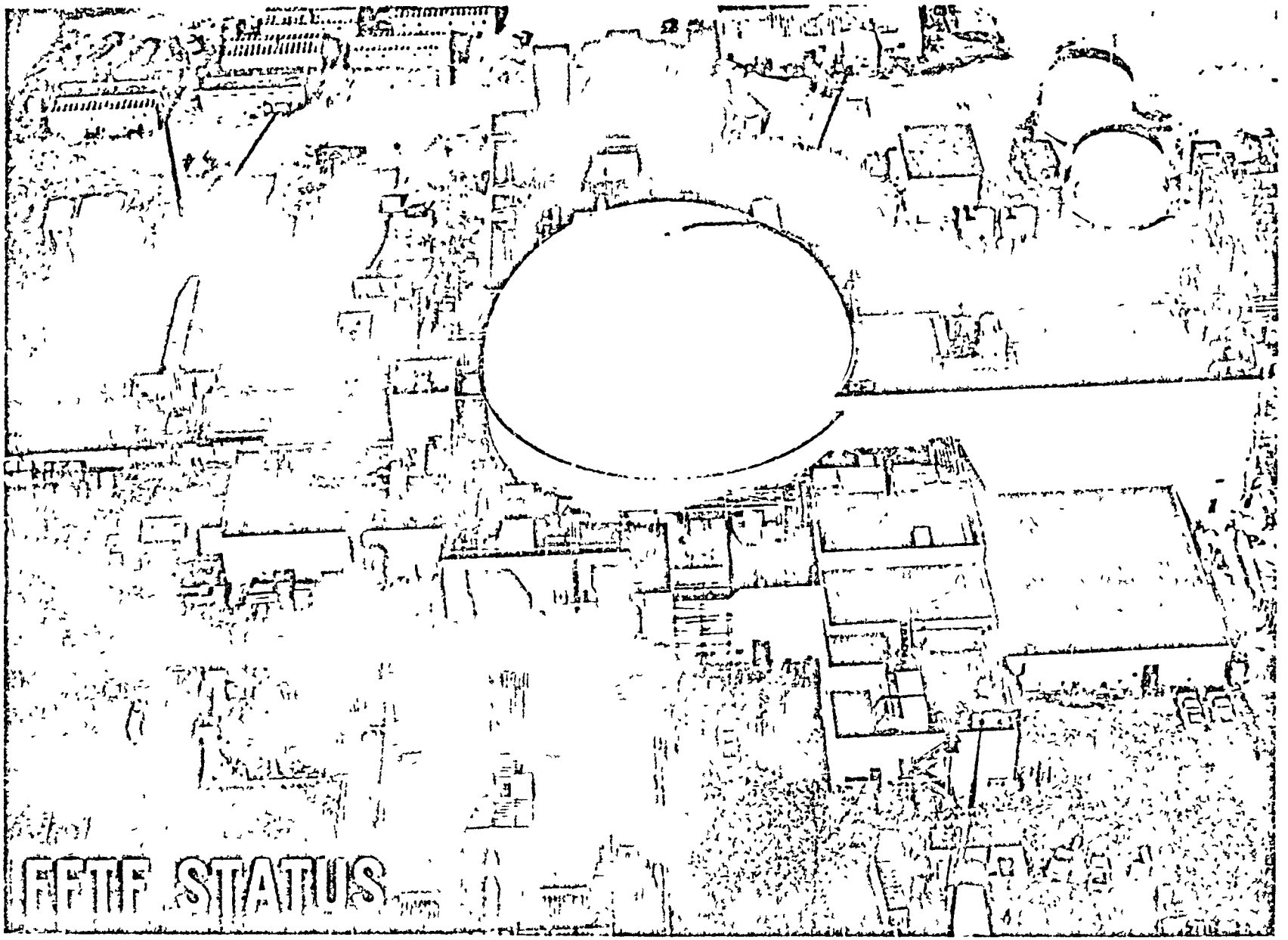
- IN SITU COLLECTION OF CORROSION PRODUCTS
- SPECIAL MATERIALS TESTS
- PROLIFERATION RESISTANT SUPPORTIVE TESTING


CORE ZONE 1 FUEL ELEMENTS
CORE ZONE 2 FUEL ELEMENTS
CONTACT INSTRUMENTED EXPERIMENTS
CLOSED LOOP IN-REACTOR ASSEMBLIES
OPEN TEST ASSEMBLIES
CONTROL ELEMENTS
REFLECTOR ELEMENTS
HEDL 7708-217.2a

FUEL STORAGE FACILITY






EFTF STATUS

KEY MILESTONES TO GO

- PLANT TESTING AT 800°F ..... MARCH 1979
- FUEL HANDLING SYSTEM CHECKOUT IN SODIUM ENVIRONMENT ..... MAY 1979
- CRITICALITY ..... AUGUST 1979
- BENEFICIAL USE ..... FEBRUARY 1980
- COMPLETE PROJECT WITHIN BUDGET OF $647M

IRRADIATION TESTING

- CONFIRM REFERENCE FUEL/ABSORBER PERFORMANCE
- MATERIALS DEVELOPMENT: ~~FUELS, ABSORBER, CLADDING, STRUCTURAL~~
  - Fuels
  - Absorber
  - Cladding
  - Structural
- ~~CLOSED LOOP TESTING~~

OPERATING PLANT PERFORMANCE

- CONFIRM COMPONENT AND SYSTEM PERFORMANCE
- CONFIRM OPERATIONAL RELIABILITY
- CONFIRM MAINTAINABILITY

FFTF UNIQUE FEATURES

- LOW PRESSURE, HIGH TEMPERATURE
- PRIMARY SYSTEM IN INERTED CELLS
- PRIMARY-SECONDARY PIPING - TRACE HEATED
- ALL CORE POSITIONS MONITORED FOR OUTLET FLOW AND TEMPERATURE
- IN VESSEL REFUELING MACHINES
- FUEL ASSEMBLIES POSITIONED BY PERIPHERAL CORE RESTRAINT
- CLOSED LOOPS IN CORE LOCATIONS
- ON LINE PURIFICATION OF PRIMARY COOLANT
- IN CONTAINMENT FUEL EXAMINATION FACILITY

HEDL 7707-218.8

Figure 7

FFTF PARAMETERS

THERMAL POWER	400 MW
MAX. CORE OUTLET TEMP.	1100°F
NOMINAL CORE ΔT	300°F
MAX. CORE ΔT CAPABILITY	350°F
PRIMARY SODIUM FLOW CAPABILITY	43,500 GPM
PRIMARY SODIUM DYNAMIC HEAD	500 FT
CORE DIAMETER	4 FT
CORE HEIGHT	3 FT
PEAK FAST FLUX INITIAL	7×10^{15} nv/cm^2/sec
PEAK FAST FLUX ULTIMATE	1.3×10^{16} nv/cm^2/sec
INITIAL INSTRUMENTED CLOSED LOOPS	2
TEST POWER	2 MW
OPEN TEST POSITIONS	6

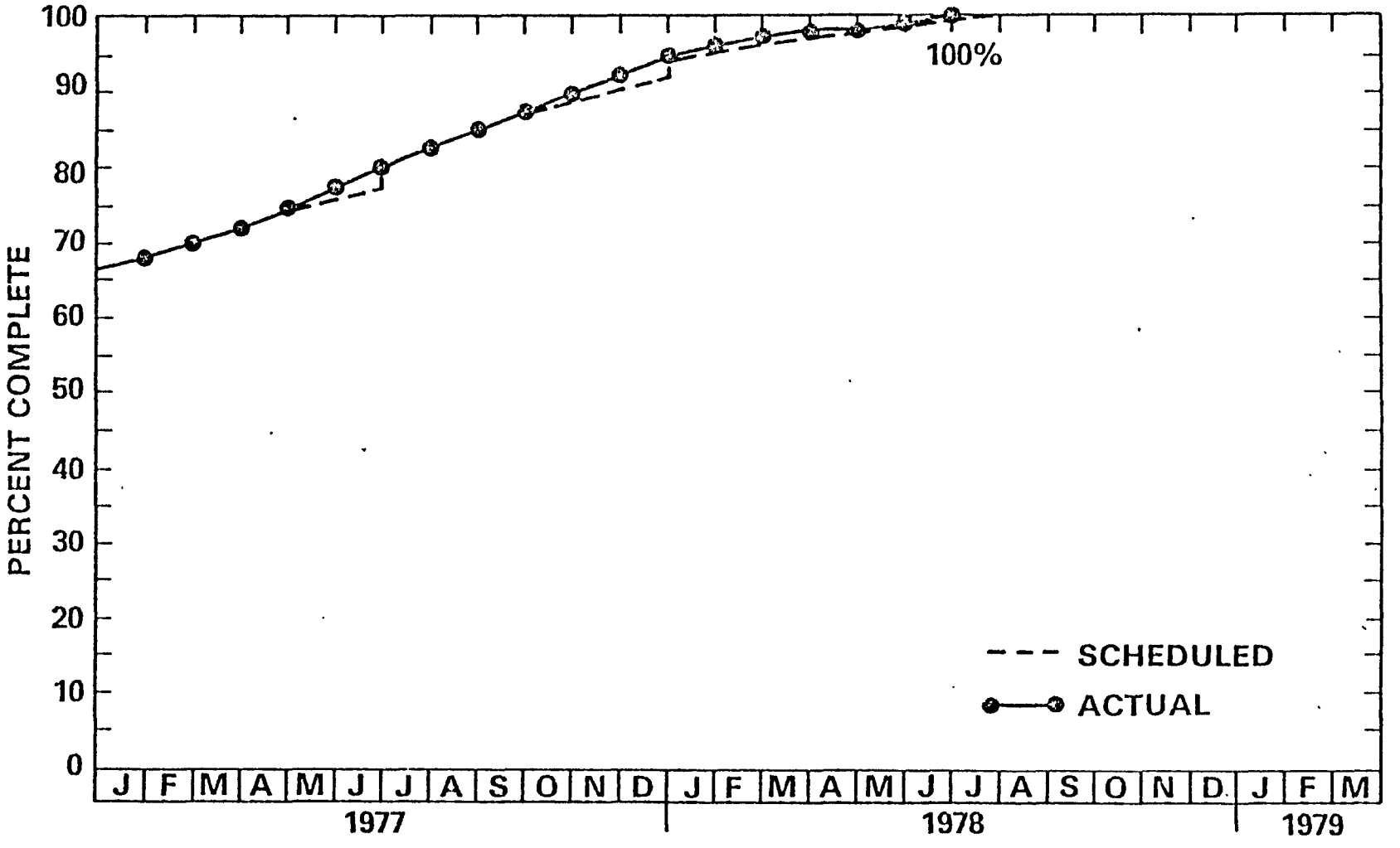
Figure-6

PRESENT STATUS:

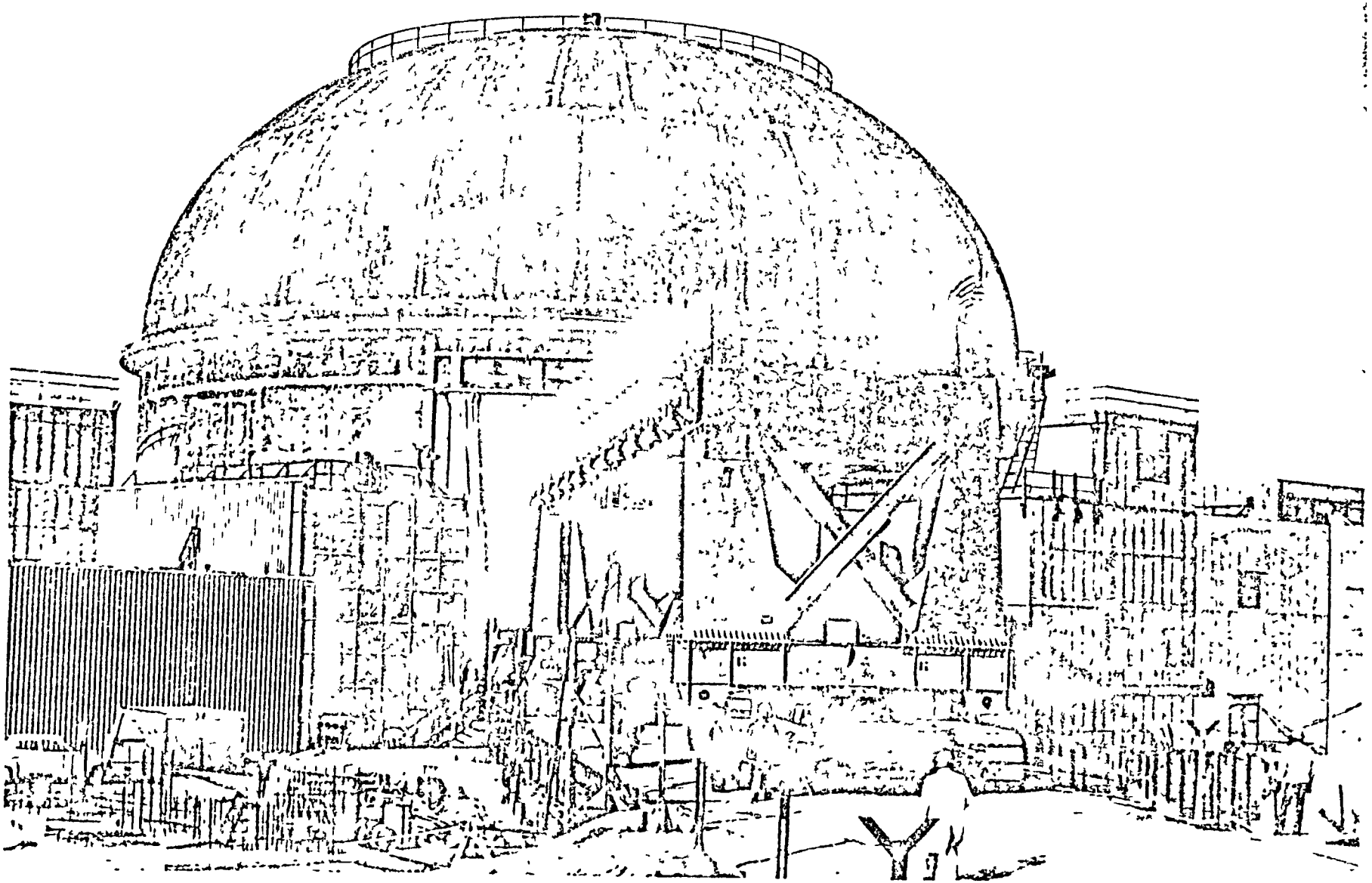
- BECHTEL HOME OFFICE COMPLETE
- ARD COMPLETE
- AI COMPLETE
- AMCO COMPLETE
- TOTAL PROJECT SUPPORT AT SITE

