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NON-DESTRUCTIVE AND DESTRUCTIVE TRANSIENT
TESTS OF THE SPERT I-D, FULLY ENRICHED,
ALUMINUM-PLATE-TYPE CORE: DATA SUMMARY REPORT

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**NATIONAL REACTOR TESTING STATION
US ATOMIC ENERGY COMMISSION**

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U. S. ATOMIC ENERGY COMMISSION

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ABSTRACT

This report is a documentation of the experimental data from each test of the series performed in the Spert I reactor with the type D, fully enriched, aluminum plate-type core. The series of tests consisted of step-wise insertions of excess reactivity under conditions of ambient temperature and atmospheric pressure. The data obtained from each test are presented in tabular form and as plots of the time behavior of reactor power, fuel plate surface temperature, and pressure. Composite figures, displaying the behavior with time, of fuel plate temperatures and pressures at various positions in the reactor are included. Correlated data figures displaying measured test data as functions of asymptotic reactor period are also included.

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CONTENTS

I. INTRODUCTION	1
II. REACTOR DESCRIPTION	2
III. TEST DESCRIPTION	3
IV. MEASUREMENTS OF TEST VARIABLES	5
1. POWER	5
2. TEMPERATURE	6
3. PRESSURE	7
4. OTHER MEASUREMENTS	8
4.1 Nuclear Energy	8
4.2 Moderator Flow	8
4.3 Strain	8
4.4 Acceleration	8
4.5 Radiological	8
4.6 Photography	9
V. DATA-PROCESSING PROCEDURES	10
VI. SUMMARY OF DATA	11
VII. REFERENCES	13
APPENDIX A - TRANSIENT DATA FIGURES	15
APPENDIX B - SUMMARY FIGURES	39
APPENDIX C - SUMMARY OF EXPERIMENTAL DATA	59

FIGURES

1. Transient 20207, 1.31-sec period	17
2. Transient 19653, 880-msec period	17
3. Transient 18887, 640-msec period	18

4. Transient 18895, 355-msec period	18
5. Transient 20215, 243-msec period	19
6. Transient 18899, 163-msec period	19
7. Transient 20223, 140-msec period	20
8. Transient 19657, 118-msec period	20
9. Transient 19688, 112-msec period	21
10. Transient 18921, 65.0-msec period	21
11. Transient 19447, 49.5-msec period	22
12. Transient 18927, 47.0-msec period	22
13. Transient 18931, 34.0-msec period	23
14. Transient 18942, 25.0-msec period	23
15. Transient 19694, 22.4-msec period	24
16. Transient 19661, 21.7-msec period	24
17. Transient 20229, 21.1-msec period	25
18. Transient 19183, 19.3-msec period	25
19. Transient 18946, 19.0-msec period	26
20. Transient 18950, 14.5-msec period	26
21. Transient 18954, 12.1-msec period	27
22. Transient 18958, 9.8-msec period	27
23. Transient 20332, 9.7-msec period	28
24. Transient 20234, 9.6-msec period	28
25. Transient 18966, 9.5-msec period	29
26. Transient 19204, 9.0-msec period	29
27. Transient 19666, 8.9-msec period	30
28. Transient 19699, 8.7-msec period	30
29. Transient 19022, 8.2-msec period	31
30. Transient 19342, 8.1-msec period	31

31. Transient 19452, 7.6-msec period	32
32. Transient 19275, 7.5-msec period	32
33. Transient 19026, 7.2-msec period	33
34. Transient 20237, 7.0-msec period	33
35. Transient 19800, 6.9-msec period	34
36. Transient 19805, 6.9-msec period	34
37. Transient 19046, 6.4-msec period	35
38. Transient 19280, 6.0-msec period	35
39. Transient 19358, 5.0-msec period	36
40. Transient 19552, 4.6-msec period	36
41. Transient 20461, 3.2-msec period	37
42. Pressure behavior along the y axis for 6.0-msec period transient .	41
43. Pressure behavior along the x axis for 6.0-msec period transient .	41
44. Pressure behavior along the z axis for 6.0-msec period transient .	42
45. Pressure behavior along the y axis for 5.0-msec period transient .	42
46. Pressure behavior along the x axis for 5.0-msec period transient .	43
47. Pressure behavior along the z axis for 5.0-msec period transient .	43
48. Pressure behavior along the y axis for 4.6-msec period transient .	44
49. Pressure behavior along the x axis for 4.6-msec period transient .	44
50. Pressure behavior along the z axis for 4.6-msec period transient .	45
51. Pressure behavior along the y axis for 3.2-msec period transient .	45
52. Pressure behavior along the x axis for 3.2-msec period transient .	46
53. Pressure behavior along the z axis for 3.2-msec period transient .	46
54. Fuel plate temperature behavior as a function of vertical position for 6.0-msec period transient	47
55. Fuel plate temperature behavior as a function of horizontal position for 6.0-msec period transient	48
56. Fuel plate temperature behavior as a function of vertical position for 5.0-msec period transient	49

