Atomics International Division
Rockwell International

COVER SHEET

U

CLASSIFICATION LEVEL
(S, C OR U)

DOCUMENT NO.

TI-652-260-001

DOCUMENT TITLE

5 Kwe Reactor Power Distributions

AUTHOR

THIS IS AN INTERNAL WORKING DOCUMENT AND MAY BE EXPANDED, MODIFIED, OR WITHDRAWN AT ANY TIME. ~~IT IS INTENDED FOR INTERNAL USE ONLY.~~

CLASSIFICATION TYPE
(RD OR DI)

~~THIS REPORT MAY NOT BE PUBLISHED WITHOUT THE APPROVAL OF THE PATENT BRANCH, AEC.~~

U

CLASSIFICATION LEVEL
(S, C OR U)

MASTER

DO NOT REMOVE THIS SHEET

DISTRIBUTION OF THIS DOCUMENT UNLIMITED

FORM 719-H-1 REV. 2-74

DISCLAIMER

#756

Atomics International
North American Rockwell

SUPPORTING DOCUMENT

NUMBER	TI-652-260-001
REV LTR/CHG NO.	SEE SUMMARY OF CHG
DOCUMENT TYPE	Technical Information
KEY NOUNS	Power Distributions
ORIGINAL ISSUE DATE	6-26-72
GO NO.	6532
S/A NO.	20310
PAGE 1 OF TOTAL PAGES	15
REL. DATE	7-17-72

PROGRAM TITLE
5 Kwe ZrH Reactor Thermoelectric Power System

DOCUMENT TITLE
5 Kwe Reactor Power Distributions

PREPARED BY/DATE	DEPT	MAIL ADDR
D. S. Bost DSB	731	LB41

IR&D PROGRAM? YES ☐ NO ☐ IF YES, ENTER TPA NO. ______

APPROVALS: H. Rood — DATE: 7-17-72

SECURITY CLASSIFICATION

(CHECK ONE BOX ONLY)	AEC	DOD
UNCL	☒	☐
CONF.	☐	☐
SECRET	☐	☐

(CHECK ONE BOX ONLY)
RESTRICTED DATA ☐
DEFENSE INFO. ☐

AUTHORIZED CLASSIFIER: H. Rood — DATE: 7-17-72

DISTRIBUTION

*	NAME	MAIL ADDR
	J. Asquith	LB02
	J. Brunings	LB27
	E. Donovan	LB25
	L. Maki	LB03
	A. Martin	LB04
	E. Moody	LB25
	W. J. Roberts	LB36
	H. Rood	LB22
	R. Wilson	LB01
	Reactor Analysis Unit (10)	LB22

* TITLE PAGE ONLY

ABSTRACT

Power distributions representative of beginning and end of life are presented for the 5 Kwe reactor. These distributions were obtained from DOT calculations in R, Z geometry. Reactivity worth of the sliding control segments was also obtained.

FORM 734-C REV 4-71

I. Introduction

The reflector design of the 5 Kwe Reactor represents a significant departure from previously operated SNAP reflector designs. Previous designs used rotating drums to regulate neutron leakage and thereby control the reactivity of the reactor. Instead of rotating drums, the 5 Kwe Reactor uses sliding segments to regulate neutron leakage. The reflector in previous designs was also uniform in thickness over the height of the core. The 5 Kwe Reactor reflector is tapered.

The purpose of the change in reflector design is to reduce the weight of the shadow shield through a reduction in shieldable envelope. Sliding segments rather than rotating drums permit a reduction in envelope diameter approximately equal to twice the reflector thickness. Tapering the reflector permits an additional reduction in shield diameter because there is no beryllium outside the shadow cone from which radiation can scatter.

The current 5 Kwe Reactor design has two sliding segments each of which substend 120^{o} of the reactor diameter. The beryllium between each segment is stationary. The sliding segments are split two inches above the axial centerline. The thinner top pieces remain stationary and the thicker bottom pieces slide a maximum of four inches. Rather than sliding parallel to the core vessel the segments move along the taper angle.

The effect the sliding segments have on the power distributions could not be very well determined using the customary one-dimensional technique. A two-dimensional model of the reactor was set up in R, Z geometry for calculations using the DOT code. Calculations were made with the segments closed, two inches open, and four inches open.

In R, Z geometry there is no azimuthal variation; therefore, it was necessary to make some approximations concerning the fixed reflector when the sliding segments were not fully closed. In one calculation with the segments two inches open, the fixed beryllium was homogenized in the gap. From this a power distribution was obtained for use in the preliminary thermal, hydraulic analysis. This distribution did not contain the desired azimuthal variation. To obtain it, a power distribution was synthesized from two DOT calculations. A calculation with the segments fully closed and a calculation with a 360° two inch opening were used. The power distributions from the two calculations were combined using a sinusoidal azimuthal variation. A timeshare computer program was written for this purpose.