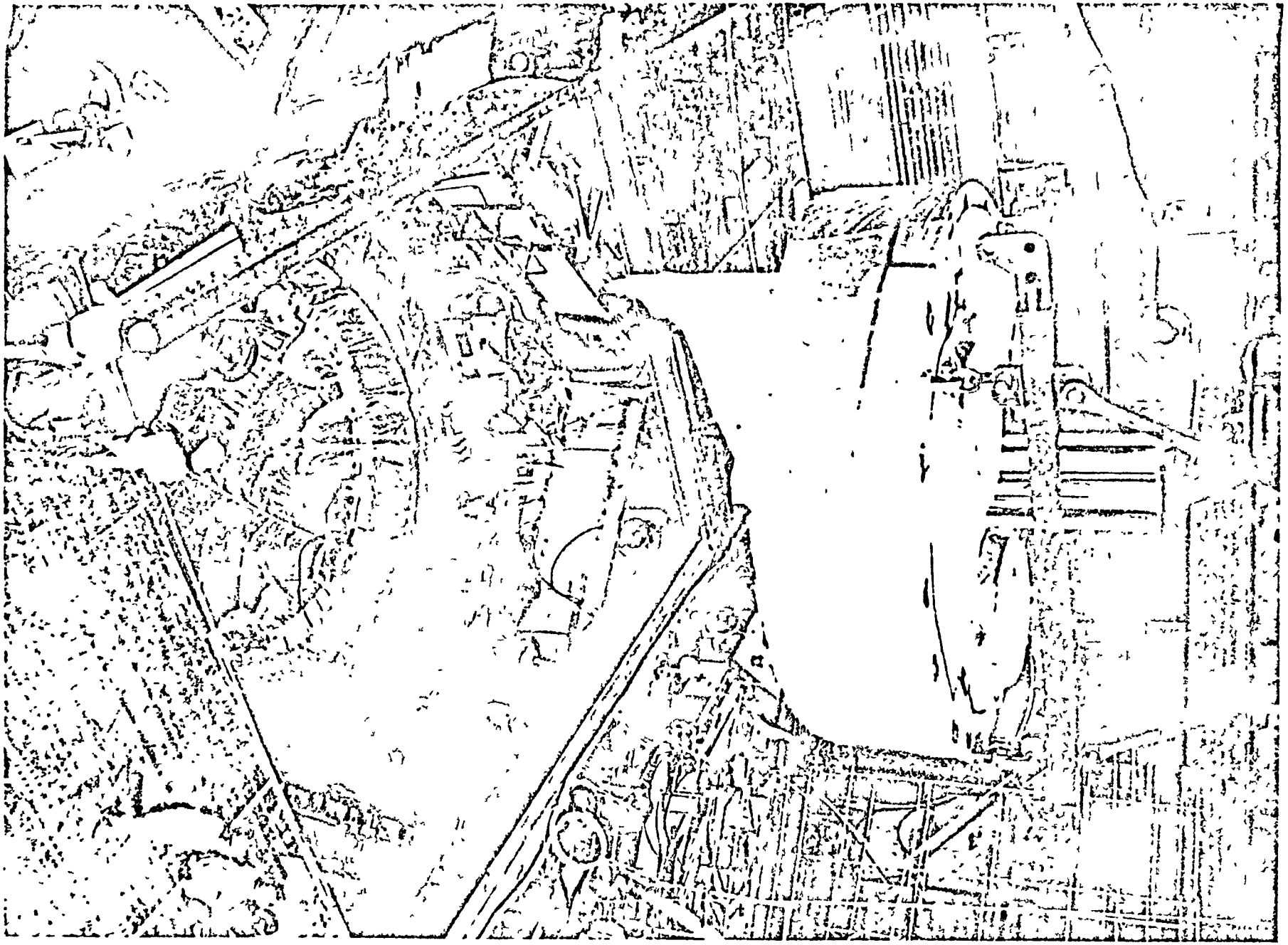
SR

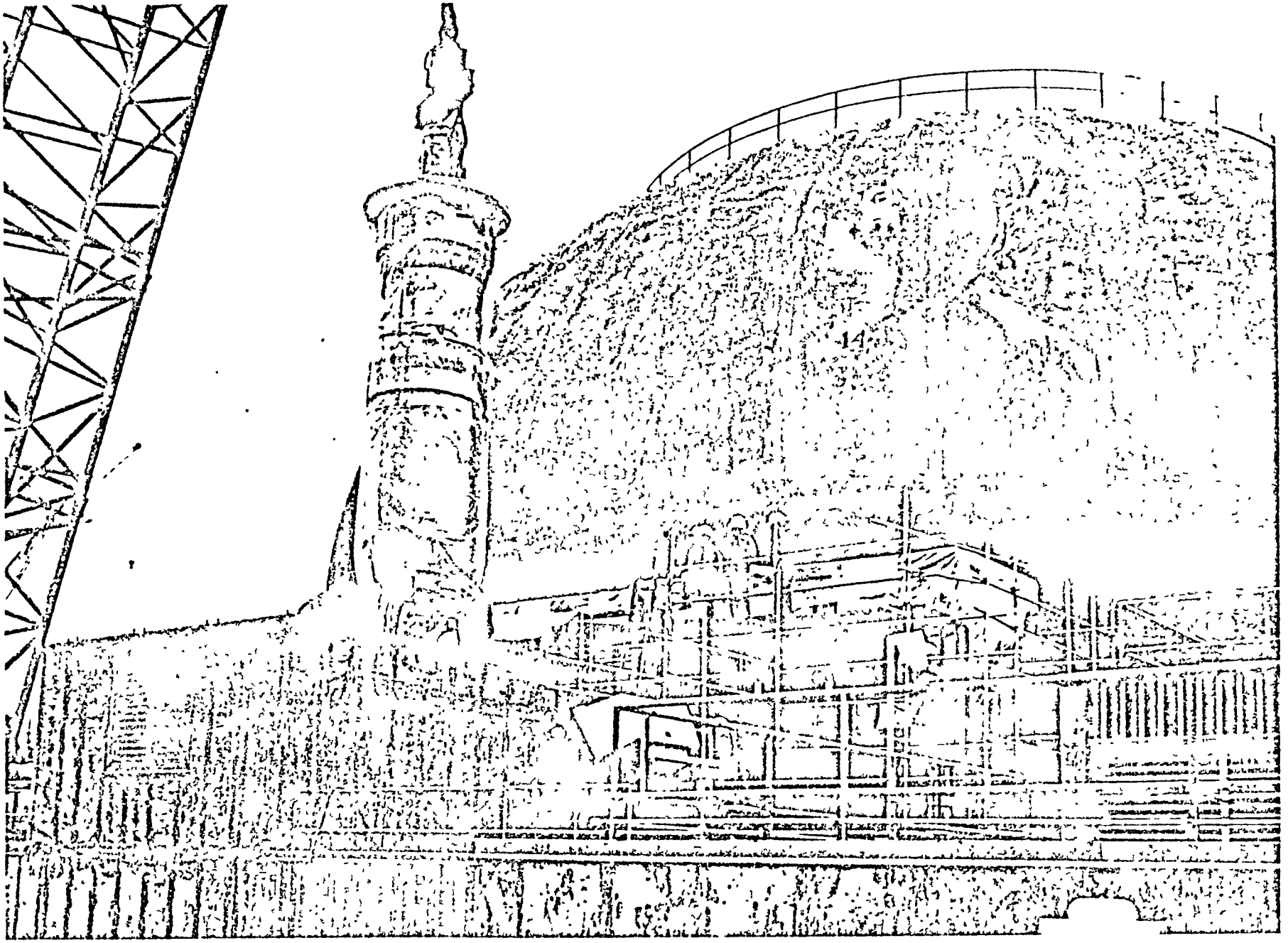
BECHTEL CONSTRUCTION PERCENT COMPLETE



HEDL 7805-363.2






14

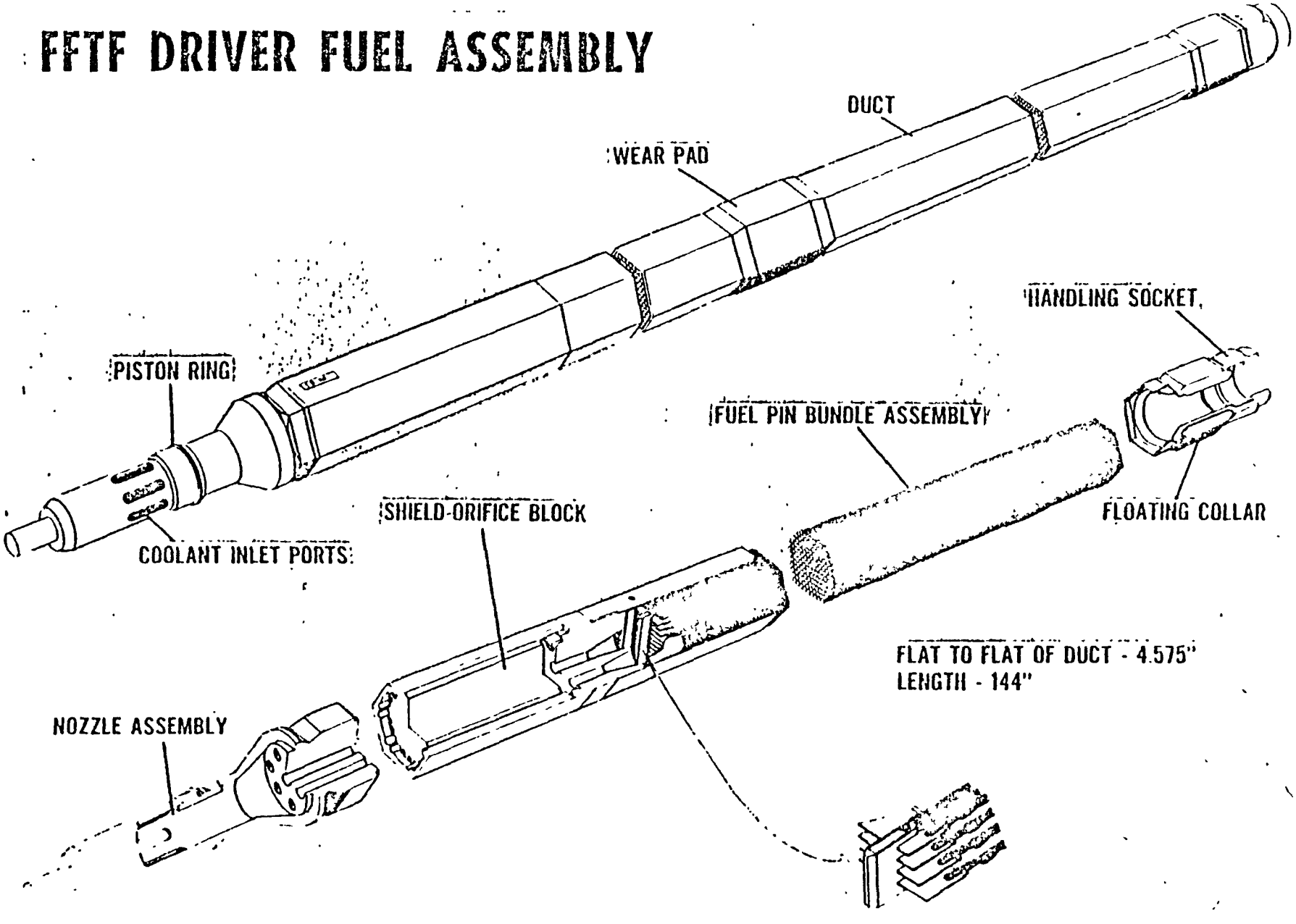
In vessel view

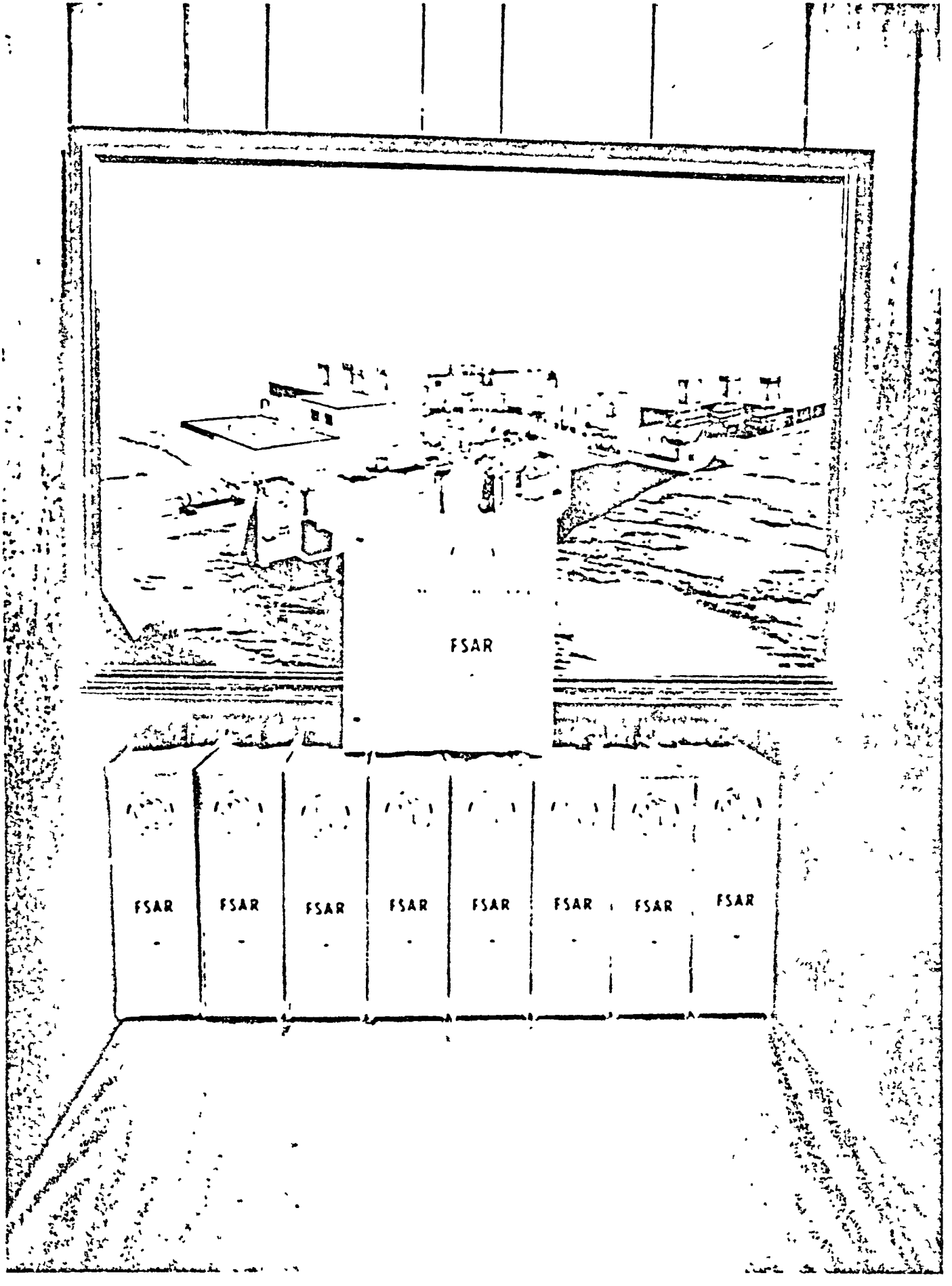
w. IT & man

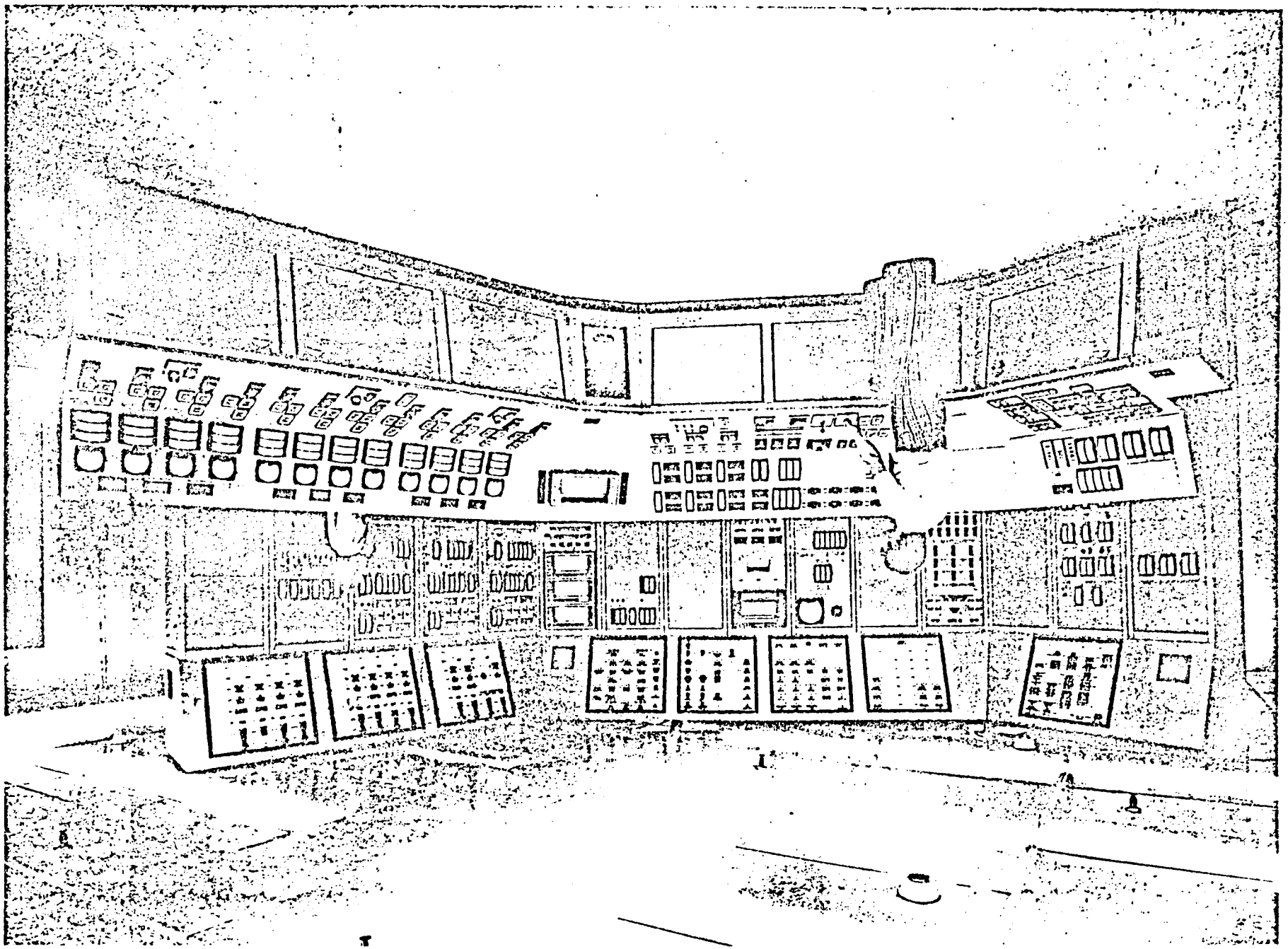
14 R-A

Control Room

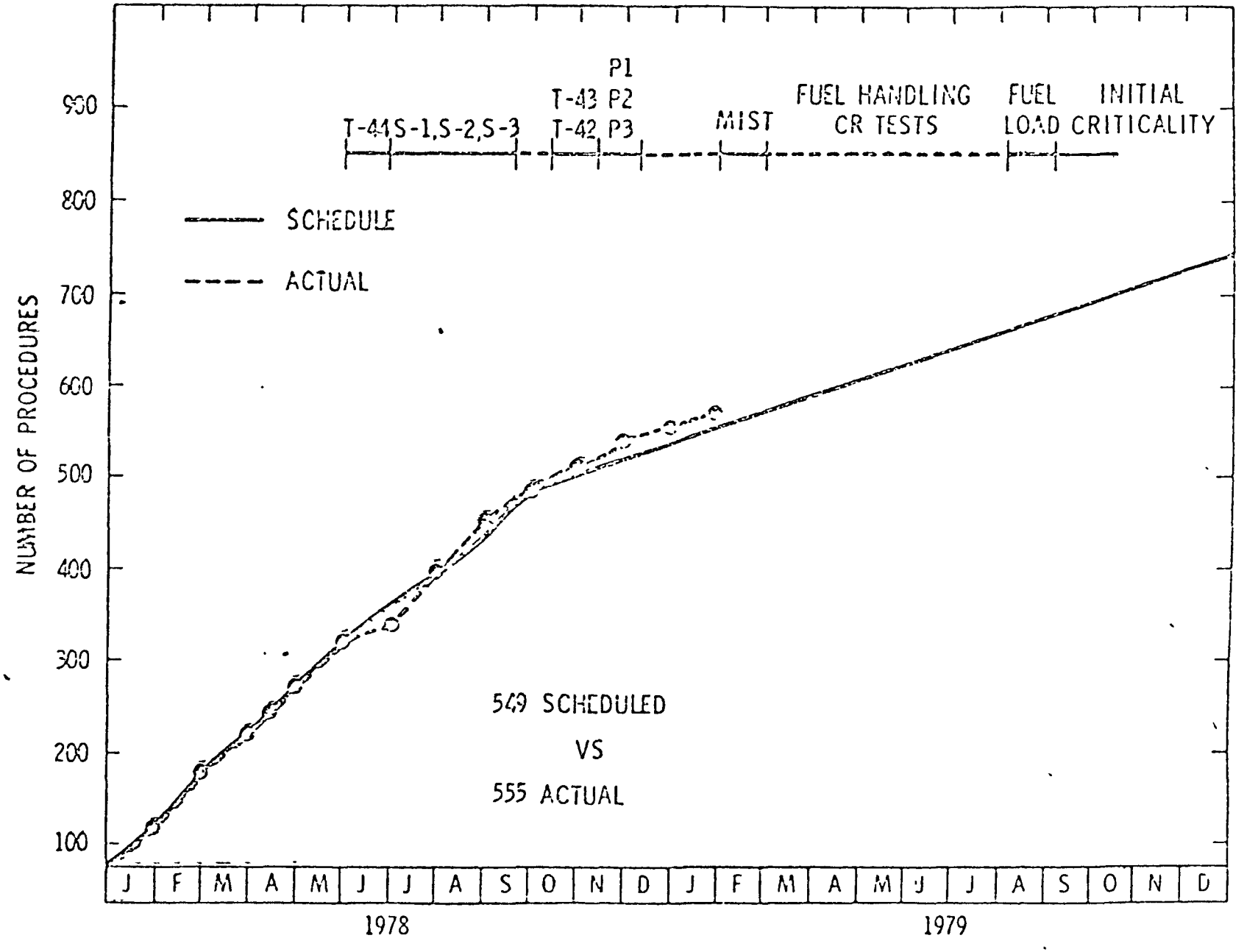
FFTF DRIVER FUEL ASSEMBLY



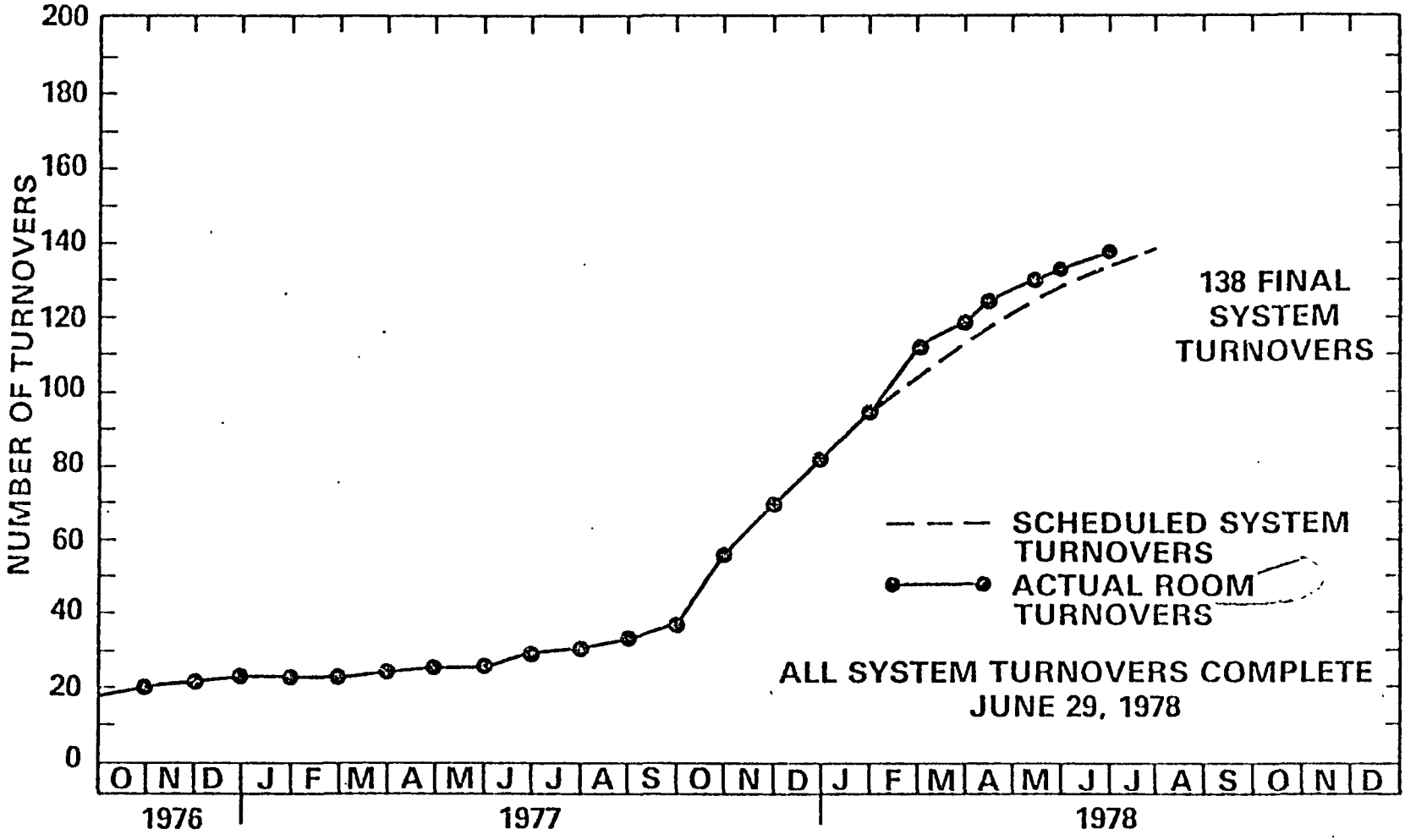

FSAR
FSAR
FSAR
FSAR
FSAR
