FUEL CLADDING INTEGRITY

Applicability:

Applies to the interrelated variables associated with fuel thermal behavior.

Objective:

To establish limits below which the integrity of the fuel cladding is preserved.

Specification:

A. Core Thermal Power Limit (Reactor Pressure > 800 Psia and Core Flow is > 10% of Rated)

When the reactor pressure is > 800 Psia and core flow is > 10% of rated, the existence of a minimum critical power ratio (MCPR) less than 1.06 shall constitute violation of the fuel cladding integrity safety limit.

2.3 FUEL CLADDING INTEGRITY

Applicability:

Applies to trip settings of the instruments and devices which are provided to prevent the reactor system safety limits from being exceeded.

Objective:

To define the level of the process variables at which automatic protective action is initiated to prevent the safety limits from being exceeded.

Specification:

The limiting safety system settings shall be as specified below:

A. Neutron Flux Scram

1. APRM -- The APRM flux scram trip setting shall be as shown in Figure 2.3.1 and shall be:

$$S \leq 0.58\ W + 62\ \%$$

where:

S = Scram setting in percent of rated thermal power
W = Percent of design recirculation driving flow

2.0 SAFETY LIMITS

B. Core Thermal Power Limit (Reactor Pressure $\leq$ 800 Psia or Core Flow $\leq$ 10% of Rated)

When the reactor pressure is $\leq$ 800 Psia or Core Flow is $\leq$ 10% of rated, the core thermal power shall not exceed 25% of rated thermal power.

C. Power Transients

To insure that the safety limit established in Specification 2.1.A is not exceeded, each required scram shall be initiated by its primary source signal as indicated by the plant process computer.

LIMITING SAFETY SYSTEM SETTINGS

In the event of operation with a total peaking factor (PF) greater than the design peaking factor (DPF), the setting shall be modified as follows:

$$S \leq (0.58\ W + 62\ \%)\ \frac{DPF}{PF}$$

where:

DPF = 3.08 for 7 x 7 fuel
= 3.04 for 8 x 8 fuel

7. IRM--Flux Scram setting shall be $\leq$ 20% of rated neutron flux

B. APRM Rod Block--The APRM rod block setting shall be shown in Figure 2.3.1 and shall be:

$$RB \leq 0.58\ W + 50\%$$

where:

RB = Rod Block setting in percent of rated thermal power
W = Percent of design recirculation driving flow

In the event of operation with a total peaking factor (PF) greater than the design peaking factor (DPF), the setting shall be modified as follows:

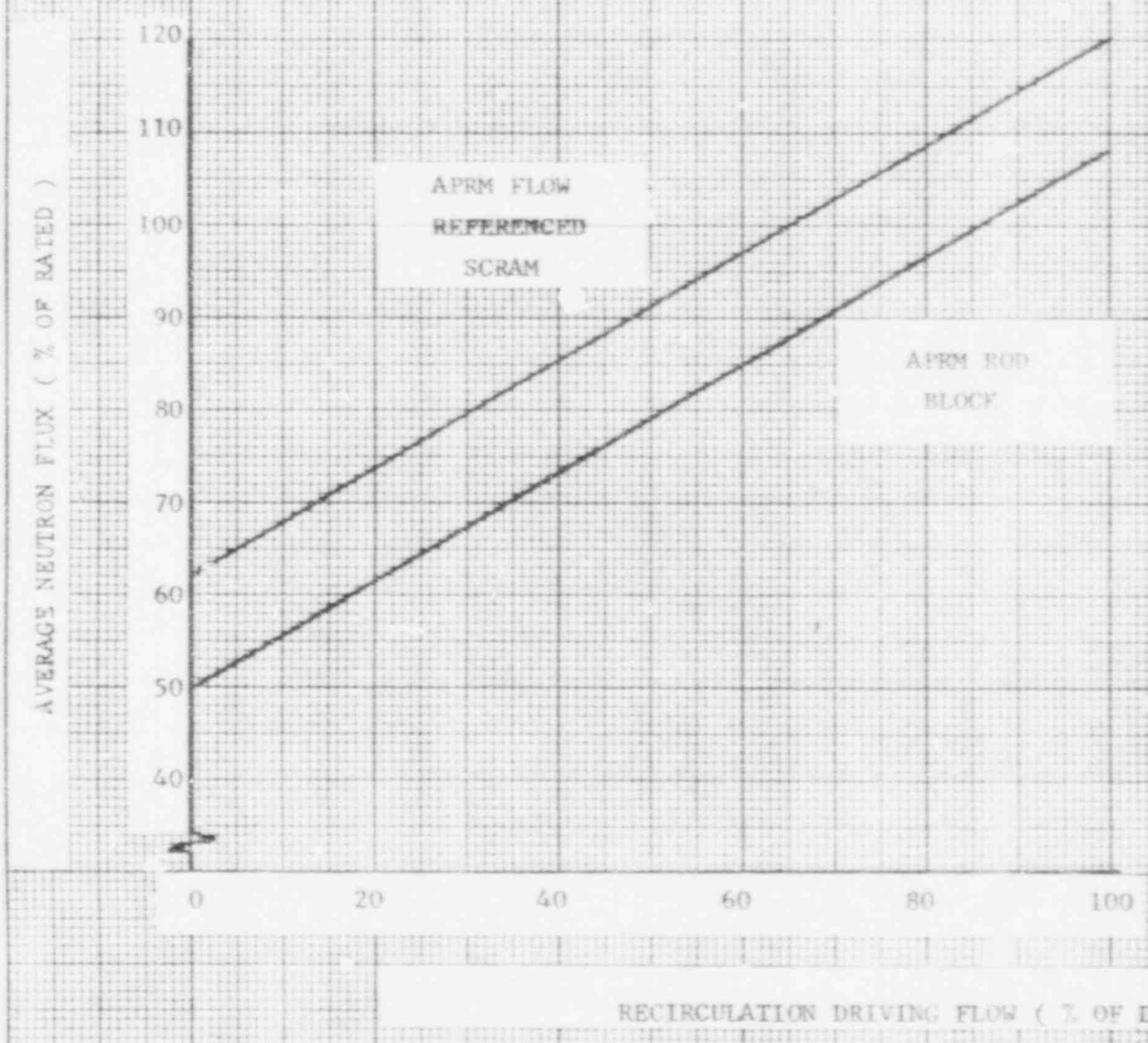
$$RB \leq (0.58\ W + 50\ \%)\ \frac{DPF}{PF}$$

where:

DPF = 3.08 for 7 x 7 fuel
= 3.04 for 8 x 8 fuel

C. Reactor Low Water Level Scram setting shall be $\geq$ 10'6 above the top of the active fuel.

FIGURE 2.3.1
APRM FLOW REFERENCED
SCRAM AND ROD BLOCK
TRIP SETTINGS



NOTES:

1. APRM SCRAM SETTING SHALL BE:
   $S \leq 0.58 W + 62 \%$
2. APRM ROD BLOCK TRIP SETTING SHALL BE:
   $RB \leq 0.58 W + 50 \%$
3. 100 % NEUTRON FLUX IS EQUIVALENT TO 1670 MWT
4. W = PERCENT OF DESIGN RECIRCULATION DRIVING FLOW.

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APPENDIX C

TYPICAL BWR GETAB APPLICATION

Plant Information Request

1. QUESTION:

Identify the scram reactivity curve used to calculate the system response following a turbine trip at the end of the equilibrium cycle. Is it the design basis curve ("D" curve)?

RESPONSE:

The scram reactivity curve applied is the Monticello End-of-Cycle 4 "C" curve (EOC-C), multiplied by the Design Conservative Factor (0.8). The EOC4-C curve reflects the expected Cycle 4 End of Cycle scram reactivity function.

2. QUESTION:

Provide the nominal values of the following parameters used in the derivation of MCPR=1.06 and 1.36: R factor, axial power shape, axial and local peaking factors, radial peaking factor, nonfuel power fraction, average power density, bundle power, bundle flow, and inlet enthalpy. Justify the parameters selected.