57. Fuel plate temperature behavior as a function of horizontal position for 5.0-msec period transient	50
58. Fuel plate temperature behavior as a function of vertical position for 4.6-msec period transient	51
59. Fuel plate temperature behavior as a function of horizontal position for 4.6-msec period transient	52
60. Fuel plate temperature behavior as a function of vertical position for 3.2-msec period transient	53
61. Fuel plate temperature behavior as a function of horizontal position for 3.2-msec period transient	54
62. Maximum reactor power vs reciprocal period	55
63. Total energy of the power excursions vs reciprocal period	56
64. Energy to peak of the power excursions vs reciprocal period	57

TABLE

1. Summary of Experimental Data	62
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I. INTRODUCTION

This report is a summary of the experimental data collected from non-destructive and destructive transient tests of the Spert I-D, fully enriched, aluminum-plate-type core [1-13]. The purposes of this report are (a) to present a complete set of graphs and tables of the data taken in these tests, (b) to describe the methods used in processing the data, and (c) to provide such information as is required for the interpretation of the data.

The report is organized as follows: In Sections II and III, the principal features of the reactor design and of the transient tests are reviewed briefly. Section IV contains descriptions of the test variables measured during the transient tests [1-5], in particular the reactor power, temperature, and pressure. In Section V, a summary is presented of the data-processing methods employed. Section VI contains a discussion of the detailed data tables and graphs presented in the appendices, and Section VII provides a list of references giving a more detailed description of the Spert I reactor, the test procedures, and the transient instrumentation.

II. REACTOR DESCRIPTION

The Spert I-D core consisted of 25 fuel assemblies, mounted in a 5 x 5 array in a rectangular grid structure and immersed in the water-filled, 10-ft-OD, open-topped Spert I reactor vessel. This facility had no provision for pressurization or forced-coolant flow. Reactor control was provided by four symmetrically placed, double-bladed, control rods. A centrally located, double-bladed, transient rod was used to apply a reactivity step for initiation of self-limiting power excursions. All of the transient tests were initiated by rapid ejection of the transient rod, and only after self-shutdown of the reactor power were the control rods automatically scrammed.

Each fuel assembly contained 12 fuel plates, except the transient rod assembly and the four control rod assemblies which contained only 6 fuel plates. The remaining space within each of these latter assemblies was occupied by the two control blades and the blade-guide tubes. The core contained a total of 270 fuel plates, all of which were removable for inspection, replacement, and/or installation of instrumentation. Each fuel plate, containing 14 g of U-235, was composed of 93% enriched uranium-aluminum alloy, clad with 0.020-in.-thick, type 6061 aluminum. The dimensions of the fueled volume in each plate were 24 x 2.45 x 0.020 in., and the thickness of the water channels between adjacent plates was nominally 0.179 in.

Criticality was achieved in the D core with a loading of 20 fuel assemblies in a 5 x 5 array and with the control rods withdrawn 17.95 in. After criticality was reached, the core was then loaded to 25 fuel assemblies. With this 5 x 5 fuel array, criticality was achieved with the control rods withdrawn 9.20 in. The available excess reactivity of the D core was determined to be approximately 8.2 dollars.

A more complete description of the Spert I facility and core has been published in IDO-16790 [1].

III. TEST DESCRIPTION

The purposes of this test series were (a) to study the reactor response to large reactivity insertions both up to and beyond the threshold of core damage and (b) to systematically investigate the consequences of reactor accidents. The overall test program was divided into three series of reactor tests plus a final Destructive Transient test. The three series, designated Static, Fiducial Transient, and Exploratory Transient, were run to provide information needed for the Destructive Transient test.

The initial Static Test series was comprised of measurements to determine the basic nuclear characteristics of the reactor, such as control rod calibrations, neutron-flux distributions, and void and temperature coefficients. The results of these measurements have been reported previously in detail [1-4].

The Fiducial Transient series consisted of transient tests to obtain reference data on the non-destructive kinetic behavior of the reactor in response to step insertions of reactivity. These data provided a basis for extrapolation to predict the reactor response in tests involving the larger reactivity insertions and shorter reactor periods required to cause limited reactor damage. The Fiducial Transient series [2-8] consisted of a total of 47 tests covering the reactor period range from 1.3 sec to about 6.5 msec. At the shortest periods, minor fuel plate deformation occurred.