FSAR
FSAR
FSAR
FSAR



PROCEDURE VERIFICATION CURVE

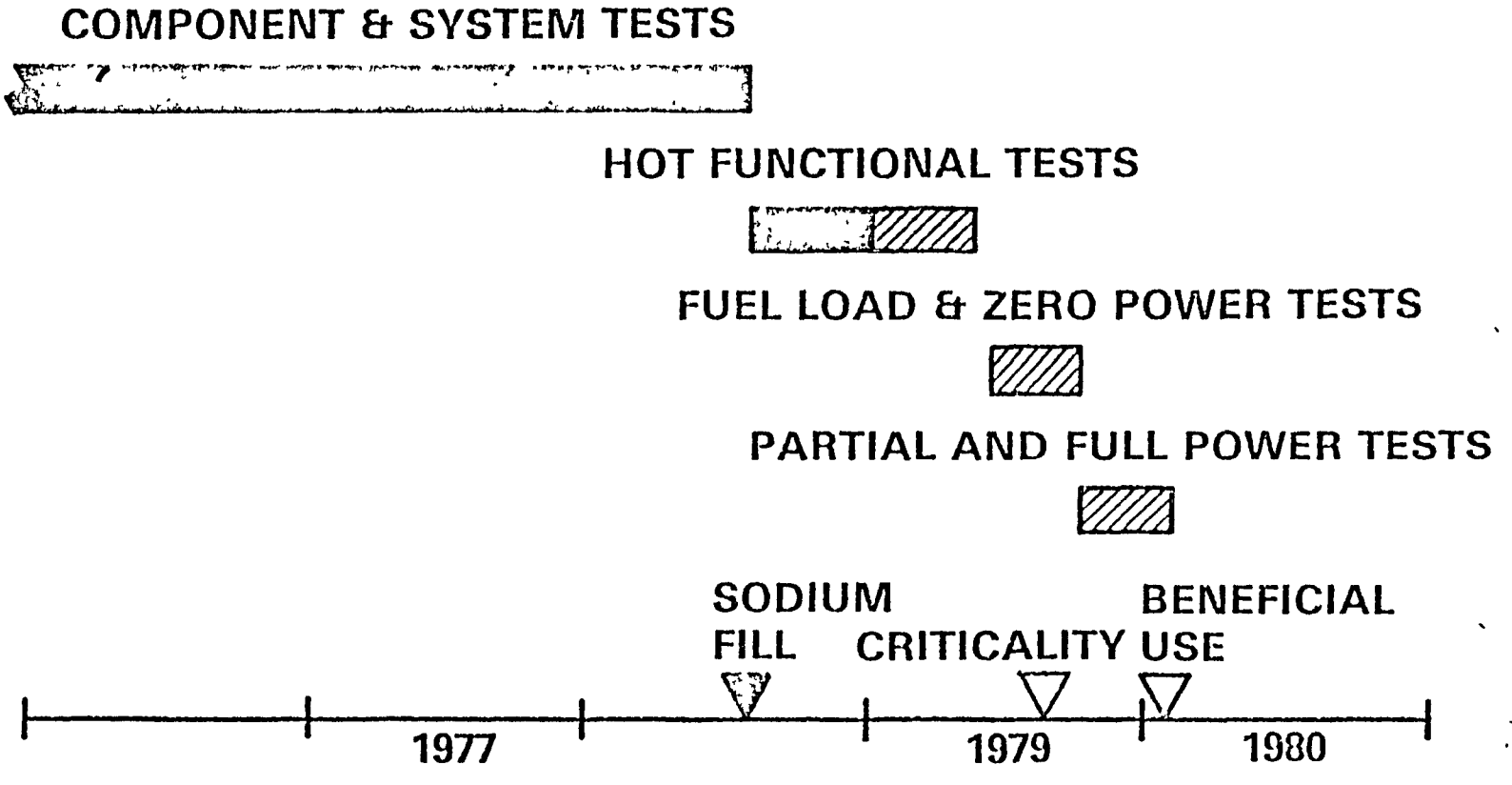


BECHTEL CONSTRUCTION - STARTUP SYSTEMS TURNOVERS



19 R

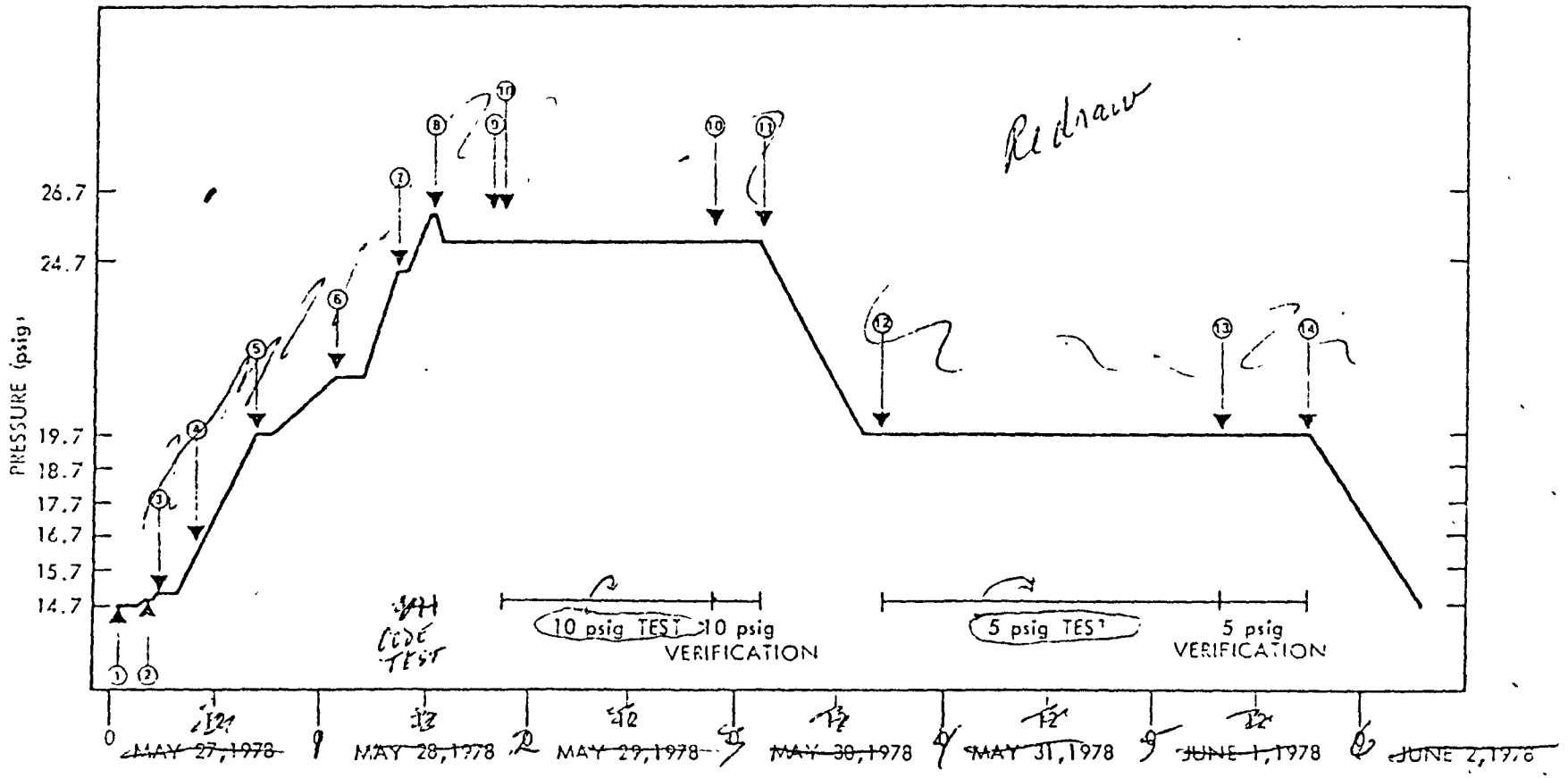
FFTF START UP SCHEDULE



ACCEPTANCE TESTING PROGRESS

- MAJOR AUXILIARY SYSTEMS TESTED AND IN OPERATION
- ILRT SUCCESSFULLY PERFORMED
- HEAT TRANSPORT SYSTEM FILLED AND OPERATING AT 400°F
- TESTING INITIATED AT ELEVATED TEMPERATURES
- FUEL HANDLING TESTS COMPLETED IN AIR