An additional calculation was made with an untapered reflector to determine the reactivity effect of tapering. A calculation with the segments four inches open was used to determine the total control worth.

II. Summary of Results

The synthesized power distribution at beginning-of-life is shown in Figure 1- Figure 5. Figure 1 shows for one quadrant the peak power per element relative to the core average power. Due to symmetry the power distribution in the remaining quadrants is the same. The axial power distribution for each element in the quadrant is shown in Figure 2- Figure 5.

Power contours are shown in Figure 6 and Figure 7. Figure 6 shows the power contours with the segments fully closed which would be representative of end-of-life conditions. Figure 7 shows the power contours with the segments two inches open with homogenized beryllium in the opening.

The calculated reactivity change between segments fully closed and 360° segments four inches open was \$12.63. It is assumed that the worth is directly proportional to the angle substended by the movable segments. The total control worth would therefore be \$8.42. The reactivity lost between a straight reflector and one with an 8° taper angle was 24¢.

III. Method of Calculation

The calculations were made using the two-dimensional transport theory code, DOT II. The S_4 approximation and the standard 28 group SNAP library was used. The two-dimensional model which was set up to describe the reactor is shown in Figure 8. The composition of the various zones is given in Table I. Macroscopic cross sections are available in the SNAP library for most materials, therefore, volume fractions may be used instead of atom densities. The only exceptions were fuel and tungsten. The atom densities of these materials without volume weights is given in Table II.