The Exploratory Transient series consisted of three step-transient tests at periods of 6.0, 5.0, and 4.6 msec. These tests covered the range of damage from minor fuel plate deformation to fuel plate melting with no structural damage external to the fuel assemblies themselves. In these tests, data were obtained not only on the time history of the reactor power, transient pressures, and fuel plate temperatures, but also on the detailed nature of the fuel plate damage. In the 6.0-msec test, thermal distortion of fuel plates was the major source of damage. In the 5.0-msec-period test [3, 8], melting and fusing together of several fuel plates in the central fuel assembly was observed. In the 4.6-msec test [4, 8], partial melting was obtained in 52 of the 270 plates, affecting about 20% of the total fuel plate area; virtually every melted plate was fused to the adjacent plate.

The Destructive Transient test [5, 8], in which a 3.6 dollar reactivity step was added to the reactor, was the final test of the program. Data obtained during the power excursion indicate that the reactor period was 3.2 msec, the peak power was 2250 Mw, the nuclear energy release to time of peak power was

13.8 Mw-sec, the total burst energy was 30.7 Mw-sec, and the initial pressure pulse at the time of peak power (associated with self-shutdown) was only 35 psig. These data were all extrapolatable from the data obtained in the earlier Fiducial Transient and Exploratory Transient series. In the Destructive test about 35% of the core volume melted, and an unpredicted pressure pulse, having a magnitude of 3000 to 4000 psi and rise time of about 0.5 msec, occurred about 15 msec after the time of peak power. This pressure pulse violently disassembled and deformed the core and extensively damaged the core support structure, the instrumentation, and the control system^[8, 11, 13].

IV. MEASUREMENTS OF TEST VARIABLES

1. POWER

Reactor power was measured by monitoring the neutron density in and near the core, using uranium-oxide-coated and boron-lined ionization chambers of miniature size (about 1/8 in. OD x 1 in. long) as well as conventional-sized boron-lined ionization chambers [1]. The conventional boron-lined ion chambers were located in the reflector region surrounding the core and in tubes outside the reactor tank. The miniature chambers, having a low neutron sensitivity, were placed in and adjacent to the core in regions of high neutron-to-gamma ratio. Some of the chambers were connected to linear-amplifier circuits, others to logarithmic-amplifier circuits. (The power data presented in this report were obtained solely from the linear circuits). The dynamic range covered by the ion chambers during each transient test was about five decades; two decades were above the expected peak power level and three were below. The asymptotic reactor period was measured from the initial part of the recorded power.

Each chamber and its associated circuitry was subjected to a three-stage calibration procedure. First, the chambers were placed in a high-neutron-flux field in the thermal column of the Materials Testing Reactor. Measurements were made of the linearity of the chamber current as a function of neutron flux, the value of the saturation current at a given neutron flux, the upper limit to the usable current, and the operating voltage range for current saturation of the chambers.

Second, a calibration of the electronic circuitry associated with each chamber was performed using a calibrated current source in place of the chamber. This calibration determined a relationship between the magnitude of deflection of the galvanometer trace and the input current in terms of deflection per unit current. This procedure was performed each week during the test series and provided a continual check on the sensitivity and linearity of all electronic circuitry. The sensitivity value obtained from this calibration had a probable error of less than $\pm 1\%$.

Third, the rate of increase in the bulk system temperature was measured with the reactor operating at some arbitrary power level. From this measured temperature rise and the calculated value for the system heat capacity, the nuclear power of the reactor was determined by considering the reactor vessel

and its contents to constitute a calorimeter^[14]. Due chiefly to lack of precision in the measurements of heating rate, the estimated probable error in the nuclear power was $\pm 1.5\%$. The nuclear power and the resulting measured current fed by each ion chamber into its associated electronic circuitry were used to compute the chamber constant in terms of power per unit current ($\text{Mw}/\mu\text{a}$). The chamber constant ($\text{Mw}/\mu\text{a}$) and the deflection-current ratio ($\text{mm}/\mu\text{a}$) from the calibration of the ion chamber circuit were used to calculate the chamber calibration factor in terms of power per unit galvanometer-trace deflection (Mw/mm). The estimated probable error in the chamber calibration factor was $\pm 2.5\%$.

During the test series, several ionization chambers were moved and others were replaced from time to time. Calibration factors were determined for the new or moved chambers by intercalibration between the galvanometer deflections of the new chambers and those of chambers which had not been moved.