- CORE COMPONENTS BEING RECEIVED



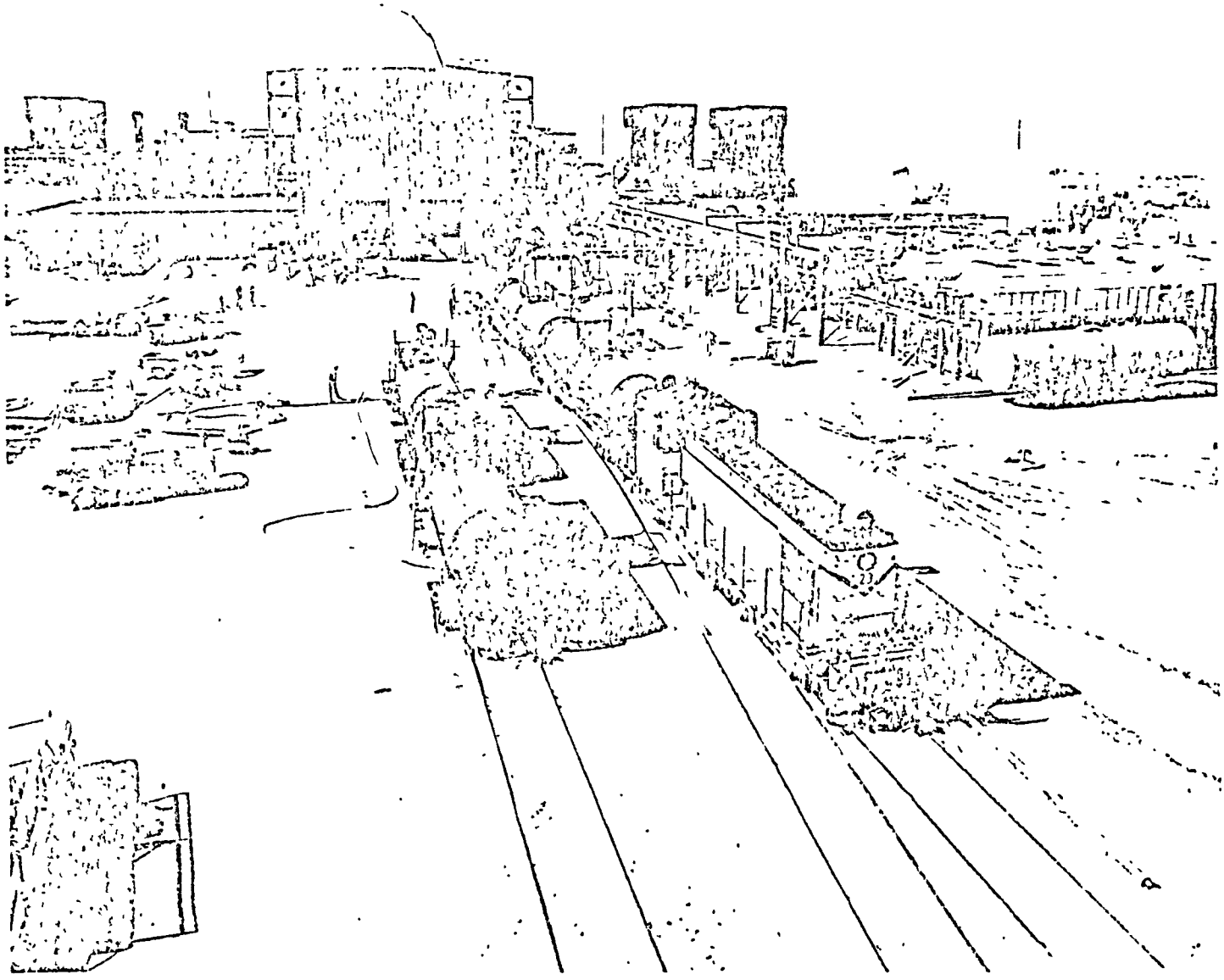
FFTF ILRT HISTOGRAM

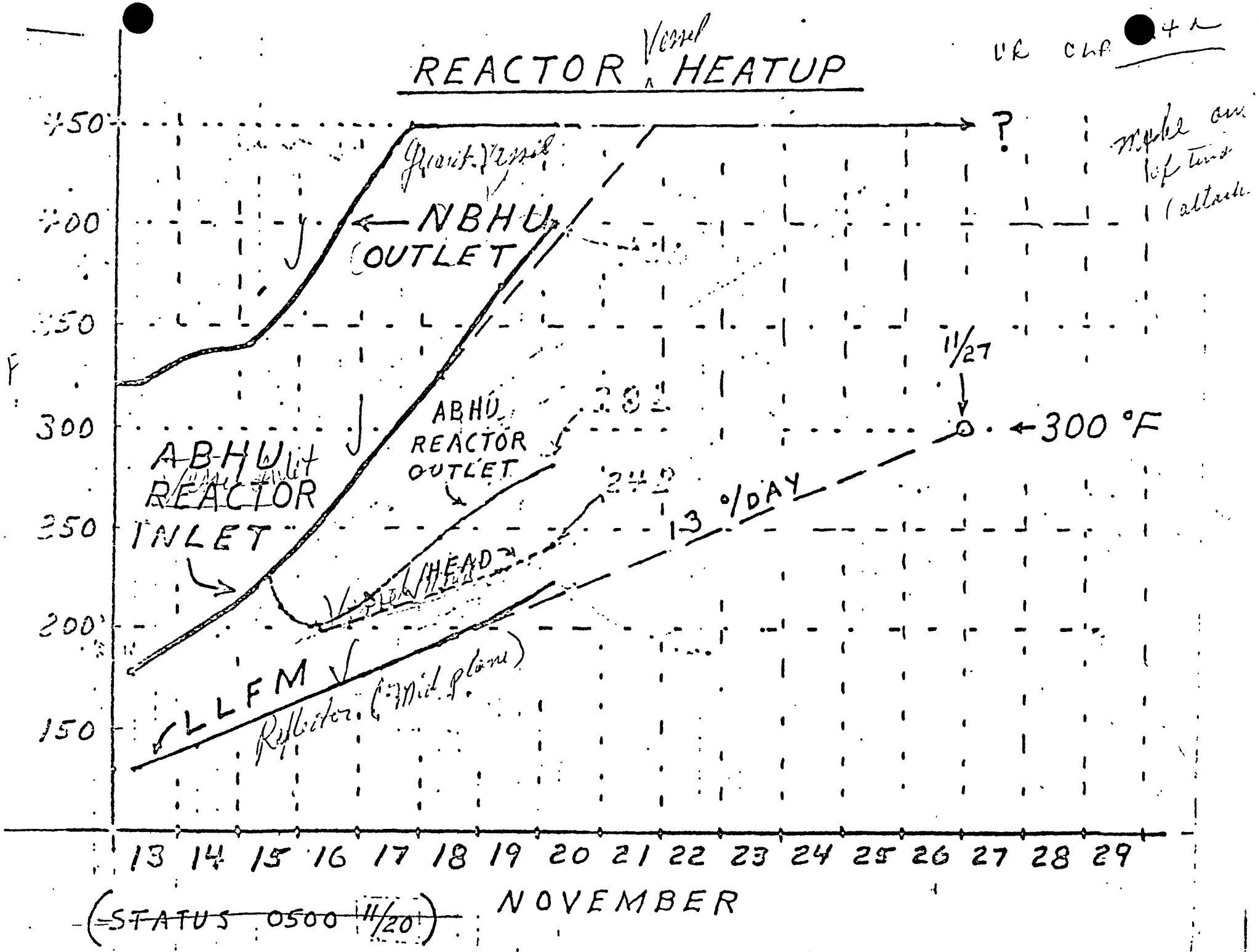
HEDL 7810-135.10

Figure 2

FFTF ILRT TEST RESULTS

PRESSURE	LEAK RATE (LA = .1% LT = .0707%)	
	MASS PLOT (CALC/95% CONF.)	TOTAL TIME (CALC/95% CONF.)
10 PSIG	.031/.033	.041/.0594
5 PSIG	-.0045/-.0015	-.0009/.-




REACTOR Vessel HEATUP
UK CLA
+50
+00
350
F
300
250
200
150
Giant Vessel
NBHU OUTLET
ABHU REACTOR INLET
ABHU REACTOR OUTLET
HEAD
LLFM
Reflector (Mid Plane)
?
11/27
300 °F
13 °/DAY
13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
NOVEMBER
(STATUS 0500 11/20)

HTS PUMPS

MECHANICAL PERFORMANCE

- PREHEAT PERFORMANCE NORMAL
  - TEMPERATURE DISTRIBUTION ACCEPTABLE
  - TORQUE CHECKS OK
- BEARING PERFORMANCE NORMAL
  - THERMOCOUPLES READ SODIUM TEMPERATURE
  - TORQUE CHECKS OK
- SEAL PERFORMANCE VERY GOOD
  - MAX. LEAKAGE 60 CC/HR
  - DESIGN GOAL 40 CC/HR
  - LMEC RESULTS 168 CC/HR
- COASTDOWN TIMES NORMAL

PRIMARY	SECONDARY
• P-1 ~105 SEC	• P-4 ~ 55 SEC
• P-2 ~101 SEC	• P-5 ~ 63 SEC
• P-3 ~ 96 SEC	• P-6 ~ 56 SEC
• PROTOTYPE/LMEC ~ 99 SEC	• H_2O/EMD ~48 SEC

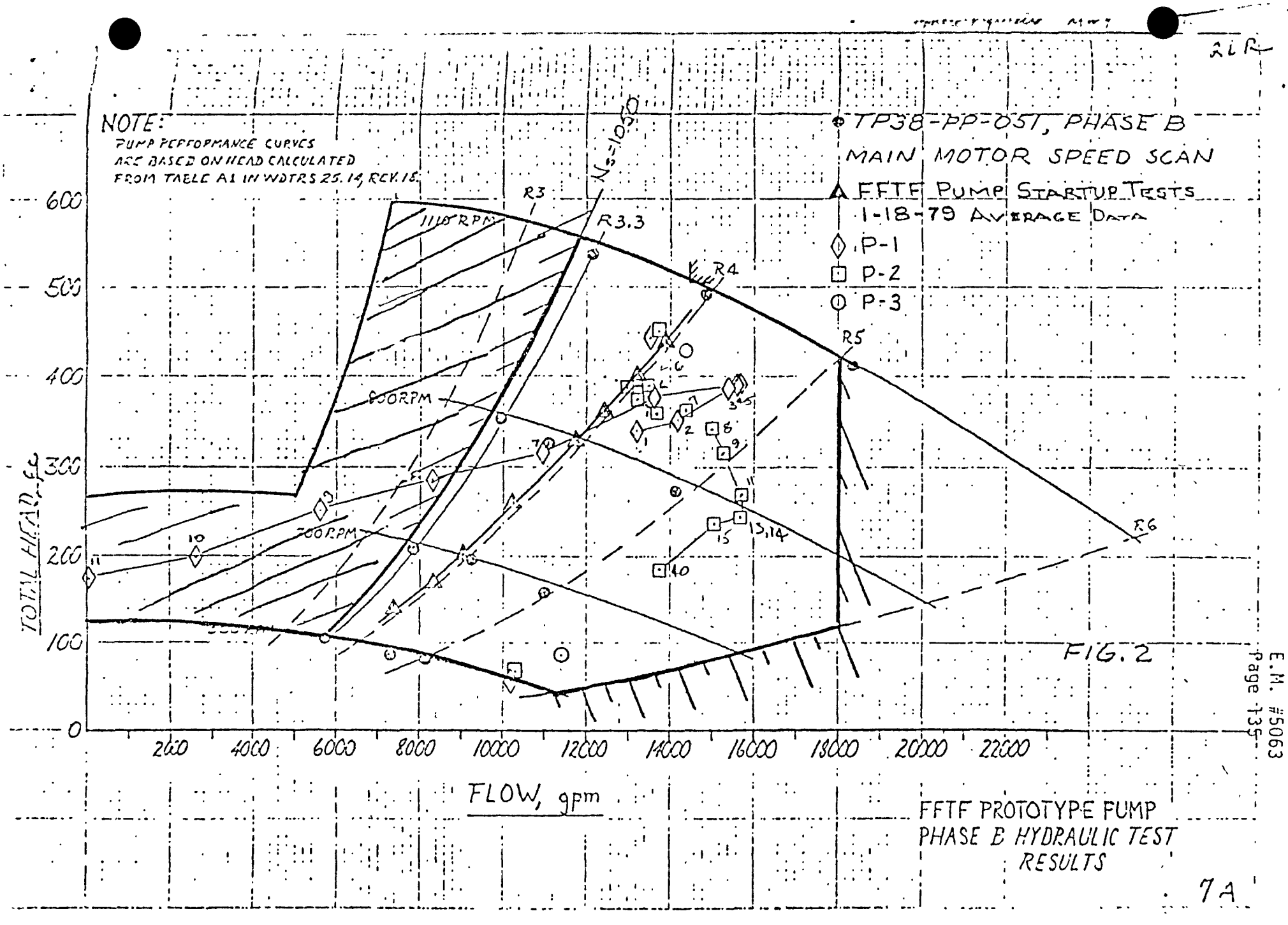


FIG. 2

FFTF PROTOTYPE PUMP
PHASE B HYDRAULIC TEST
RESULTS

7A

E.M. #5063
Page 135

TESTING AT MIST

PUMP PERFORMANCE - MINIMUM → MAXIMUM SPEED AND COASTDOWN

REACTOR CORE VIBRATION - ZERO → FULL FLOW

REACTOR CORE FLOW MAPPING - AT FULL FLOW

~~SECONDARY LOOP DRAIN VALVES~~ - ~~MONITOR TEMPERATURES TO LOCATE LEAKING VALVE(S)~~
CHECK VALVES - VERIFY OPERABILITY

~~H2S EQUILIBRATION SAMPLES~~ - ~~O_2 & H_2 CHARACTERIZATION~~ (1 ONLY)

COVER GAS PURITY - GAS CHROMATOGRAPH MEASUREMENT EACH SHIFT

DIMENSIONAL CHECKS - ~ 220 MEASUREMENTS

~~ELECTRICAL NOISE~~ - ~~SURVEY~~

~~LLFM~~ - ~~OPERABILITY CHECK~~
↳ RX HEAD

HEAT REMOVAL SYSTEMS - CELL TEMPERATURE DATA & BALANCING AS REQUIRED

~~INSTRUMENTATION~~ - ~~OPERABILITY & CHARACTERIZATION~~

NATURAL CIRCULATION - PERFORM AS PART OF PUMP COASTDOWN

UP 25.C

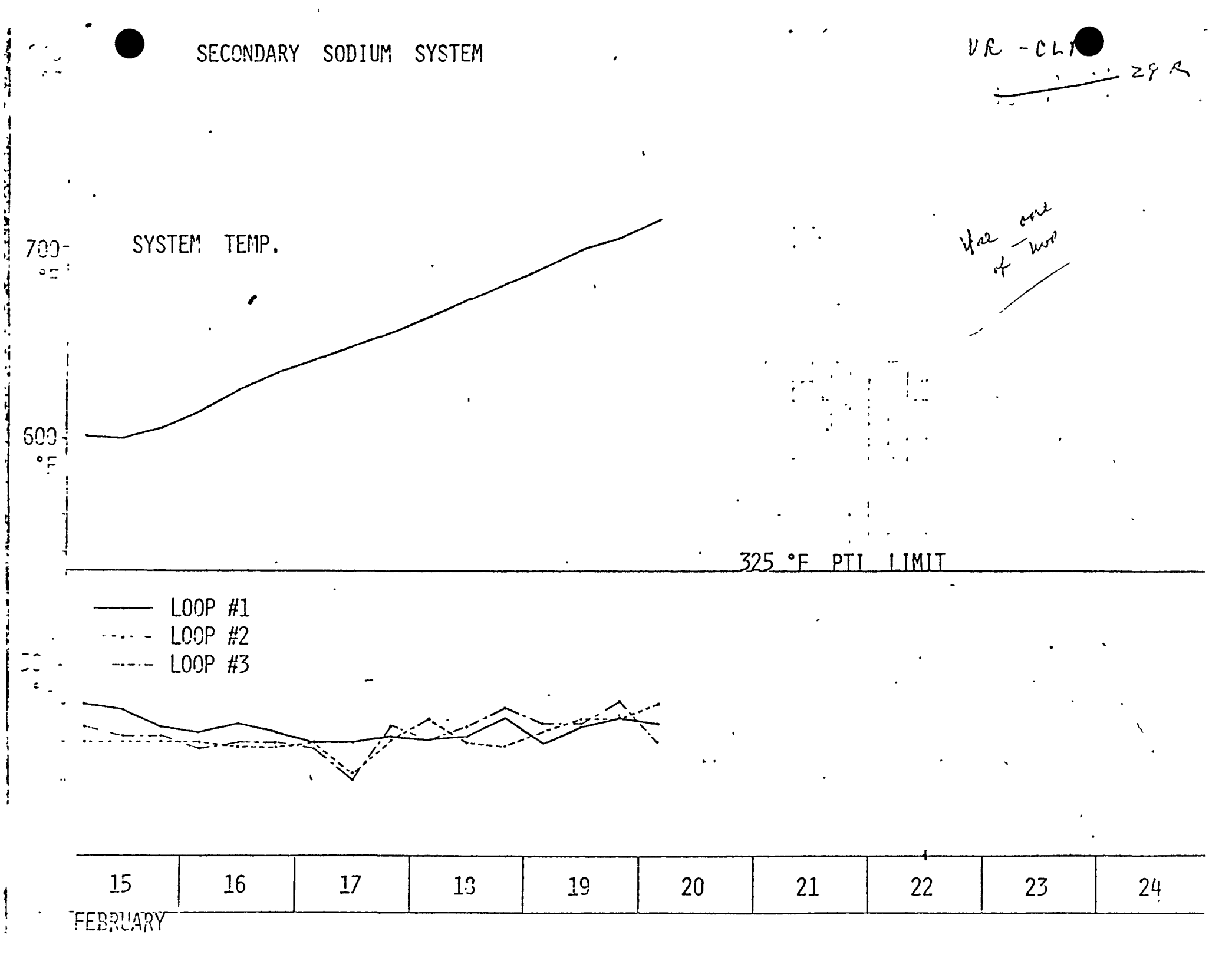
INERT GAS COOLER HEAT LOADS

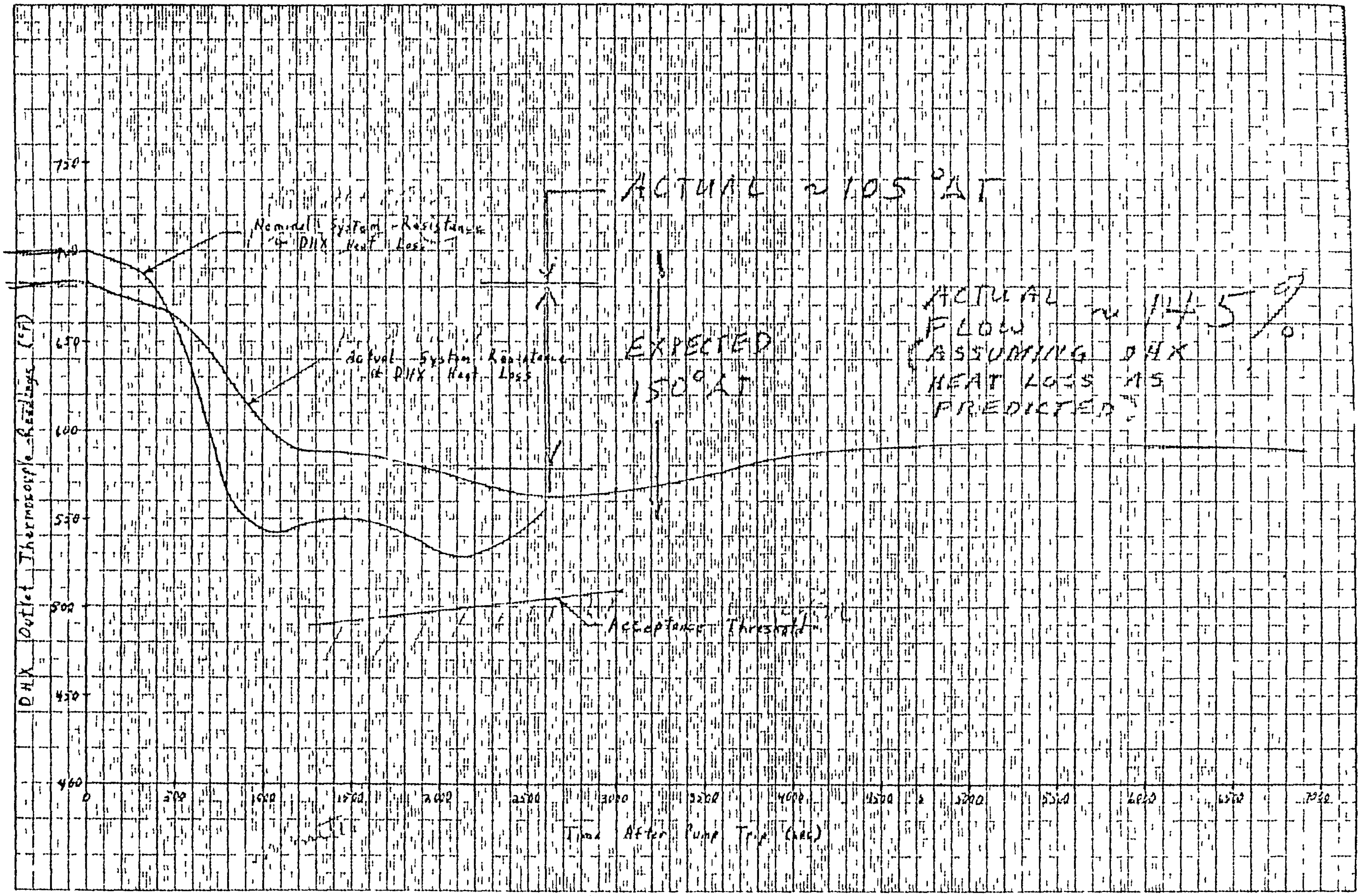
UNIT	SERVICE	400°F (KW)	600°F (KW)	750°F (KW)	NOMINAL DESIGN (KW)
E-201	CAVITY & PIPEWAY	146	190	195*	280
E-203	HTS-1	67	71	108	190
E-205	HTS-2	36	53	69	190
E-206	HTS-3	65	79	95	216
E-208	MISC.	58	59	66	142
E-222	IDS & MISC.	--	103	99**	155
E-224	EM PUMP CELLS	--	32	36	235