Figure 1
Peak Power Per Element
Relative to Core Average
5 Kwe Reactor at BOL

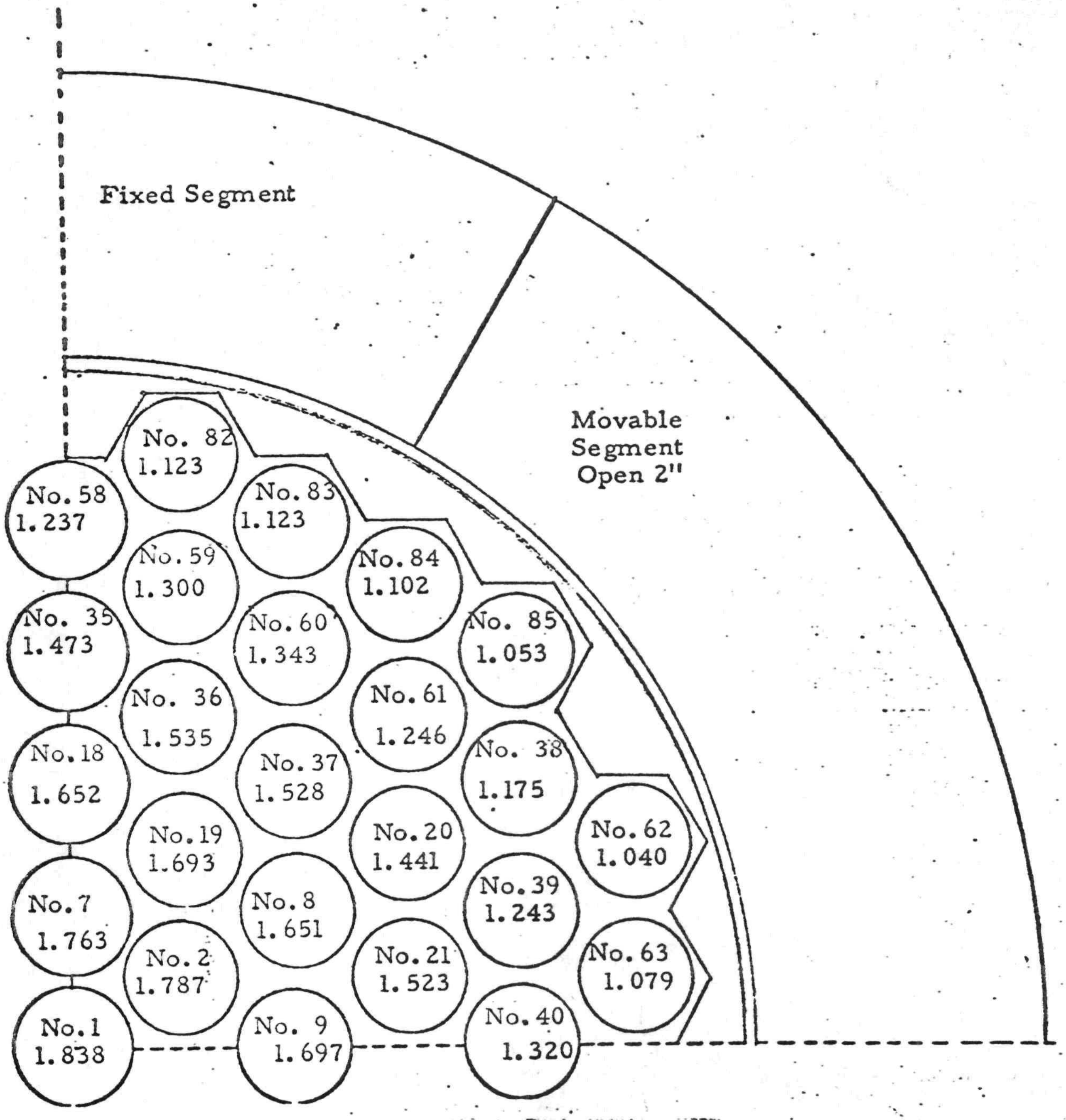
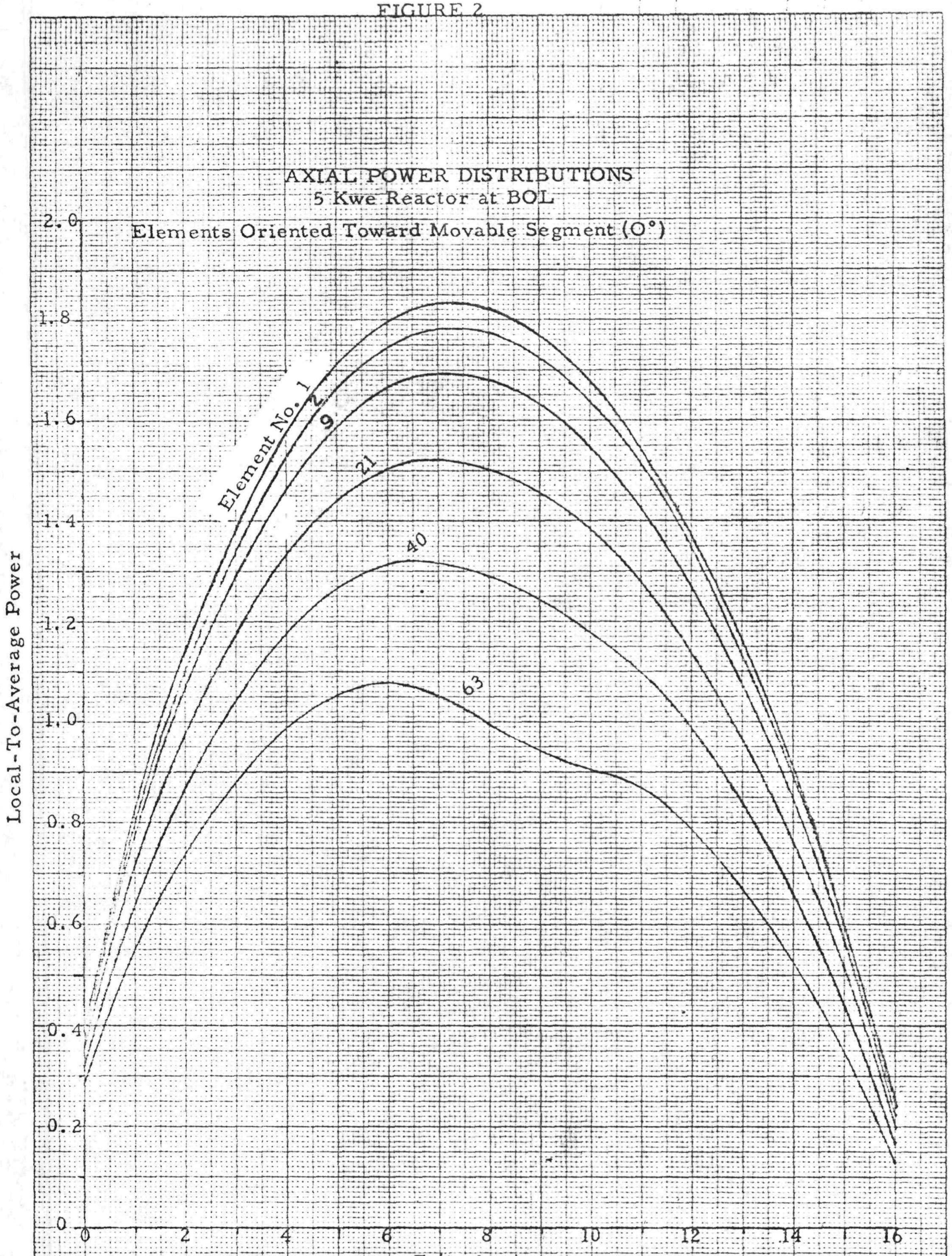


FIGURE 2


AXIAL POWER DISTRIBUTIONS
5 Kwe Reactor at BOL
Elements Oriented Toward Movable Segment (0°)
Element No. 1
2
9
21
40
63
Local-To-Average Power
Z (inches)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
16
NO. 341-M DIETZGEN GRAPH PAPER
MILLIMETER
EUGENE DIETZGEN CO.
MADE IN U. S. A.