2. TEMPERATURE

Thermocouples were used for measurement of plate surface temperatures in the D core. The thermocouples consisted of 5-mil-diam, chromel-alumel wires, with the ends flattened to form tabs approximately 0.5-mil-thick and spot-welded to the surface of the fuel plates. Other thermocouples were embedded in the fuel plates to a depth of approximately 30 mils to measure internal temperatures. Both the surface and embedded thermocouples had a frequency response of about 10 kc, and a probable error in absolute temperature of $\pm 1^\circ\text{C}$.

The thermocouples were mounted in various radial and axial positions to provide a three-dimensional map of the temperature distribution in one quadrant of the core. The symmetry of the measured neutron flux distribution in the core indicated that the temperature distributions in all four quadrants should be essentially identical [1, 3].

The following is the scheme used to specify the thermocouple locations. First, the location of the fuel assembly was specified by assigning each with a Row letter and a Column number. Second, each fuel plate (within the fuel assembly) was numbered by counting from east to west. East or west (E or W) was used to indicate the side of the fuel plate bearing the thermocouple. Third, the vertical distance from the reactor-core centerline, measured in inches, was used to specify the vertical location of the thermocouples. An example of one thermocouple location is [E5 7W (-3)]. The E5 refers to the fuel assembly,

located in Row E of Column 5; the 7W indicates that the thermocouple was on the west side of the seventh fuel plate (always counting the fuel plates from east to west); and the (-3) indicates the thermocouple was spot-welded to the surface three inches below the geometric center of the fuel plate. If the thermocouple had been embedded in the body of the plate rather than spot-welded to the surface, the designation would have been [E5 7W (-3b)].

The electronic circuitry associated with the thermocouples was calibrated each week during the test series, in a manner similar to the calibration of the ion chamber circuitry described above, to give the galvanometer deflection per unit potential. The thermocouple calibration factors, in terms of temperature rise per unit galvanometer deflection, were then computed with the aid of the measured sensitivity of the chromel-alumel thermocouples (24.4°C/mv).

3. PRESSURE

Transient pressure measurements were made using commercial, strain-gage-type, diaphragm transducers mounted in protective steel covers, with only the diaphragm exposed to the water. The transducer location was specified by means of an X, Y, Z left-hand rectangular coordinate system with the origin at the center of the core. The X axis was parallel to the columns of fuel assemblies; the Y axis was parallel to the Rows; and the Z axis was vertical. All three coordinates were measured in inches. An example of one pressure transducer location is (-4, 3, -51), where $x = -4$, $y = 3$, $z = -51$ (inches).

The pressure transducers had an overall resolution (including the effects of radiation sensitivity) of approximately 5% of full scale and a frequency response of about 10 kc. The resolution and frequency response measurements were made in tests conducted by Phillips Petroleum Co. personnel in the General Atomics TRIGA facility in San Diego, Calif. [15].

The relationship between input pressure and output voltage (ie, the transducer sensitivity) in terms of pressure per unit potential was provided by the manufacturer. The electronic circuitry associated with the transducers was calibrated each week, in a manner similar to the calibration of the ion chamber circuitry discussed above, to yield the galvanometer deflection per unit potential. From the transducer sensitivity (psi/mv) and the circuitry calibration (mm/mv),

the transducer calibration factors were calculated in terms of pressure per unit galvanometer deflection (psi/mm).

4. OTHER MEASUREMENTS

The remaining variables that were measured throughout the test series are presented below. Except for nuclear energy, the data from these test variables do not appear in this report but do appear in other reports as indicated.

4.1 Nuclear Energy

Integration of the reactor power yielded the nuclear energy release as a function of time during the power excursion. These energy calculations were made both by planimeter integration of the expanded linear power traces and by computer integration of the digitized power data. Also, integral measurements of the total nuclear energy release were obtained from the activation of foils and flux wires [6].

4.2 Moderator Flow

The flow measurements made during the self-limiting power excursions were those associated with the expulsion of the moderator from the fuel assemblies in the core. The moderator flow is of interest because of its applicability to the study of the transient shutdown processes. The flow measurement techniques and results have been reported elsewhere [1, 5, 6].

4.3 Strain

The transient pressures and large thermal gradients developed during the transient tests caused strain, plastic deformation, and failure of the core materials. Strain measurements were taken in an attempt to get information about these processes [1, 5, 6].

4.4 Acceleration

Motion of reactor components during short-reactor-period transients were measured by the use of accelerometers. The acceleration data were to provide information about the speed, displacement, and forces acting on the instrumented component [1, 6].