* SUPPLEMENTAL COOLING BEING PROVIDED TO HTS VALVE CELLS 531 AB/ 532 AB/ 533 AB

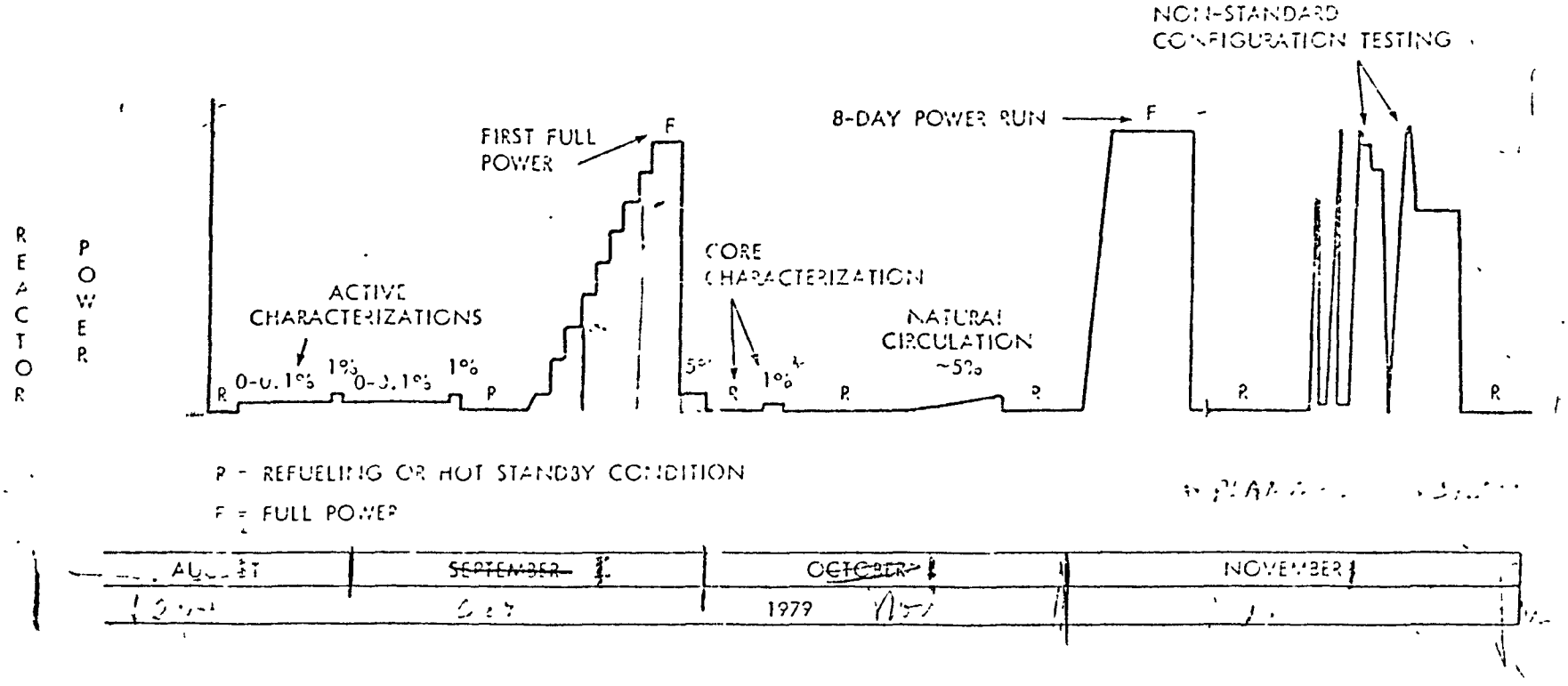
** IDS PREHEAT SYSTEM SHUTDOWN

SECONDARY SODIUM SYSTEM




ACTUAL ~105°ΔT
EXPECTED 150°ΔT
ACTUAL FLOW ~145%
ASSUMING DHX HEAT LOSS AS PREDICTED
Nominal System Resistance + DHX Heat Loss
Actual System Resistance + DHX Heat Loss
Acceptance Threshold
DHX Outlet Thermocouple Readings (°F)
Time After Pump Trip (sec)
750
700
650
600
550
500
450
400
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000