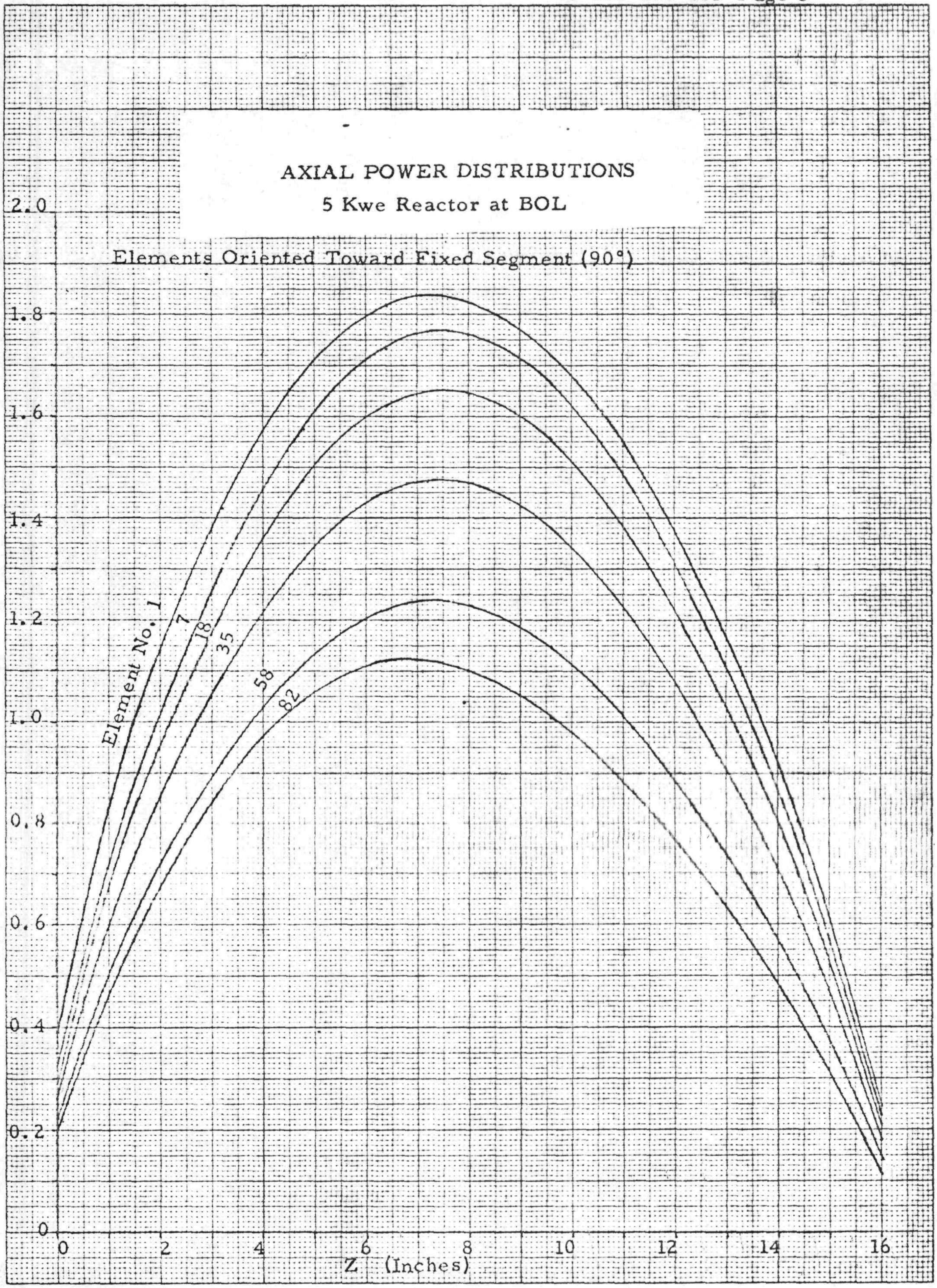

AXIAL POWER DISTRIBUTIONS
5 Kwe Reactor at BOL
Elements Oriented Toward Fixed Segment (90°)
Element No. 1
7
18
35
58
82
Local-To-Average Power
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
16
Z (Inches)