4.5 Radiological

The radiological measurements made during the Destructive Transient test were conducted as a joint effort by personnel of Phillips Petroleum Co. and the Health and Safety Branch of the AEC's Idaho Operations Office. The measure-

ments were intended to show not only the immediate radiological consequences of a destructive nuclear excursion, but also the delayed consequences associated with fallout and contamination [1, 5, 6, 12].

4.6 Photography

The photographic documentation of the transient tests was initiated during the Exploratory Transient series and was continued with increased scope during the Destructive Transient test. The motion picture coverage of the Destructive Transient test was divided into two phases; the first covered the actual transient, and the second covered the re-entry and cleanup operations [1, 5, 6, 10].

V. DATA-PROCESSING PROCEDURES

The primary methods for data collection included use of both high-speed optical-recording galvanometers (ie, oscillographs) and high-speed magnetic-tape recorders. Signals from the transducers at the reactor area (neutron-detecting ion chambers, pressure transducers, thermocouples, etc) were amplified and transmitted to the oscillographs and magnetic tape recorders located in the control center one-half mile away. Data from 104 different channels were recorded in analog form on the oscillograph records. Fourteen of these data channels also were recorded on the magnetic-tape recorder. (The data presented in this report were obtained from the oscillograph records.) Each of the 104 channels had a full-scale deflection of 76 mm without saturating the associated amplifiers.

The analog data recorded on the oscillograph records were processed through both an analog-to-digital and an analog-to-analog conversion system. The former consisted of a manually operated analog curve reader and a digital converter with tabulated and punch-card outputs; the data on the punched cards were plotted on a digital X-Y plotter. The analog-to-analog conversion system consisted of a manually operated analog curve reader that transferred the data directly from the oscillograph records to an analog X-Y plotter. In both of the conversion systems, the X-Y coordinates could be varied in such a way that the processed data were available in the desired engineering units.

The operation of the analog curve reader introduced an error estimated to be $\pm 1/2$ mm (or about $\pm 0.7\%$ of the full-scale deflection) due to the parallax encountered in positioning the curve reader on the analog curve. The estimated error of the analog-to-digital conversion was ± 1 unit in the least significant digit in the output of the converter; this error was usually less than 1% at the peak of the curve. The analog and digital X-Y plotters had errors estimated to be 0.2% of the full-scale deflection of the outputs.

Each conversion system has a combined error of less than 2.0%, provided the original analog curve deflection is 35 mm or larger. At 10 mm the combined error is less than 8.0%. The general criteria for useful data is that which deflects from 10 to 76 mm.

VI. SUMMARY OF DATA

All of the pertinent transient test data from the Spert I-D core tests are presented in graphical and tabular form in the appendix in the following manner:

Appendix A consists of linear analog graphs which permit a comparison of the time histories of pressure, temperature, and reactor power for each transient test. Each test is represented by two or more curves and indexed according to the initial asymptotic reactor period (τ) and the transient record number (No.). The pressures measured for reactor periods greater than 9 msec were very small (less than 1 psig); hence, these pressure data have been omitted. Each pressure curve is labeled with the location of the corresponding transducer. The transient temperature curves presented are usually those recorded at the hottest fuel-plate thermocouple and are labeled with the corresponding location of each thermocouple.

The temperature data were obtained by adding the initial temperature of the bulk reactor assembly (about 15°C) to the measured fuel-plate temperature rise as recorded from the thermocouples. For the shortest reactor-period transients, the chromel-alumel thermocouples measured the temperature to approximately the melting of aluminum; however, many of the thermocouples were broken before this melting point was reached because of thermal stresses on the fuel plates.

The reactor power for each transient test is presented in linear form. The maximum reactor power varies throughout the test series from 0.390 to 2250 Mw over the reactor period range of 1310 to 3.2 msec

Appendix B contains graphs of (a) peak power, (b) total energy, and (c) energy to the peak of the power excursion vs the inverse asymptotic reactor period (α). Also included are several figures showing the temperature and pressure profiles with respect to time for different locations in the reactor for the Exploratory and Destructive Transient tests. These figures illustrate the radial temperature and pressure profiles existing in the reactor during the test cited.

Appendix C is a tabulation of test data taken from oscillograph records. The table serves as a ready source for comparison and reference of the experimental data. It contains the figure number, the transient record number, the

initial asymptotic reactor period, the inverse period, the peak power, the energy at the time of peak power, the total energy, the maximum temperature (including the location of the corresponding thermocouple), the maximum pressure (including the location of the corresponding transducer), and the time measured from the initiation of each transient (ie, rod-drop) to peak power.

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APPENDIX A

TRANSIENT DATA FIGURES

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FIG. 1 TRANSIENT 20207, 1.31-SEC PERIOD.