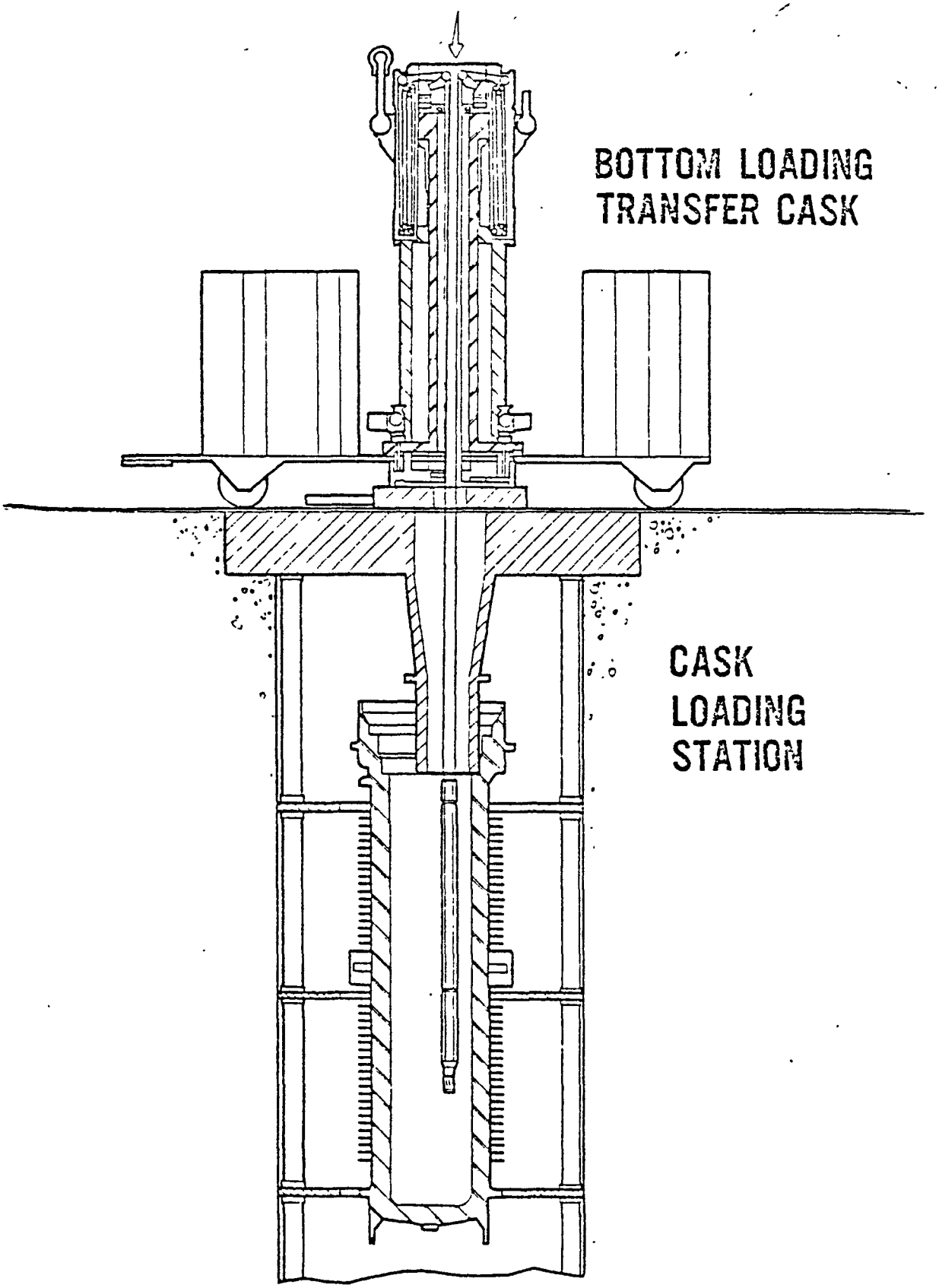
FFTF REACTOR POWER PROFILE PHASE 4 & 5

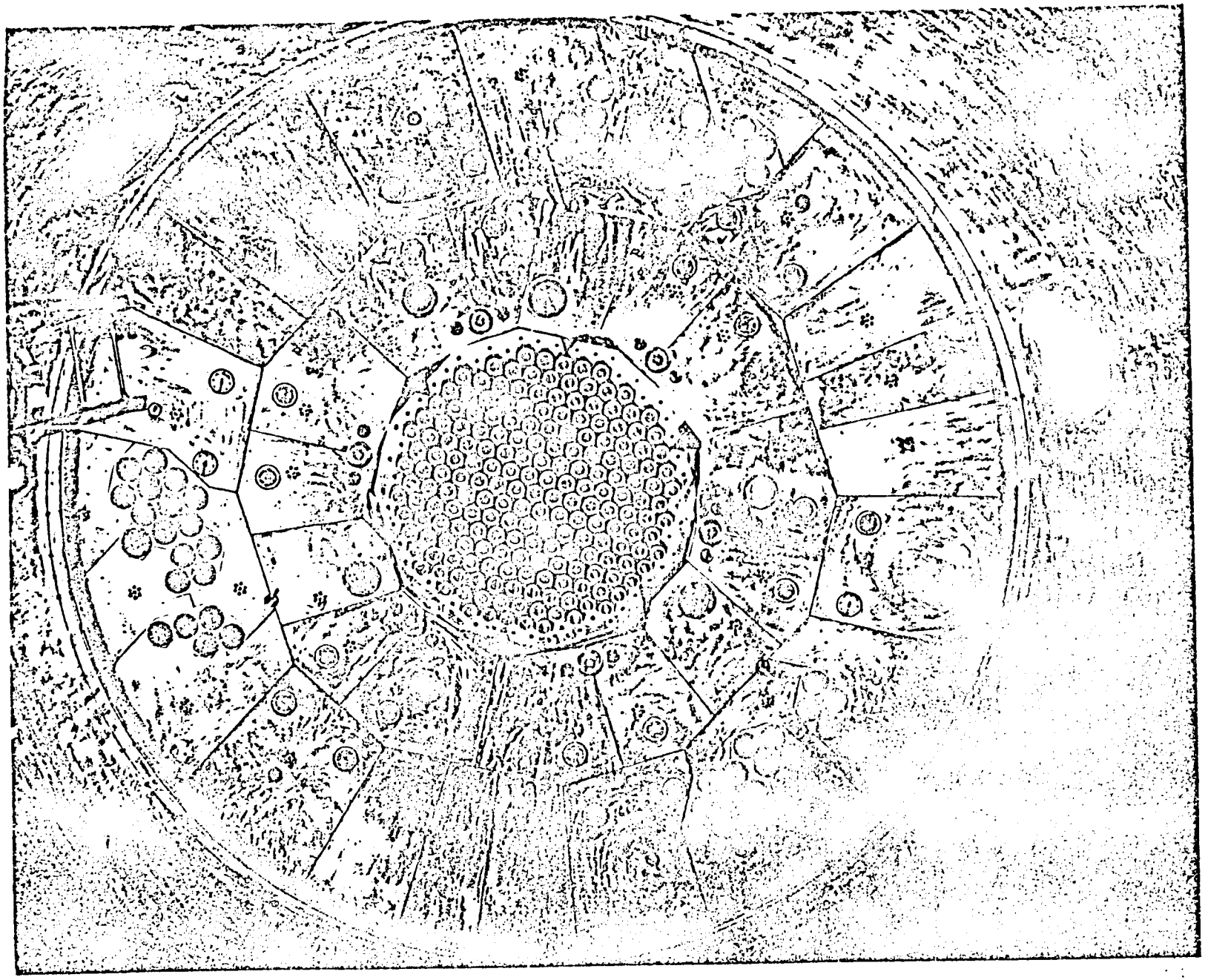


HEDL 7707-218.14

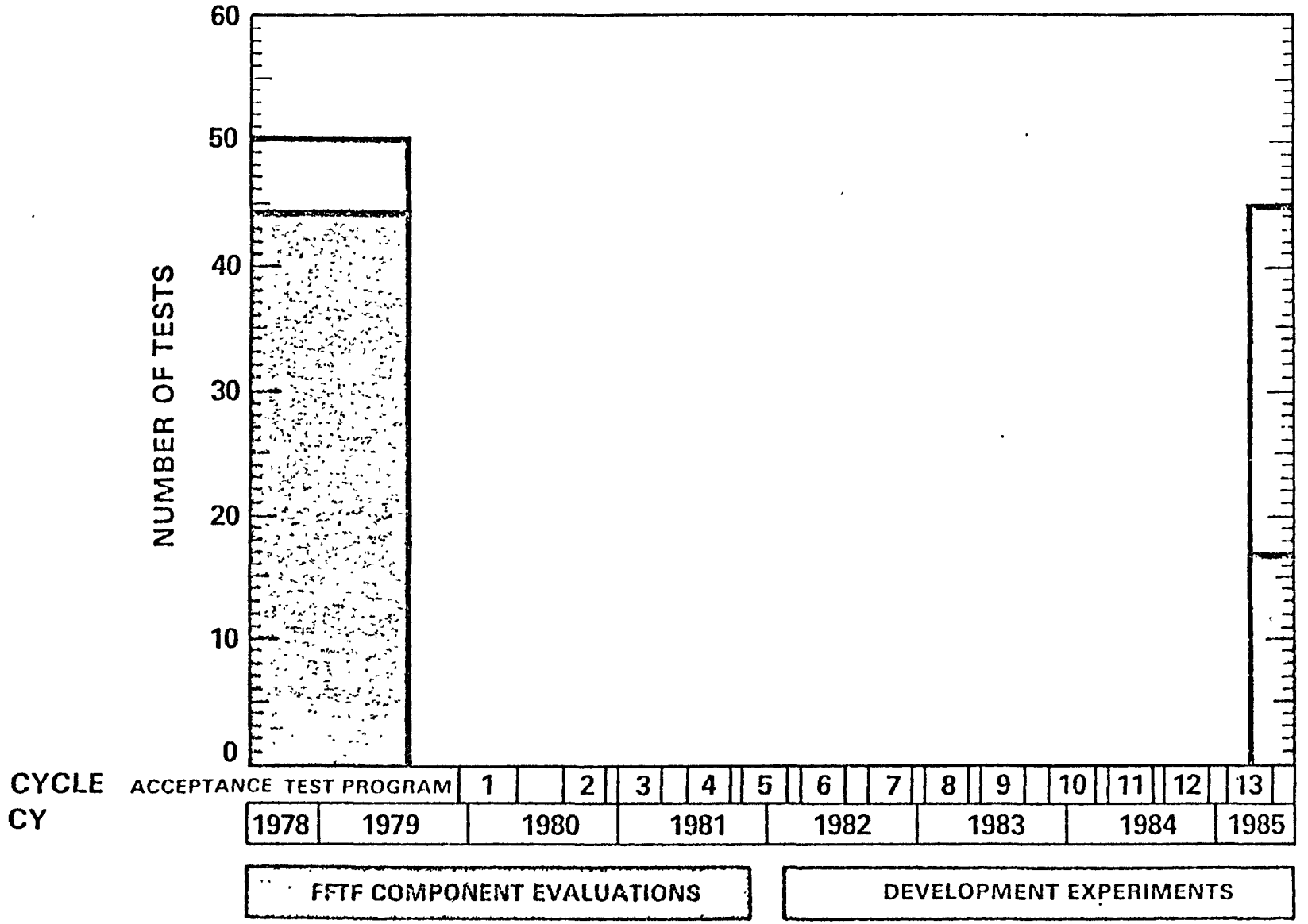
Figure 24


MACHINE


BOTTOM LOADING
TRANSFER CASK
CASK
LOADING
STATION



FFTF EXPERIMENT PROGRAM



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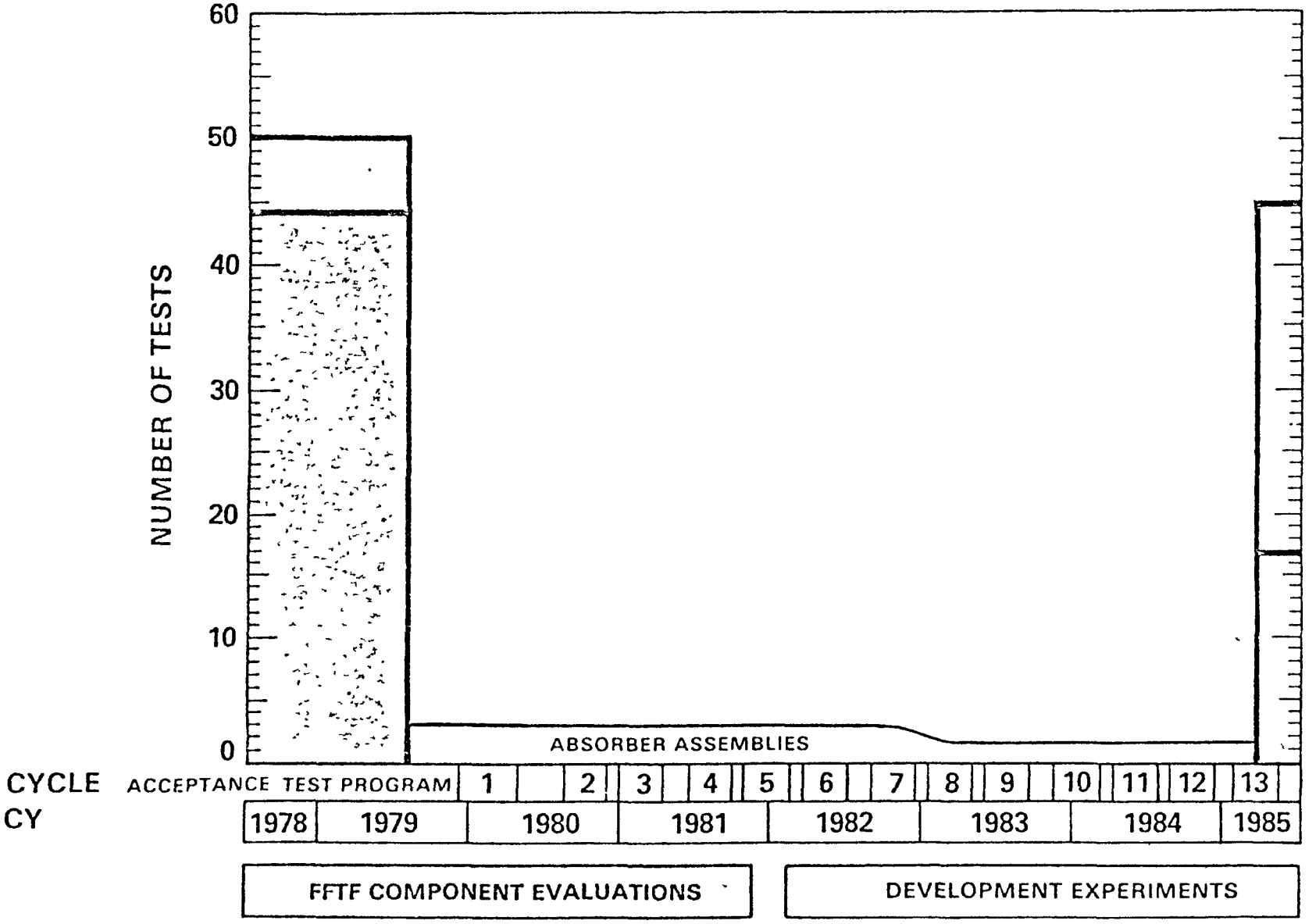
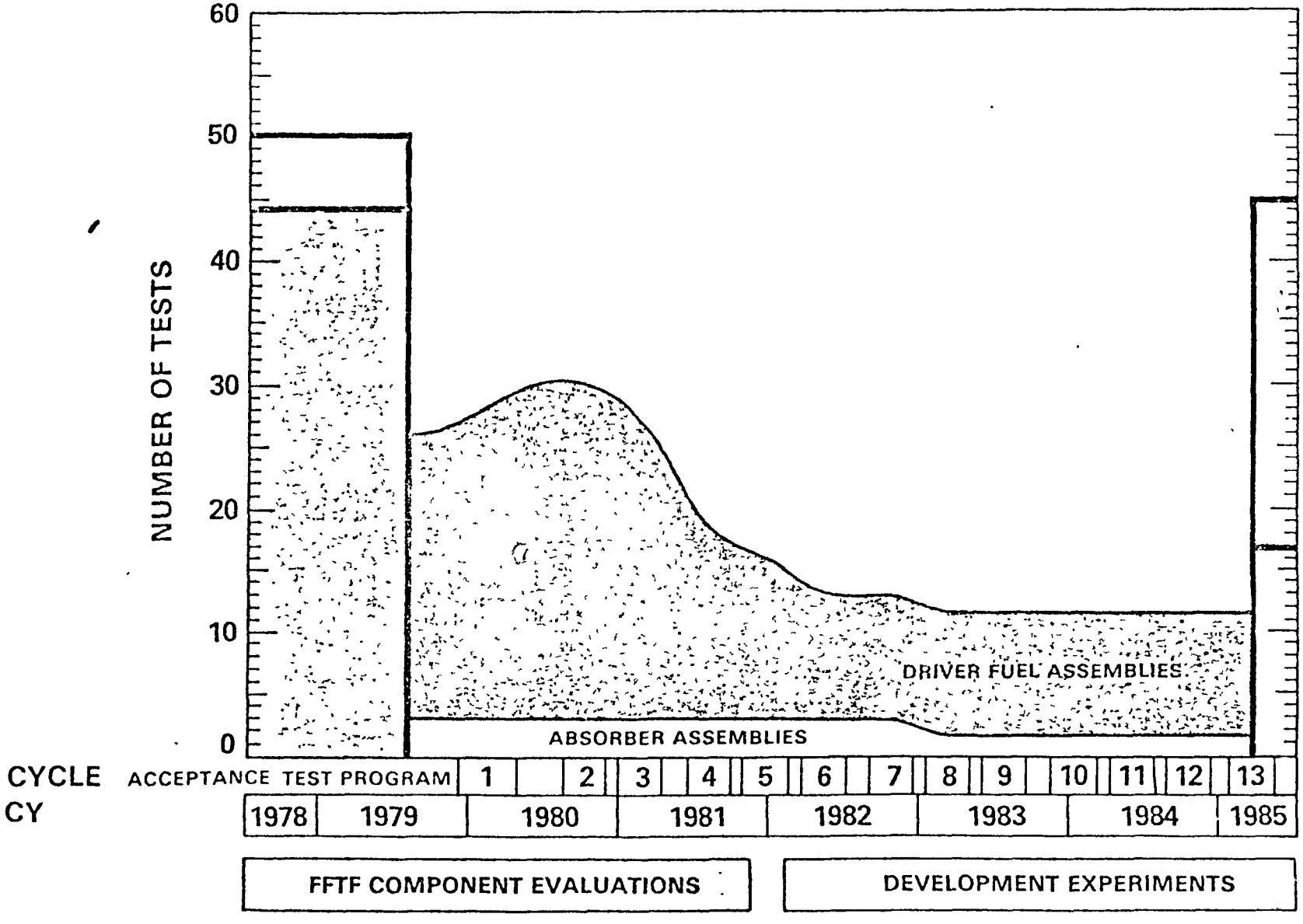
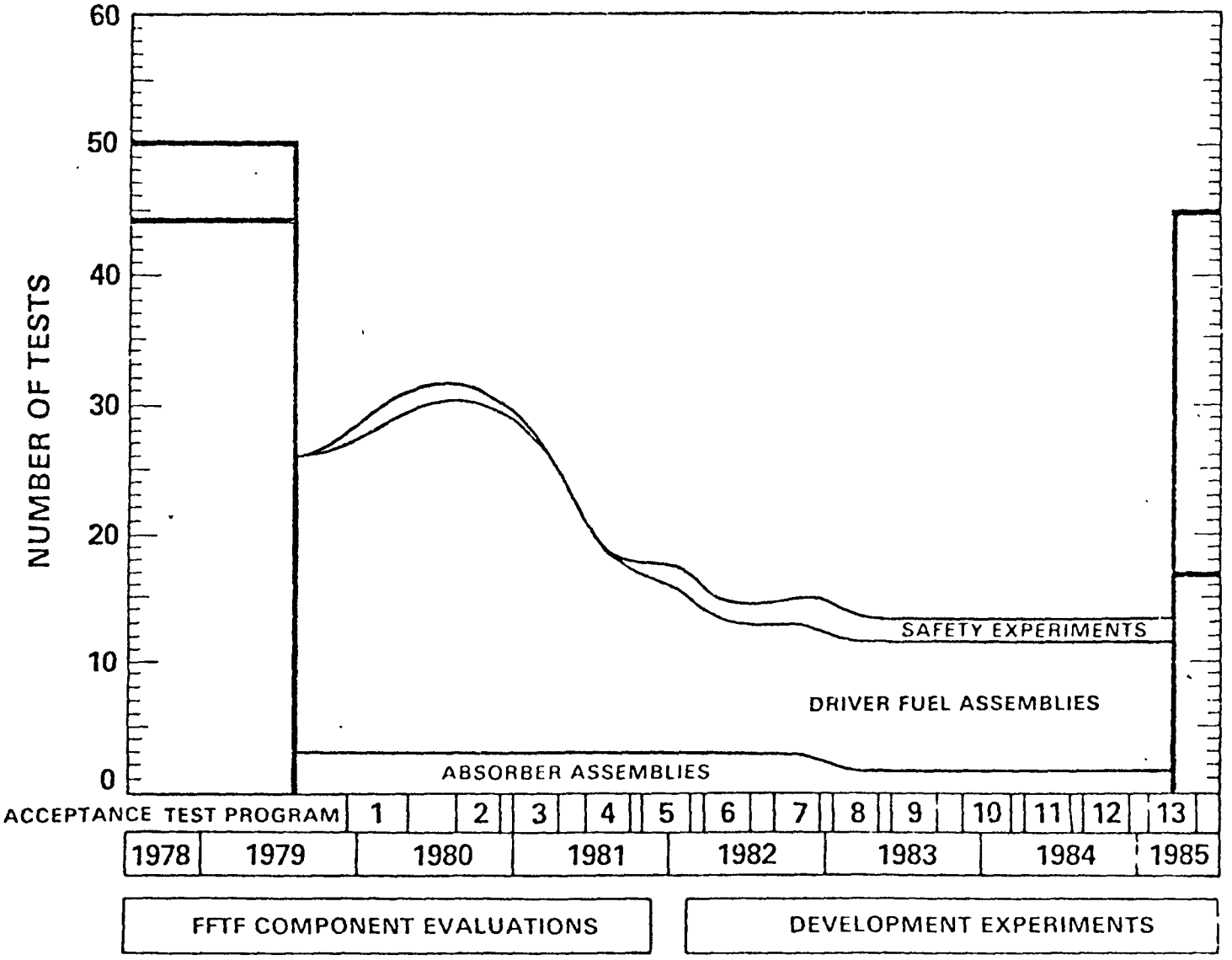


FFTF EXPERIMENT PROGRAM



FFTF EXPERIMENT PROGRAM



40R

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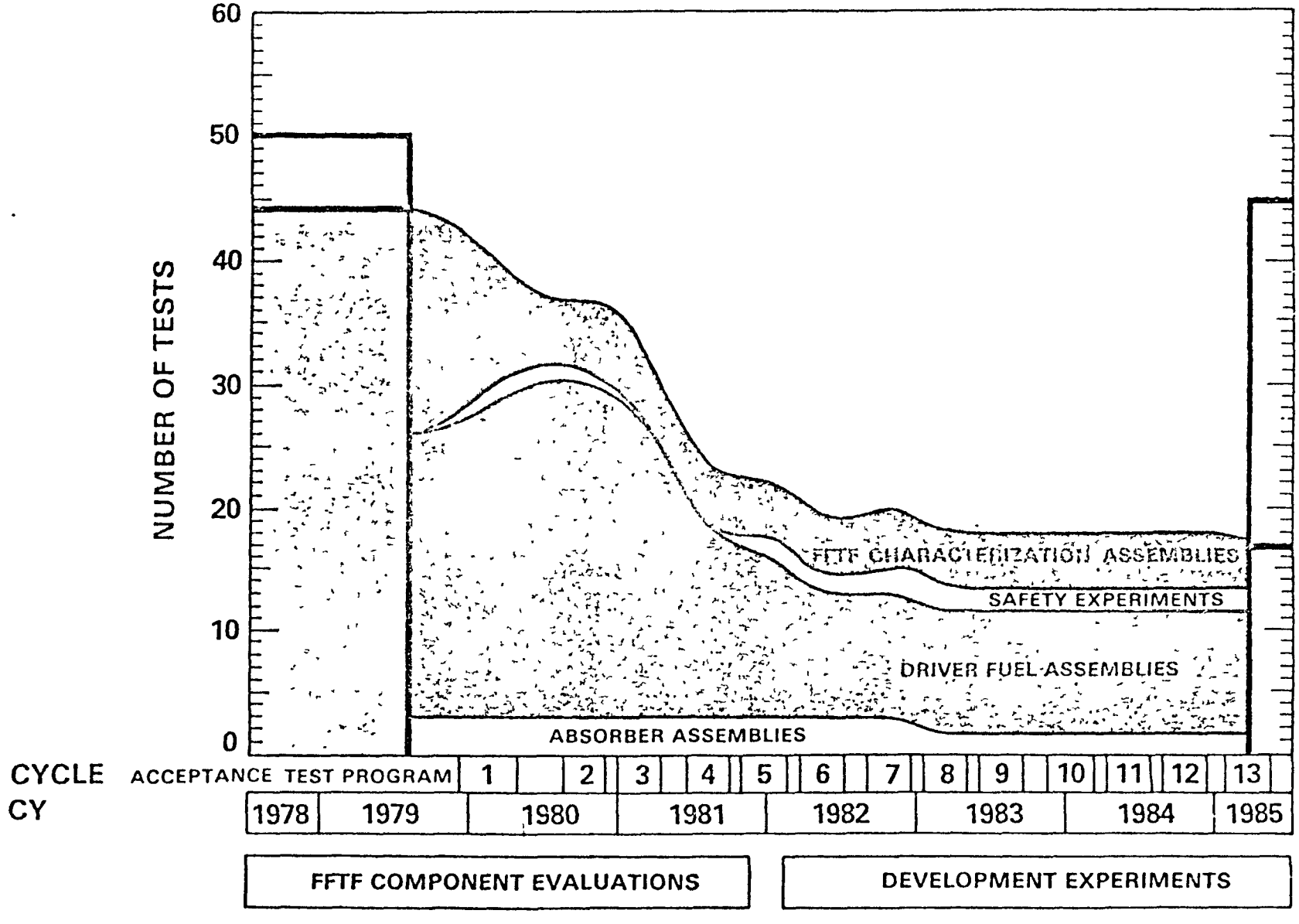

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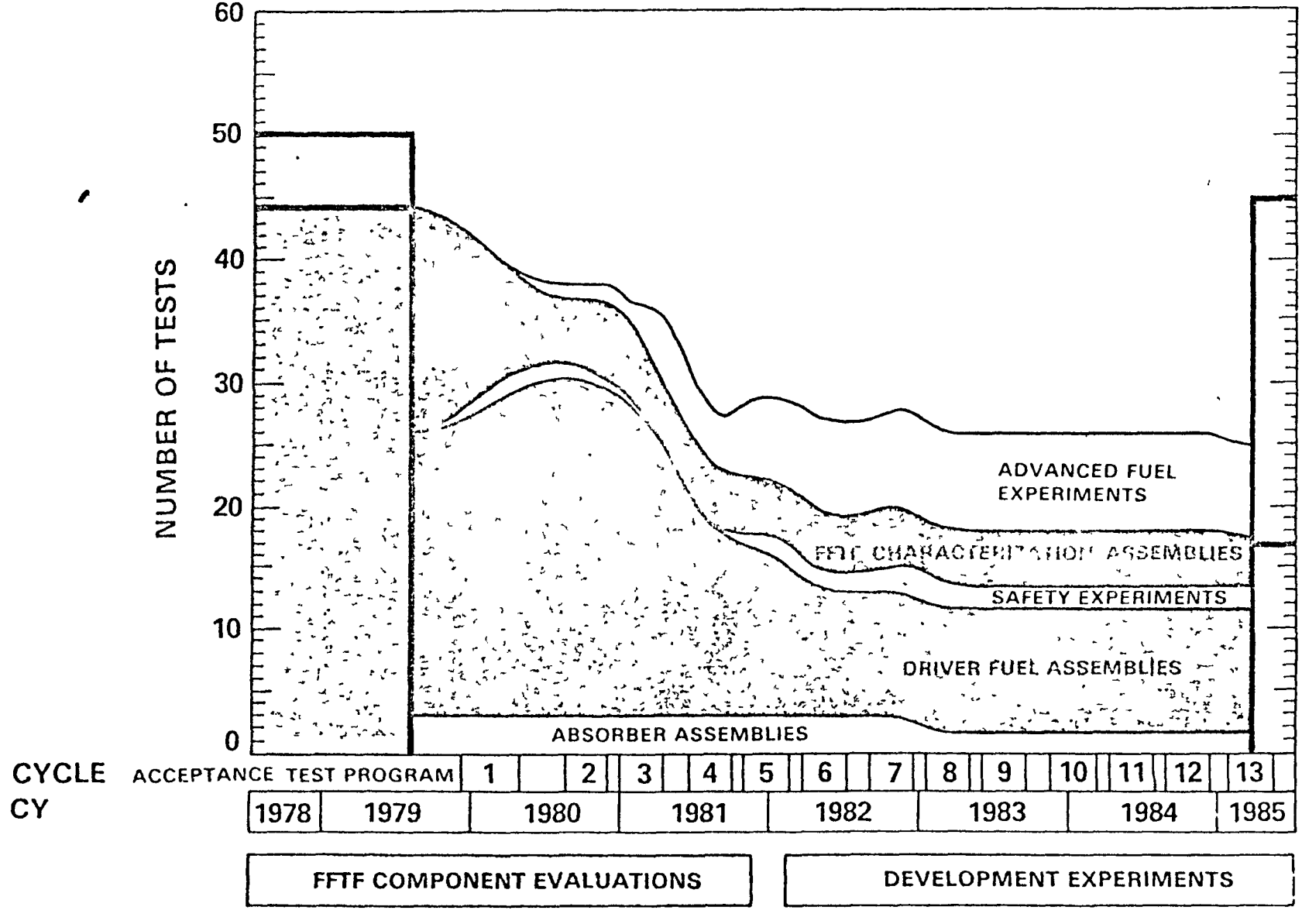