RESPONSE:

The following list summarizes the requested information.

1. R-factor = 1.102. This value is the highest expected R-factor during the operating cycle.

2. Axial Power Shape:

APF	NODE	APF	NODE
0.38	1 (Bottom)	1.44	13
0.45	2	1.51	14
0.50	3	1.55	15
0.53	4	1.57	16
0.60	5	1.55	17
0.65	6	1.50	18
0.70	7	1.42	19
0.79	8	1.28	20
0.88	9	1.10	21
1.00	10	0.90	22
1.16	11	0.69	23
1.34	12	0.51	24 (Top)

2. RESPONSE:

2. Axial Power Shape: (Continued)

The above design axial power shape yields a conservative representation of the conditions which might exist during an operating cycle as discussed further in NEDO-10958 Appendix 1.

3. Axial Peaking Factor = 1.57 at node 16 as shown above.

4. Local Peaking Factor = 1.22 (design value, but not used directly in GETAB analyses.)

5. Radial Peaking Factor = 1.47. This design value is larger than the highest expected bundle radial peaking factor; therefore, it establishes a conservative upper limit.

6. Nonfuel Power Fraction = 0.035 (Design value, but not critical to GETAB evaluations.

7. Average Power Density = 40.6 KW/L (Design value, but not used directly in GETAB analyses.

8. Bundle Power = 4.962 (Based on the design core power and the maximum radial peaking factor discussed in item 5.)

9. Bundle Flow = 1.065×10^5 Lbs/hr (This value is the steady-state flow in the fuel bundle operating at the highest bundle power.

10. Inlet Enthalpy = 523.0 Btu/Lb (Design value determined from a reactor heat balance operating with rated core flow, 100% power and maximum feedwater temperature.)

3. QUESTION:

Identify the relative bundle to bundle power distribution (by histogram method) that is employed in the application of the GETAB statistical analysis to Monticello.

RESPONSE:

The histogram of relative bundle power used in GETAB statistical analysis for Monticello is shown in Figure 3-1. This histogram was generated by arranging the control rod pattern such that the maximum number of fuel assemblies were placed at positions of minimum MCPR as described further in NEDO-10958 Appendix IV.

4.a QUESTION:

What is the relative bundle power distribution of the Monticello plant at the worst time of the fuel cycle? Is it the same as the one used in the statistical rod boiling transition analysis. If not, justify why it is not used in the derivation of MCPR values.

RESPONSE:

Because the power distribution described in the answer to Question 3 is selected and forced to be conservative (NEDO-10958 Appendix IV-4), the worst distribution for Monticello during its fuel cycle is not expected to be as severe as the distribution used in the analysis.

To illustrate the conservatism inherent in the selected power distribution, comparative analyses were performed using an actual operating power distribution from a typical BWR/4. The analysis showed that the 99.9% limit is met with an MCPR 0.05 lower than the value derived with the conservative power distribution. Hence, the selected power distribution is indeed very conservative.

4.b QUESTION:

Provide a Monticello bundle power histogram (calculated result) in order to see that the predicted Monticello case is not as severe as that used in GETAB analyses and reported in the response to 4.a, above.

RESPONSE:

The requested histogram is shown in Figure 4-1. The case chosen is an end-of-cycle condition which typically exhibits highest radial peaking. Comparison with that used for GETAB analysis (question 3) will show that the Histogram used in GETAB analyses is skewed more to the right than the calculated histogram. Therefore, in the response to question 4a above, it can be concluded that the Histogram used for GETAB analyses is indeed conservative for Monticello.

5. QUESTION:

The TIP uncertainty of 8.7% is presumably based on a symmetric, reload core, and LPRM extrapolated TIP data (based on the information shown in NEDO-20340). Justify the assumption of power symmetry for the Monticello reload core.

RESPONSE:

The 8.7% uncertainty accounts for no identified physical assymmetry in the Monticello core. If some assymmetry exists, it has not been detected and is therefore not taken into account. The 8.7% relates only to TIP assymmetry.