FIG. 2 TRANSIENT 19653, 880-MSEC PERIOD.

FIG. 3 TRANSIENT 18887, 640-MSEC PERIOD.

FIG. 4 TRANSIENT 18895, 355-MSEC PERIOD.

FIG. 5 TRANSIENT 20215, 243-MSEC PERIOD.

FIG. 6 TRANSIENT 18899, 163-MSEC PERIOD.

FIG. 7 TRANSIENT 20223, 140-MSEC PERIOD.

FIG. 8 TRANSIENT 19657, 118-MSEC PERIOD.

FIG. 9 TRANSIENT 19688, 112-MSEC PERIOD.

FIG. 10 TRANSIENT 18921, 65.0-MSEC PERIOD.

FIG. 11 TRANSIENT 19447, 49.5-MSEC PERIOD.

FIG. 12 TRANSIENT 18927, 47.0-MSEC PERIOD.

FIG. 13 TRANSIENT 18931, 34.0-MSEC PERIOD.

FIG. 14 TRANSIENT 18942, 25.0-MSEC PERIOD.

FIG. 15 TRANSIENT 19694 22.4-MSEC PERIOD.

FIG. 16 TRANSIENT 19661, 21.7-MSEC PERIOD.

FIG. 17 TRANSIENT 20229, 21.1-MSEC PERIOD.

FIG. 18 TRANSIENT 19183, 19.3-MSEC PERIOD.

FIG. 19 TRANSIENT 18946, 19.0-MSEC PERIOD

FIG. 20 TRANSIENT 18950, 14.5-MSEC PERIOD.

FIG. 21 TRANSIENT 18954, 12.1-MSEC PERIOD.

FIG. 22 TRANSIENT 18958, 9.8-MSEC PERIOD.

FIG. 23 TRANSIENT 20332, 9.7-MSEC PERIOD.

FIG. 24 TRANSIENT 20234, 9.6-MSEC PERIOD.

FIG. 25 TRANSIENT 18966, 9.5-MSEC PERIOD.

FIG. 26 TRANSIENT 19204 9.0-MSEC PERIOD.

FIG. 27 TRANSIENT 19666, 8.9-MSEC PERIOD.

FIG. 28 TRANSIENT 19699, 8.7-MSEC PERIOD.

FIG. 29 TRANSIENT 19022, 8.2-MSEC PERIOD.

FIG. 30 TRANSIENT 19342, 8.1-MSEC PERIOD.

FIG. 31 TRANSIENT 19452, 7.6-MSEC PERIOD.

FIG. 32 TRANSIENT 19275, 7.5-MSEC PERIOD.

FIG. 33 TRANSIENT 19026, 7.2-MSEC PERIOD.

FIG. 34 TRANSIENT 20237, 7.0-MSEC PERIOD.

FIG. 35 TRANSIENT 19800, 6.9-MSEC PERIOD.

FIG. 36 TRANSIENT 19805, 6.9-MSEC PERIOD.

FIG. 37 TRANSIENT 19046, 6.4-MSEC PERIOD.

FIG. 38 TRANSIENT 19280, 6.0-MSEC PERIOD.

FIG. 39 TRANSIENT 19358, 5.0-MSEC PERIOD.

FIG. 40 TRANSIENT 19552, 4.6-MSEC PERIOD.

FIG. 41 TRANSIENT 20461, 3.2-MSEC PERIOD.

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APPENDIX B

SUMMARY FIGURES

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FIG. 42 PRESSURE BEHAVIOR ALONG THE Y AXIS FOR 6.0-MSEC PERIOD TRANSIENT.

FIG. 43 PRESSURE BEHAVIOR ALONG THE X AXIS FOR 6.0-MSEC PERIOD TRANSIENT.

FIG. 44 PRESSURE BEHAVIOR ALONG THE Z AXIS FOR 6.0-MSEC PERIOD TRANSIENT.

FIG. 45 PRESSURE BEHAVIOR ALONG THE Y AXIS FOR 5.0-MSEC PERIOD TRANSIENT.

FIG. 46 PRESSURE BEHAVIOR ALONG THE X AXIS FOR 5.0-MSEC PERIOD TRANSIENT.

FIG. 47 PRESSURE BEHAVIOR ALONG THE Z AXIS FOR 5.0-MSEC PERIOD TRANSIENT.

FIG. 48 PRESSURE BEHAVIOR ALONG THE Y AXIS FOR 4.6-MSEC PERIOD TRANSIENT.

FIG. 49 PRESSURE BEHAVIOR ALONG THE X AXIS FOR 4.6-MSEC PERIOD TRANSIENT.