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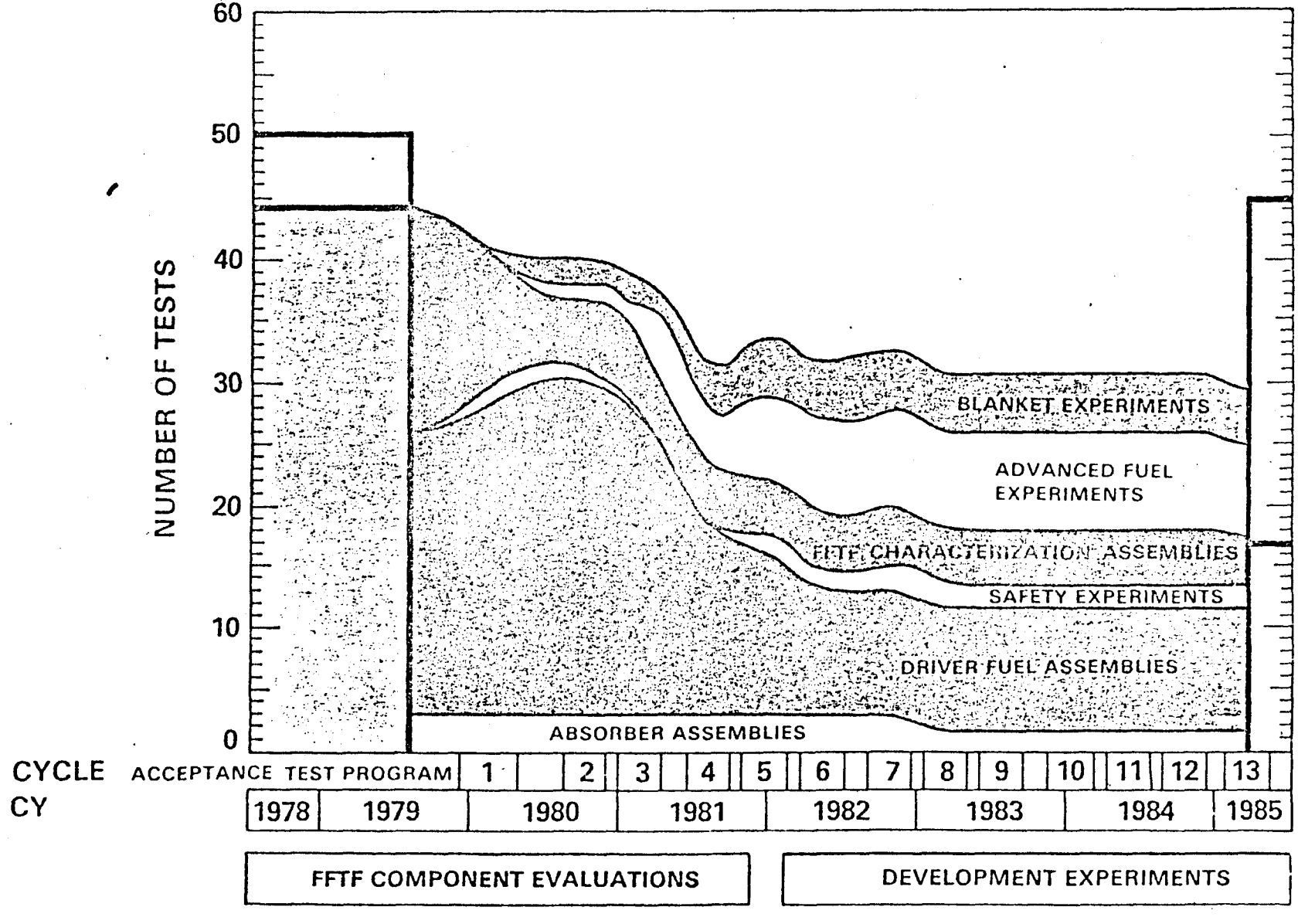

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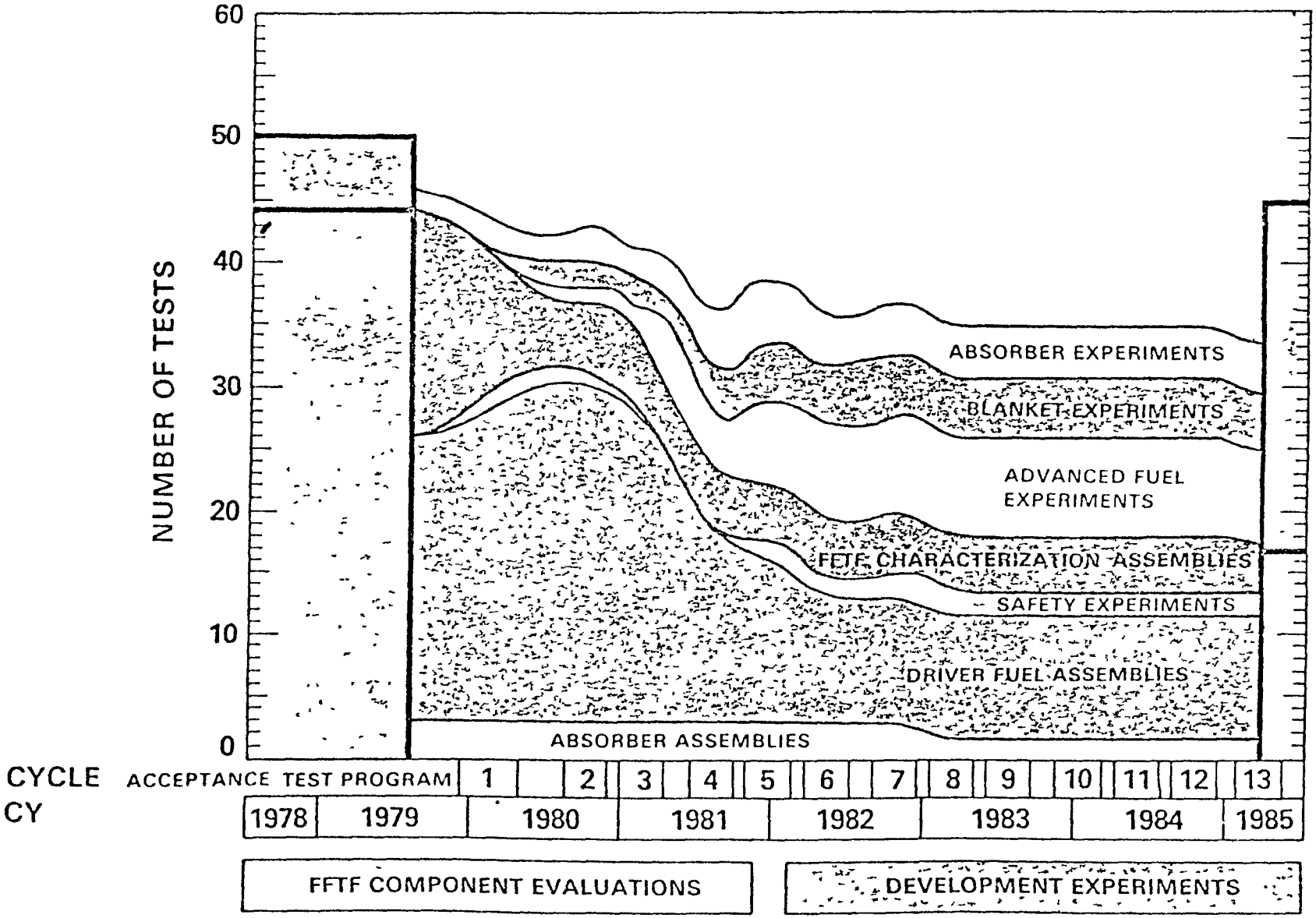

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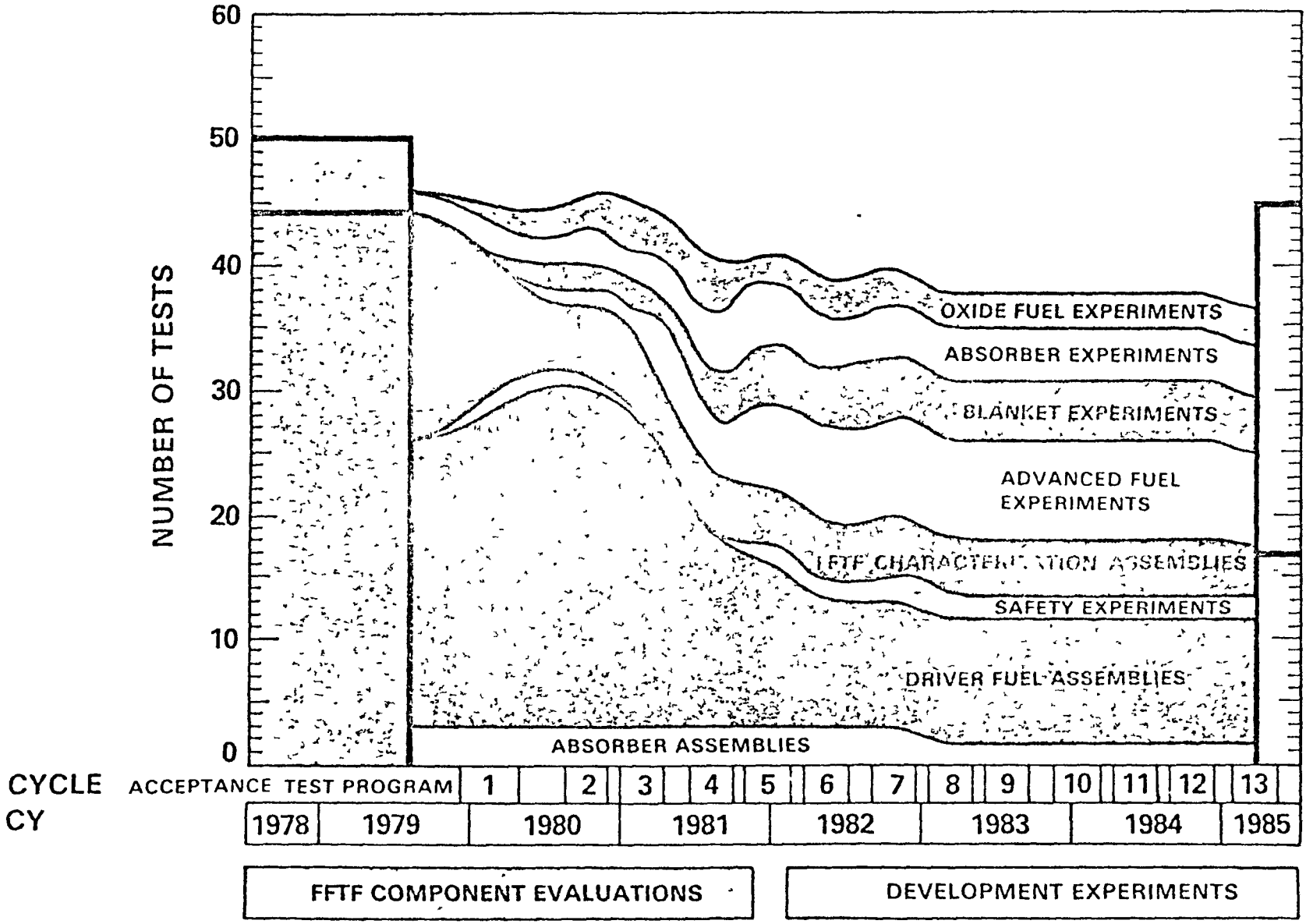

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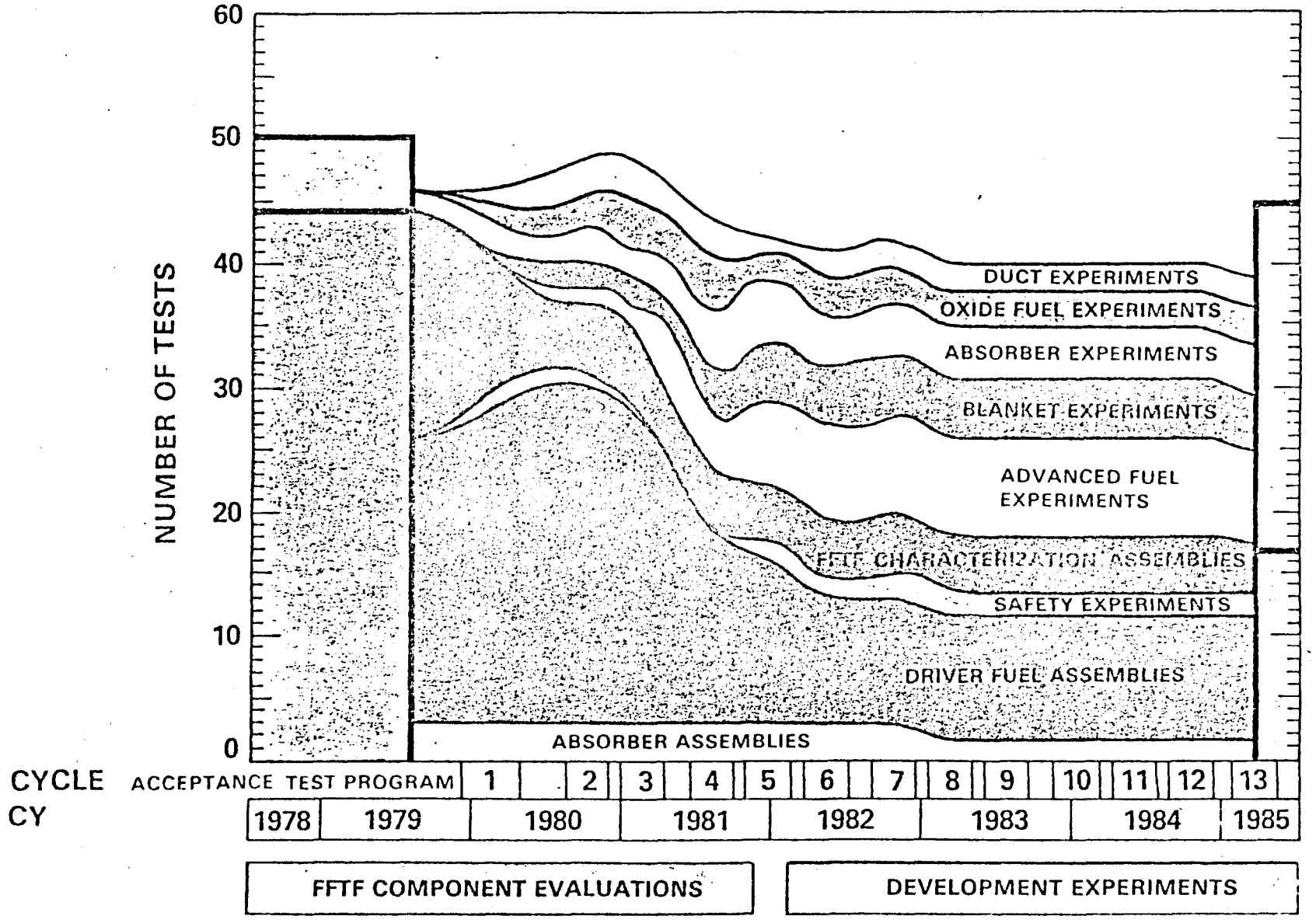