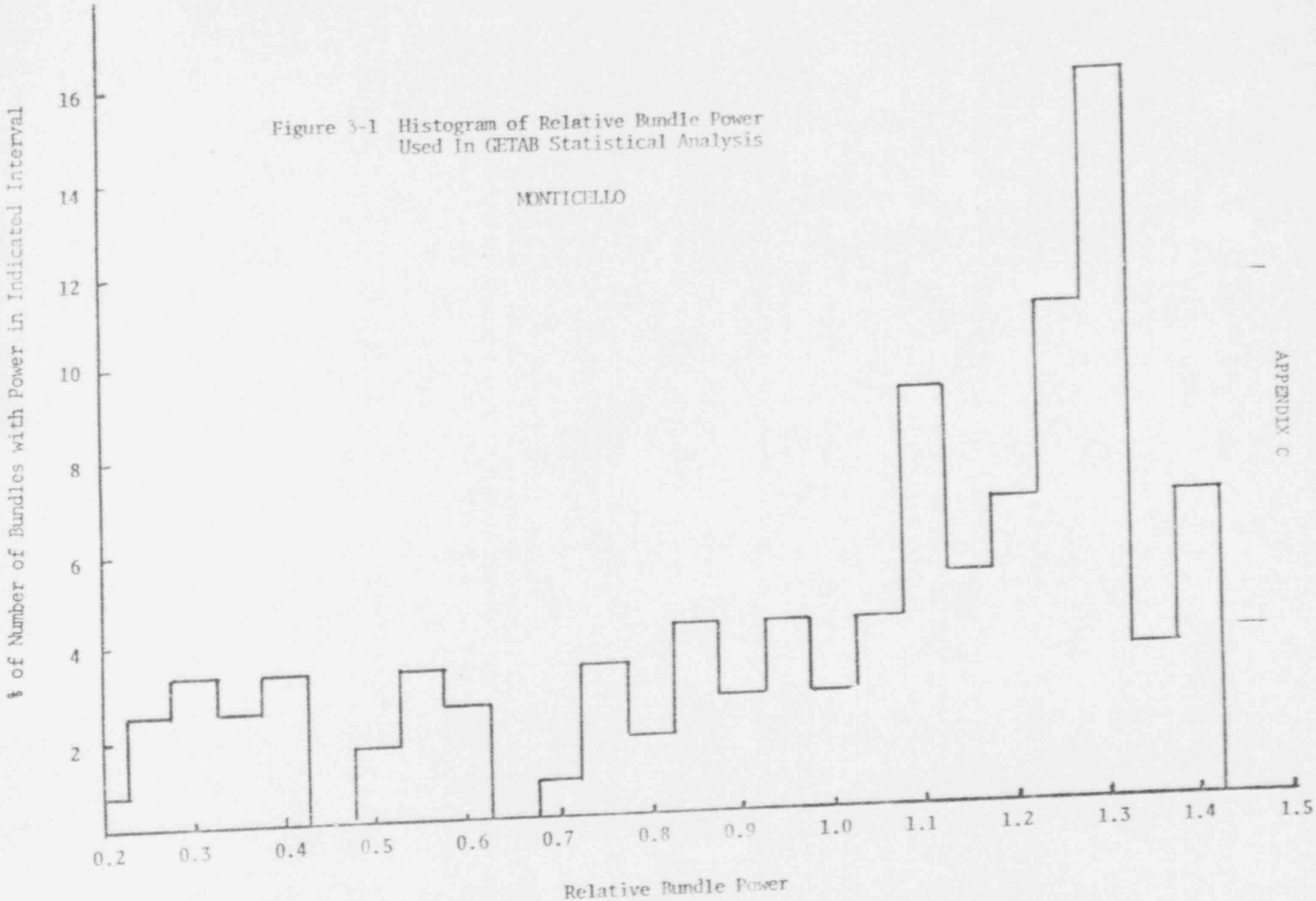

Figure 3-1 Histogram of Relative Bundle Power Used In GETAB Statistical Analysis

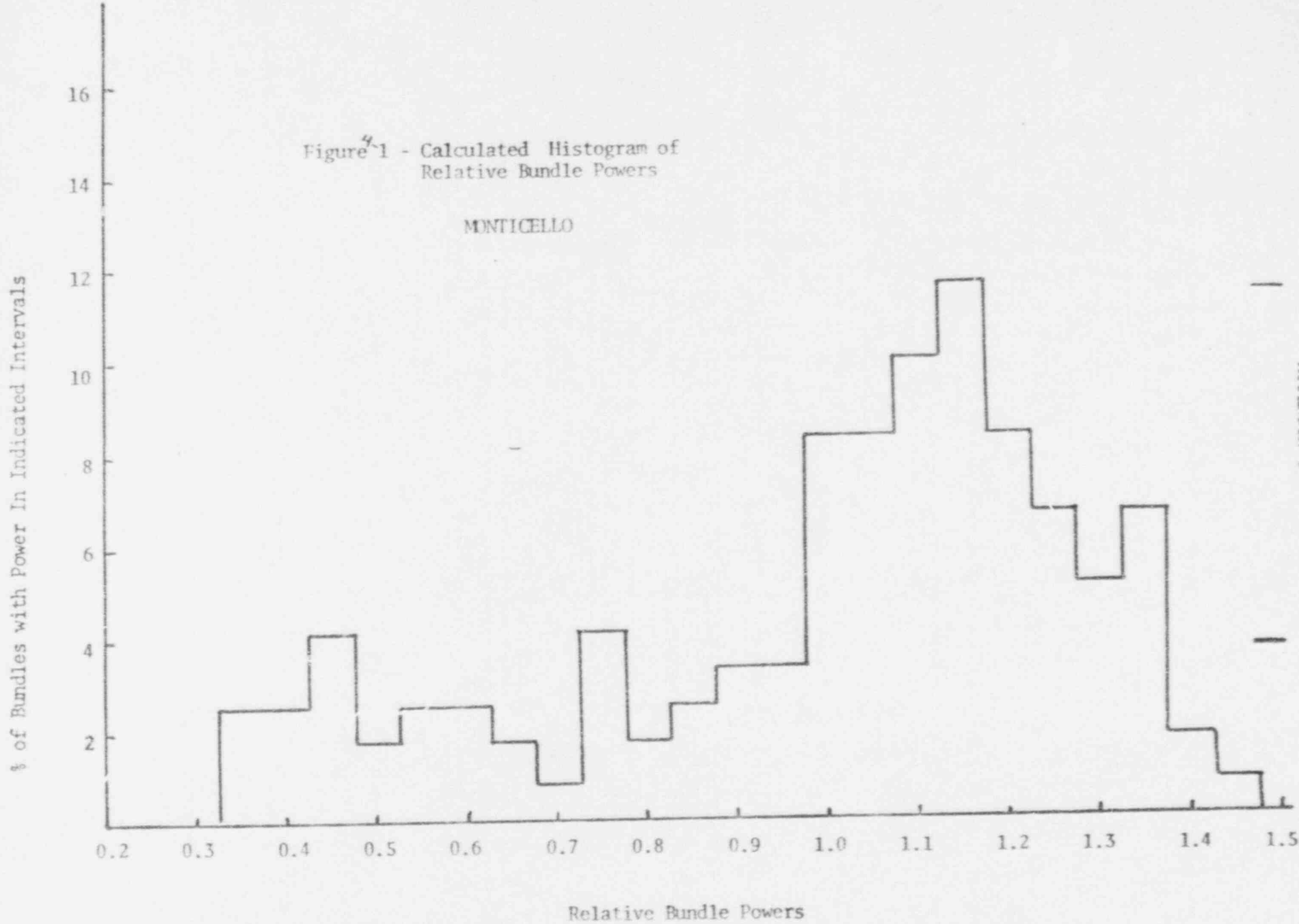
Figure 4-1 - Calculated Histogram of Relative Bundle Powers
MONTICELLO
% of Bundles with Power In Indicated Intervals
2
4
6
8
10
12
14
16
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
Relative Bundle Powers

APPENDIX C