FIG. 50. PRESSURE BEHAVIOR ALONG THE Z AXIS FOR 4.6-MSEC PERIOD TRANSIENT.

FIG. 51. PRESSURE BEHAVIOR ALONG THE Y AXIS FOR 3.2-MSEC PERIOD TRANSIENT.

FIG. 52 PRESSURE BEHAVIOR ALONG THE X AXIS FOR 3.2-MSEC PERIOD TRANSIENT.

FIG. 53 PRESSURE BEHAVIOR ALONG THE Z AXIS FOR 3.2-MSEC PERIOD TRANSIENT.

FIG. 54 FUEL PLATE TEMPERATURE BEHAVIOR AS A FUNCTION OF VERTICAL POSITION FOR 6.0-MSEC PERIOD TRANSIENT.

FIG. 55 FUEL PLATE TEMPERATURE BEHAVIOR AS A FUNCTION OF HORIZONTAL POSITION FOR 6.0-MSEC PERIOD TRANSIENT.

FIG. 56 FUEL PLATE TEMPERATURE BEHAVIOR AS A FUNCTION OF VERTICAL POSITION FOR 5.0-MSEC PERIOD TRANSIENT.

FIG. 57 FUEL PLATE TEMPERATURE BEHAVIOR AS A FUNCTION OF HORIZONTAL POSITION
FOR 5.0-MSEC PERIOD TRANSIENT.

FIG. 58 FUEL PLATE TEMPERATURE BEHAVIOR AS A FUNCTION OF VERTICAL POSITION FOR 4.6-MSEC PERIOD TRANSIENT.

FIG. 59 FUEL PLATE TEMPERATURE BEHAVIOR AS A FUNCTION OF HORIZONTAL POSITION FOR 4.6-MSEC PERIOD TRANSIENT.

FIG. 60 FUEL PLATE TEMPERATURE BEHAVIOR AS A FUNCTION OF VERTICAL POSITION FOR 3.2-MSEC PERIOD TRANSIENT.

FIG. 61 FUEL PLATE TEMPERATURE BEHAVIOR AS A FUNCTION OF HORIZONTAL POSITION FOR 3.2-MSEC PERIOD TRANSIENT.

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FIG. 62 MAXIMUM REACTOR POWER VS RECIPROCAL PERIOD.

FIG. 63 TOTAL ENERGY OF THE POWER EXCURSIONS VS RECIPROCAL PERIOD.

FIG. 64 ENERGY TO PEAK OF THE POWER EXCURSIONS VS RECIPROCAL PERIOD.

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APPENDIX C

SUMMARY OF EXPERIMENTAL DATA

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The following tabulation is an explanation of symbols used in Table I.

<u>Tabular Information</u>	<u>Symbol</u>	<u>Units</u>
Oscillograph Record Number	No.	---
Asymptotic Reactor Period	τ	msec
Reciprocal of Asymptotic Reactor Period	α	sec ⁻¹
Maximum Reactor Power	$\phi_{(tm)}$	Mw
Energy to Time of Max Reactor Power	$E_{(tm)}$	Mw-sec
Total Energy	E_T	Mw-sec
Maximum Fuel Plate Temperature	θ_m	°C
Thermocouple Location	Tc. Loc.	---
Maximum Pressure	P_m	psig
Pressure Transducer Location	Pxd. Loc.	---
Time of Peak Power After Initiation of the Transient Rod	$T_{(tm)}$	sec