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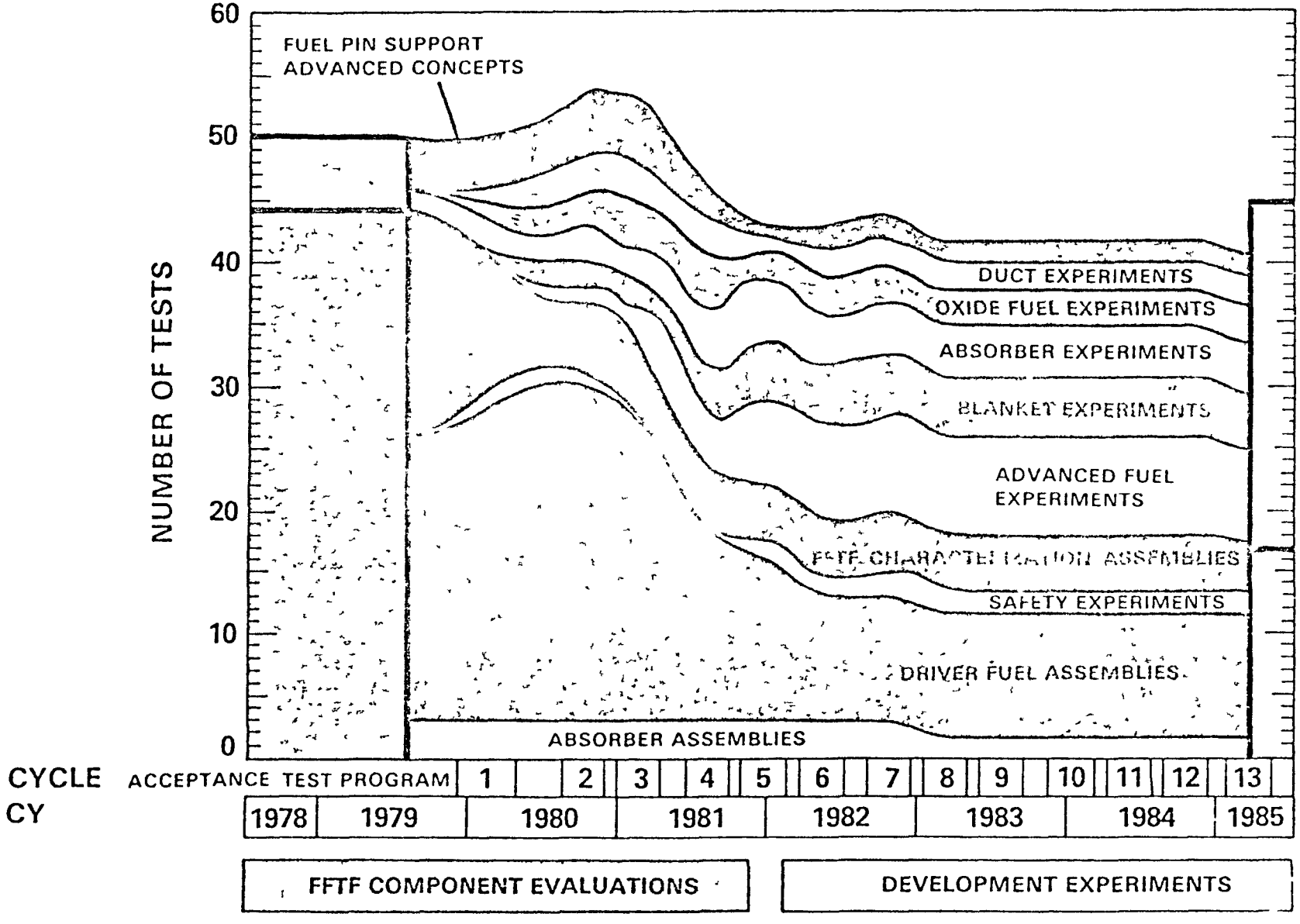
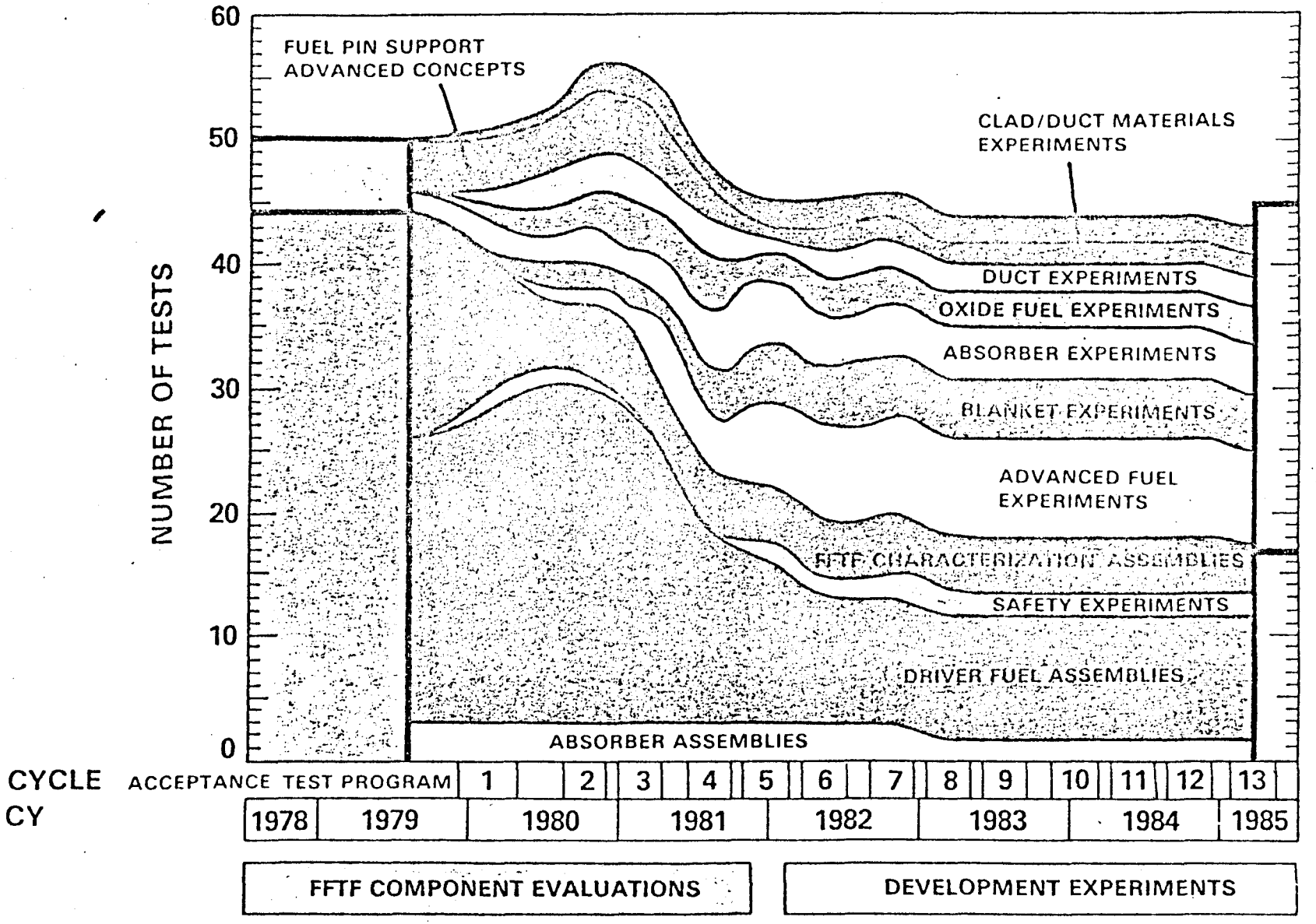
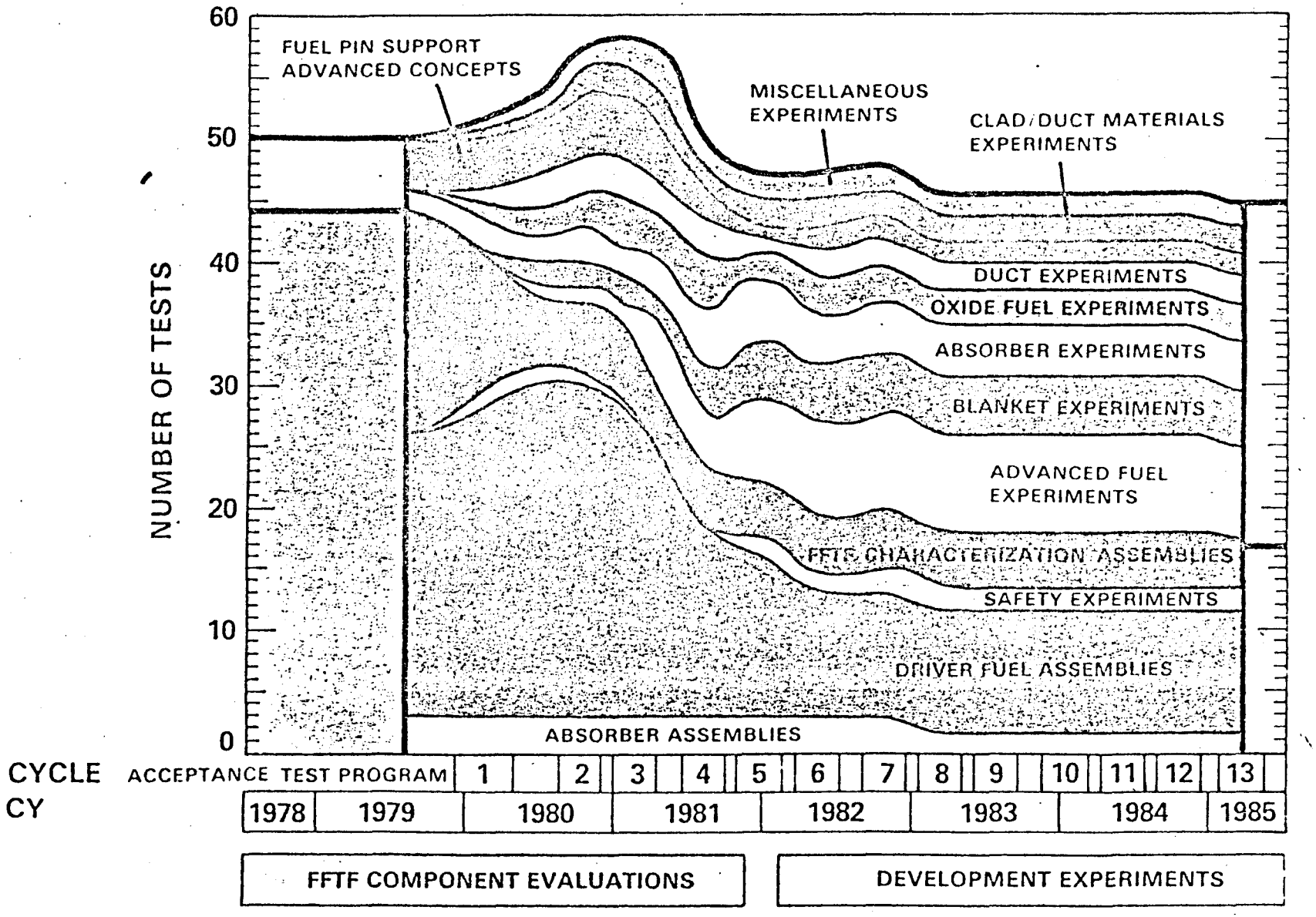


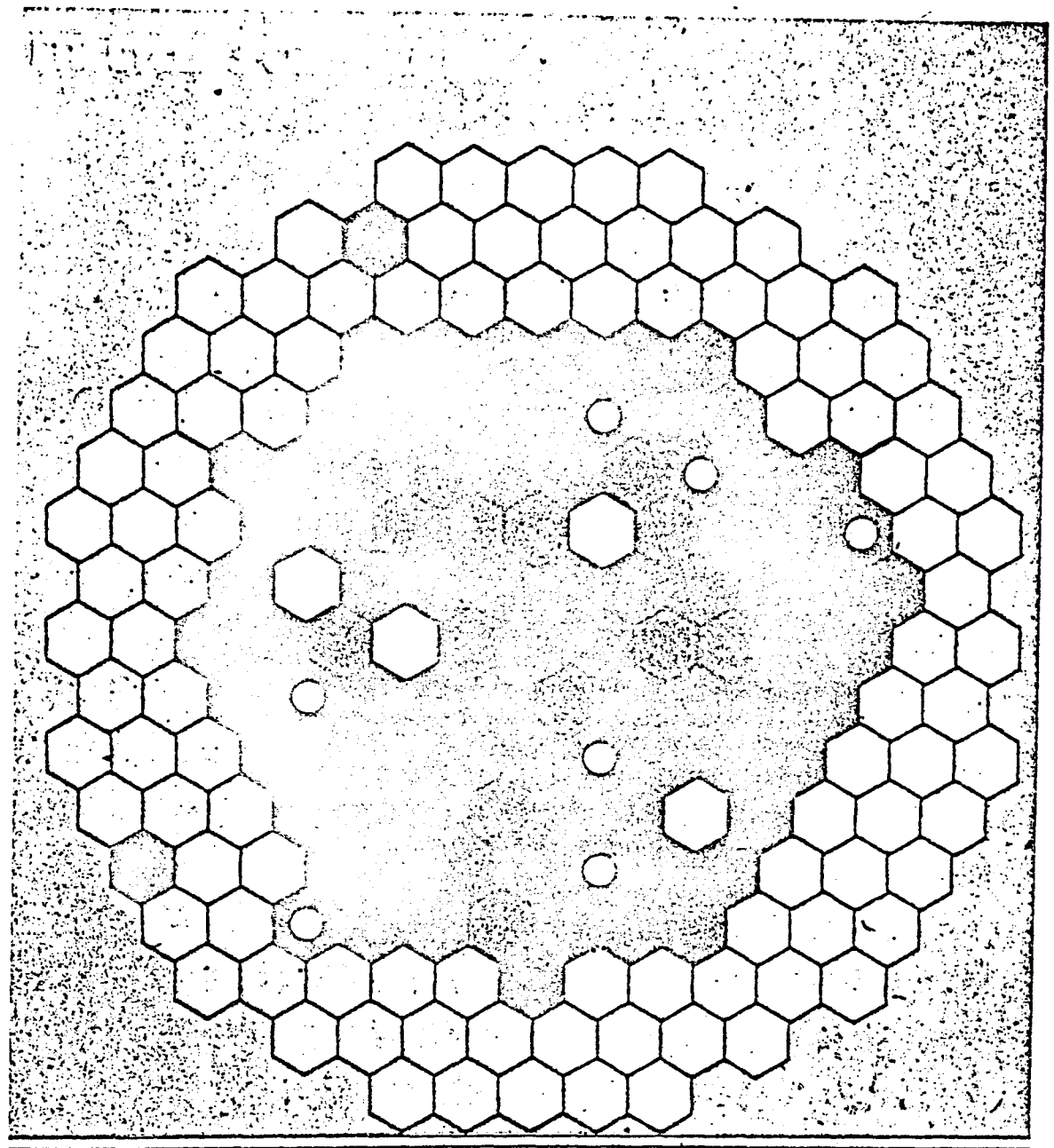
47R

FFTF EXPERIMENT PROGRAM



FFTF EXPERIMENT PROGRAM





EXPERIMENTS

CONTROL MATERIALS EXPERIMENTS

CONTACT INSTRUMENTED EXPERIMENTS
CLOSED LOOP IN-REACTOR ASSEMBLIES
OPEN TEST ASSEMBLIES

DRIVER FUEL EVALUATION PROGRAM

CORE ZONE 1 FUEL ELEMENTS

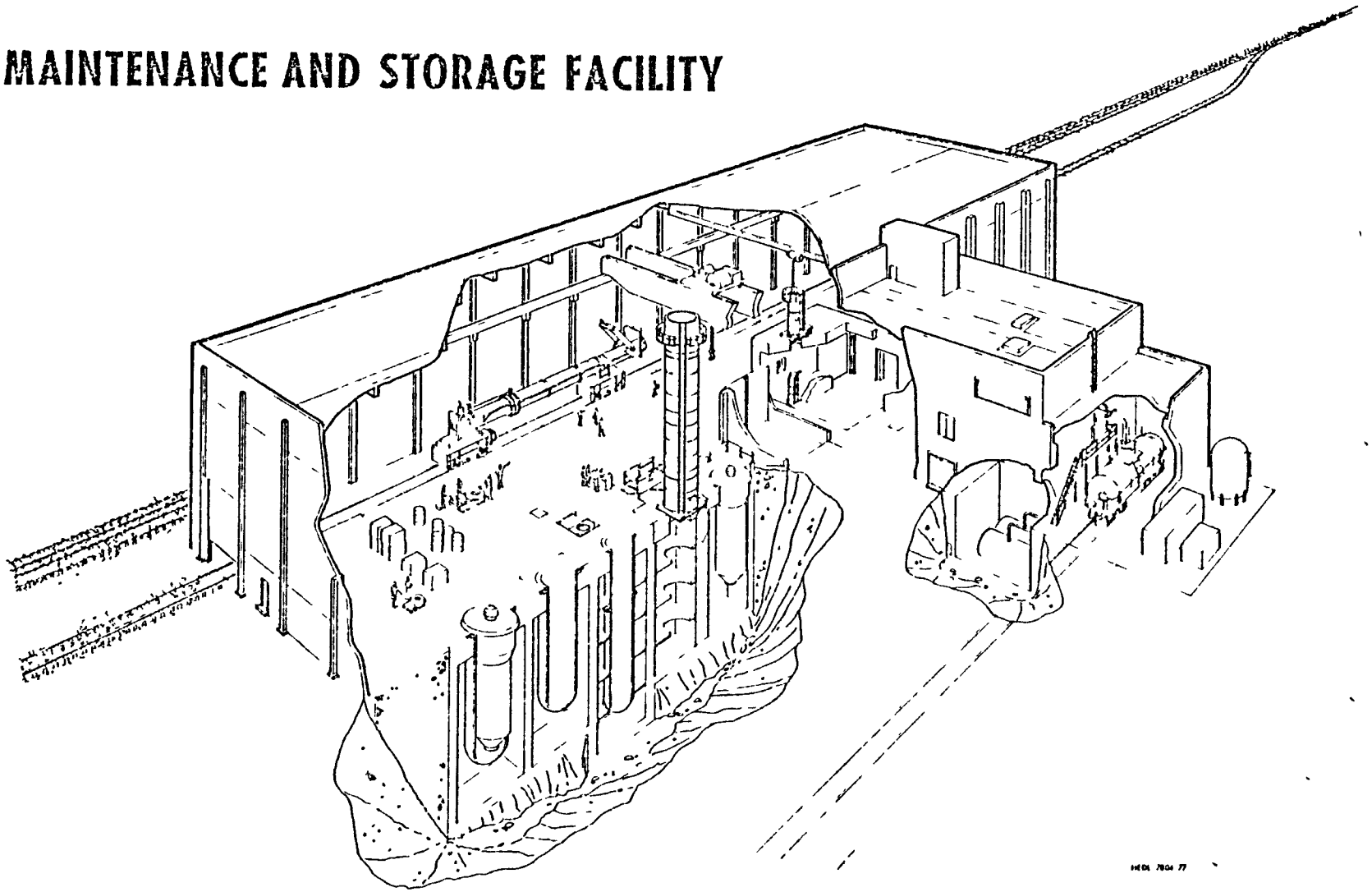
CORE ZONE 2 FUEL ELEMENTS

CONTROL ELEMENTS

REFLECTOR ELEMENTS

HEDL 7708-217.2

MAINTENANCE AND STORAGE FACILITY



1.

52K