FIGURE 4

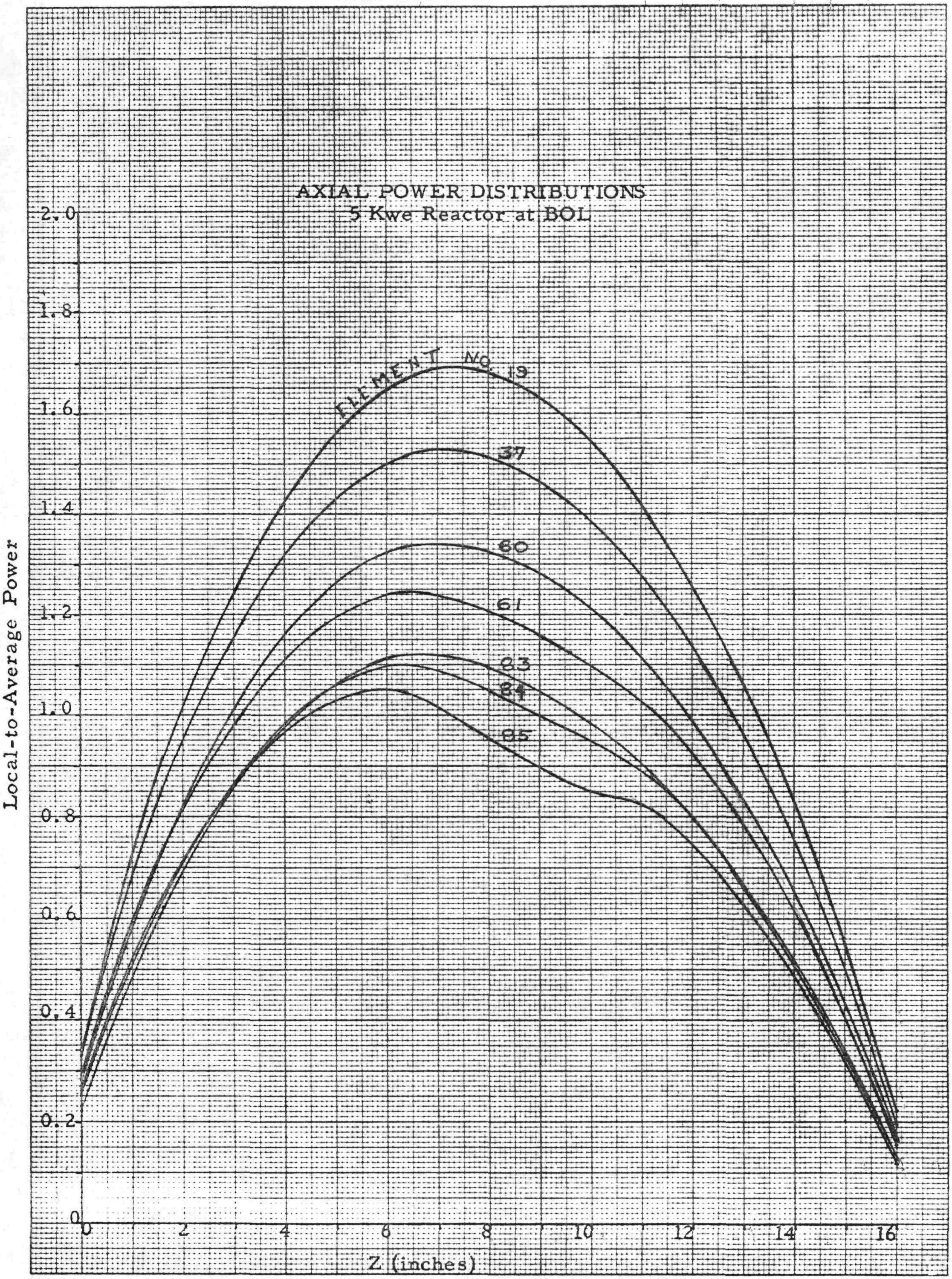

AXIAL POWER DISTRIBUTIONS
5 Kwe Reactor at BOL
ELEMENT No. 19
37
60
61
83
84
85
Local-to-Average Power
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
16
Z (inches)