TABLE I

SUMMARY OF EXPERIMENTAL DATA

No.	τ msec	α sec ⁻¹	ϕ (tm) Mv	E(tm) Mw-sec	E _T Mw-sec	θ_m °C	Tc. Loc.	P _m psi	Pxd. Loc.	T(tm) sec	Fig.
20207	1310	0.760	0.390	1.49	---	80	E5 7W (-4b)	---	---	24.72	A-1
19653	880	1.14	0.760	1.79	---	94	E5 6E (-3)	---	---	15.38	A-2
18887	640	1.56	0.980	1.76	---	95	E5 7W (-3)	---	---	11.56	A-3
18895	355	2.82	1.50	1.47	----	98	E5 7W (-3)	---	---	6.407	A-4
20215	243	4.12	1.43	0.910	----	93	E5 7W (0)	---	---	----	A-5
18899	163	6.14	3.25	1.13	---	104	E5 7W (-3)	---	---	3.202	A-6
20223	140	7.14	3.80	0.940	---	112	E5 12W (-6)	---	---	2.593	A-7
19657	118	8.48	4.50	1.00	---	109	E5 6E (0)	---	---	2.748	A-8
19688	112	8.93	5.05	1.18	---	117	E5 6E (0)	---	---	2.198	A-9
18921	65.0	15.4	14.2	1.68	---	115	E5 7W (-3)	---	---	1.312	A-10
19447	49.5	20.2	19.1	1.84	3.20	128	E5 7W (-3)	---	---	1.344	A-11
18927	47.0	21.3	27.5	2.25	3.95	117	E5 7W (-3)	---	---	1.002	A-12
18931	34.0	29.4	50.0	2.90	4.90	124	E5 7W (-3)	---	---	0.7535	A-13
18942	25.0	40.0	87.0	3.20	4.90	132	E5 7W (-3)	---	---	0.5905	A-14
19694	22.4	45.8	105	3.60	5.40	154	E5 6E (-3)	---	---	0.6612	A-15
19661	21.7	46.1	107	3.40	5.05	155	E5 6E (0)	---	---	0.7130	A-16
20229	21.1	47.4	110	3.60	5.40	153	E5 7W (0)	---	---	0.6295	A-17
19183	19.3	52	120	3.40	4.70	132	E5 7W (-3)	---	---	0.5940	A-18
18946	19.0	53	141	4.05	5.85	150	E5 7W (-3)	---	---	0.4655	A-19
18950	14.5	69	210	4.10	5.80	165	E5 7W (-3)	---	---	0.3778	A-20

TABLE I. SUMMARY OF EXPERIMENTAL DATA (CONT.)

No.	τ msec	α sec ⁻¹	ϕ (tm) Mw	E (tm) Mw-sec	E_T Mw-sec	θ_m °C	Tc. Loc.	P_m psi	Pxd. Loc.	T (tm) sec	Fig.
18954	12.1	83	290	4.60	6.45	180	E5 7W (-3)	---	-----	0.3153	A-21
18958	9.8	102	380	5.15	7.55	227	E5 7W (-3)	---	-----	0.2730	A-22
20332	9.7	103	360	5.05	7.45	234	E5 7W (-4b)	---	-----	0.3627	A-23
20234	9.6	104	380	5.10	7.25	229	E5 7W (-4b)	---	-----	0.3595	A-24
18966	9.5	105	430	5.70	7.85	255	E5 7W (-3)	---	-----	0.2605	A-25
19204	9.0	111	395	4.70	7.10	300	E5 7W (-3)	1.7	(3, 3, 19-1/2)	0.3805	A-26
19666	8.9	112	460	5.05	7.65	350	E5 6E (-3)	2.0	(-4, 3, -51)	0.3820	A-27
19699	8.7	115	470	5.25	8.20	234	E5 7W (-3)	---	-----	0.3855	A-28
19022	8.2	122	530	5.85	8.55	315	E5 7W (-3)	3.6	(3, 3, -30-1/2)	0.2305	A-29
19342	8.1	124	505	5.45	9.20	325	E5 7W (-3)	1.6	(3, 3, 19-1/2)	0.3585	A-30
19452	7.6	132	510	5.20	9.40	400	E5 7W (-3)	2.1	(3, 3, 19-1/2)	0.3590	A-31
19275	7.5	133	555	5.55	8.80	355	E5 7W (-3)	2.5	(3, 3, 19-1/2)	0.3620	A-32
19026	7.2	139	630	6.00	9.32	375	E5 12W (-3)	4.2	(3, 3, -30-1/2)	0.2790	A-33
20237	7.0	143	620	6.45	10.2	305	E5 7W (-4b)	3.1	(5, 4-3/4, 23-1/4)	0.2837	A-34
19800	6.9	145	660	6.35	10.4	330	E5 7W (-3)	2.8	(-4, 3, -51)	0.3539	A-35
19805	6.9	145	665	6.60	10.4	440	E5 6E (-3b)	3.1	(-4, 3, -51)	0.3535	A-36
19046	6.4	156	745	6.60	10.5	455	E5 7W (-3)	4.3	(3, 3, -30-1/2)	0.3165	A-37
19280	6.0	167	890	7.20	13.2	560	E5 7W (0)	4.6	(10-1/2, 0, 0)	0.3848	A-38
19358	5.0	200	1130	8.35	17.5	585	E5 7W (-3)	7.0	(10-1/2, 0, 0)	0.3727	A-39
19552	4.6	218	1270	8.90	19.0	680	E6 6E (0b)	8.2	(3, 3, -27-1/2)	0.3520	A-40
20461	3.2	313	2250	13.8	30.7	615	E5 7W (-4b)	35	(3, -3-3/8, -19-7/3)	0.1534	A-41

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