FIGURE 5

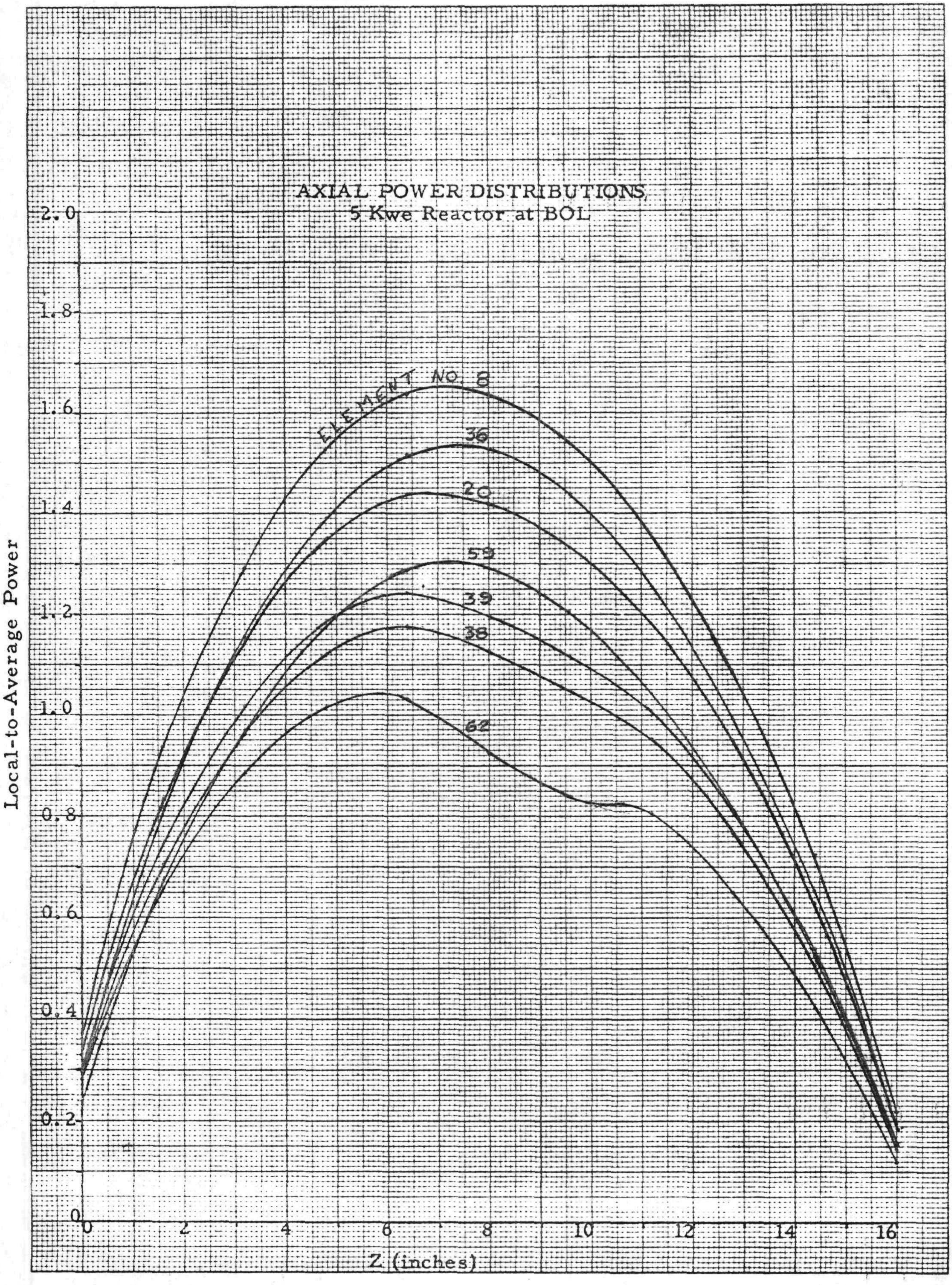

AXIAL POWER DISTRIBUTIONS
5 Kwe Reactor at BOL
ELEMENT NO. 8
36
20
59
39
38
62
Local-to-Average Power
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
16
Z (inches)

FIGURE 6
LOCAL-TO-AVERAGE POWER
- SEGMENTS CLOSED -

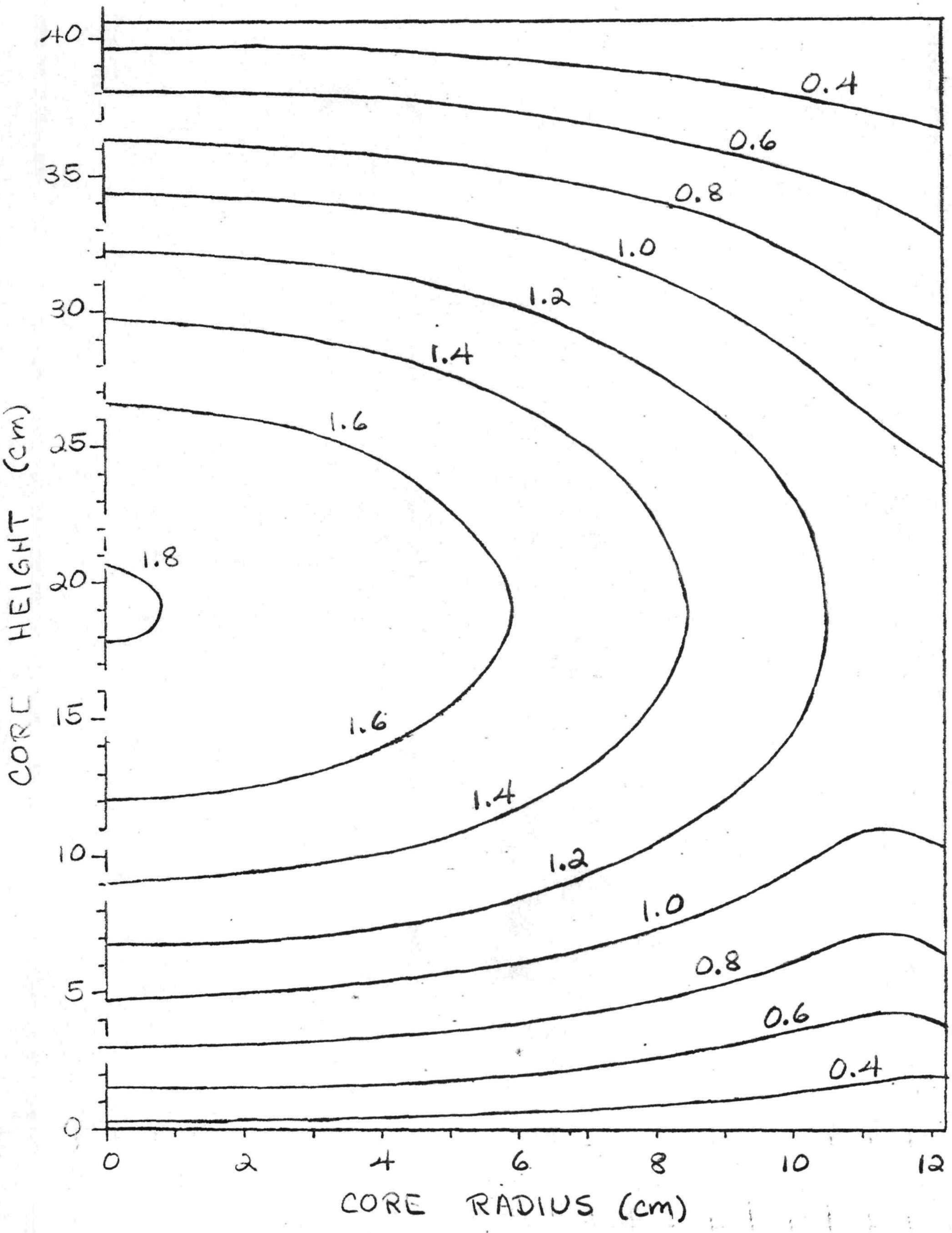


FIGURE 7

LOCAL-TO-AVERAGE POWER

- SEGMENTS 2" OPEN - HOMOGENIZED BERYLLIUM -

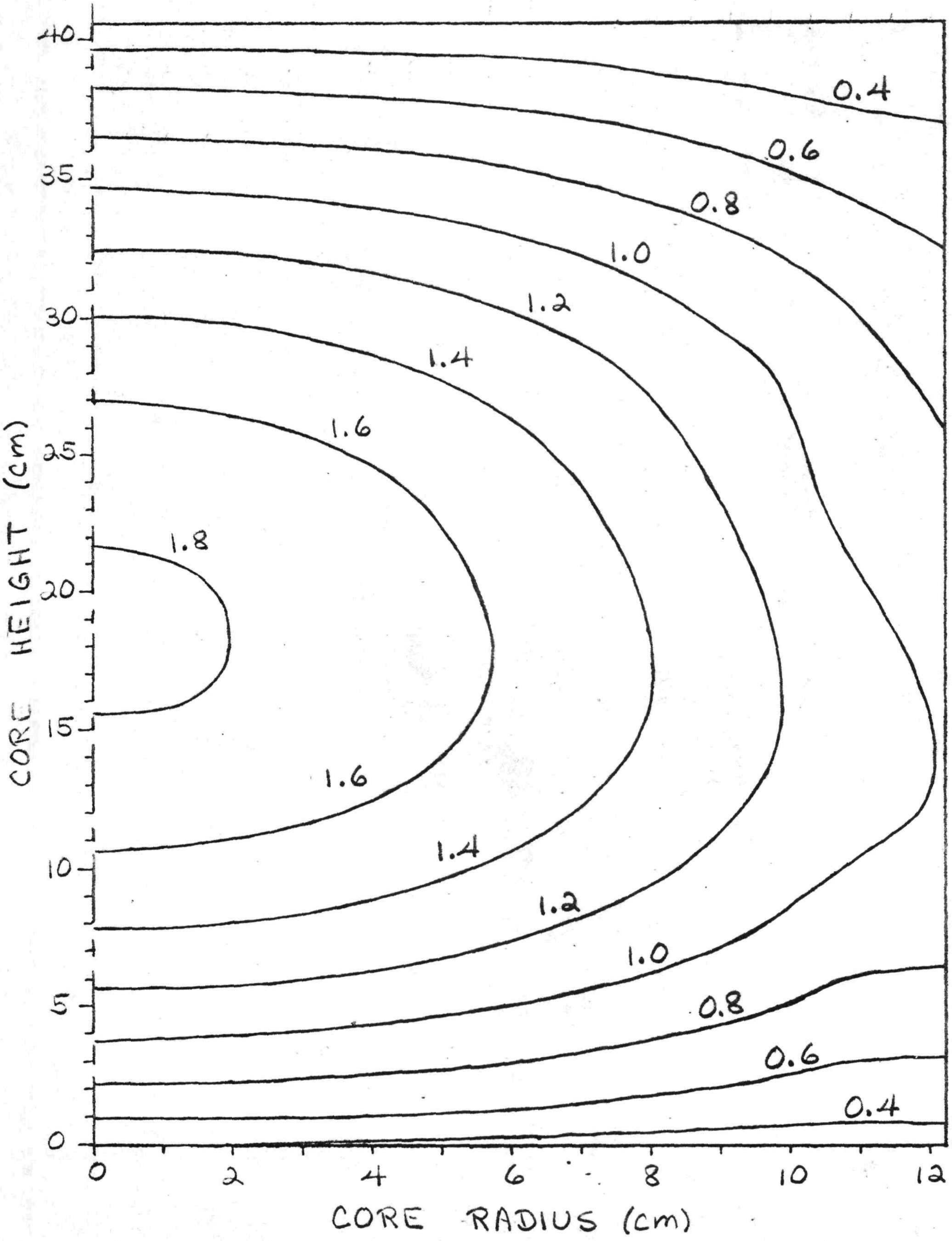
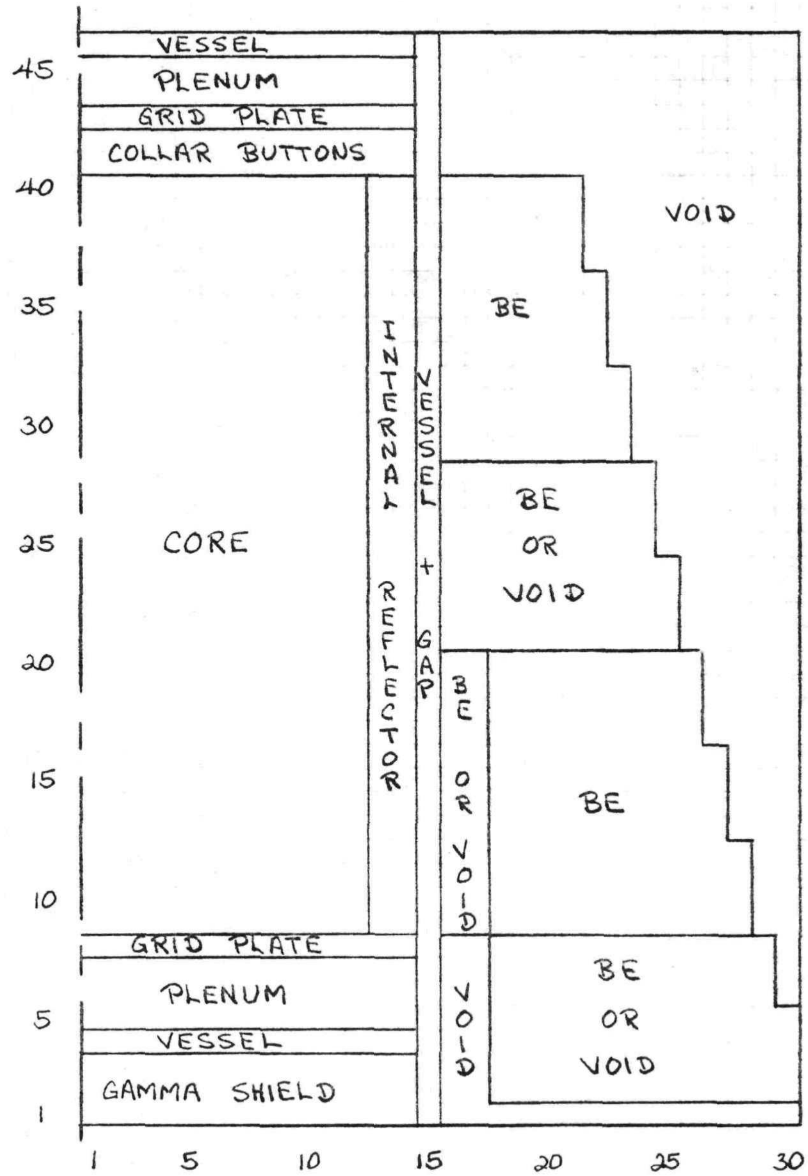


FIGURE 8

DOT R,Z MODEL



INTERVALS	RADIUS	INTERVALS	HEIGHT	INTERVALS	HEIGHT
1 - 12	12.236 cm	1	1.588 cm	8	11.748 cm
13 - 14	12.879	2	4.128	9 - 40	52.388
15	13.139	3	5.08	41 - 42	54.928
16 - 17	14.567	4	5.398	43	56.198
18 - 21	16.990	5	6.668	44 - 45	61.278
22 - 30	23.416	6	9.208	46	61.595
		7	10.488		

Table I
DOT Model Volume Fractions

Zone	Material	Volume Fraction
Core	Fuel	0.7546
	Glass	0.0068
	Clad + Fins	0.0919
	NaK	0.1243
	Gap	0.0224
Internal	BeO	0.6
Reflector	316 SS	0.4
Vessel + Gap	316 SS	0.39
	Void	0.61
Grid Plate	NaK	0.32
	316 SS	0.57
	Hast X-280	0.11
Collar Buttons	NaK	0.1243
	Hast X-280	0.1
	Void	0.7757
Plenum	NaK	1.0
Vessel	316 SS	1.0
Gamma Shield	Tungsten	1.0
Reflector	Be	1.0

Table II

Atom Densities

Isotope	Atom Density (atoms/barn-cm)
U-235	0.001503
U238	0.000109
Zr	0.03534
H	0.05725
W	0.0619