

APPENDIX B

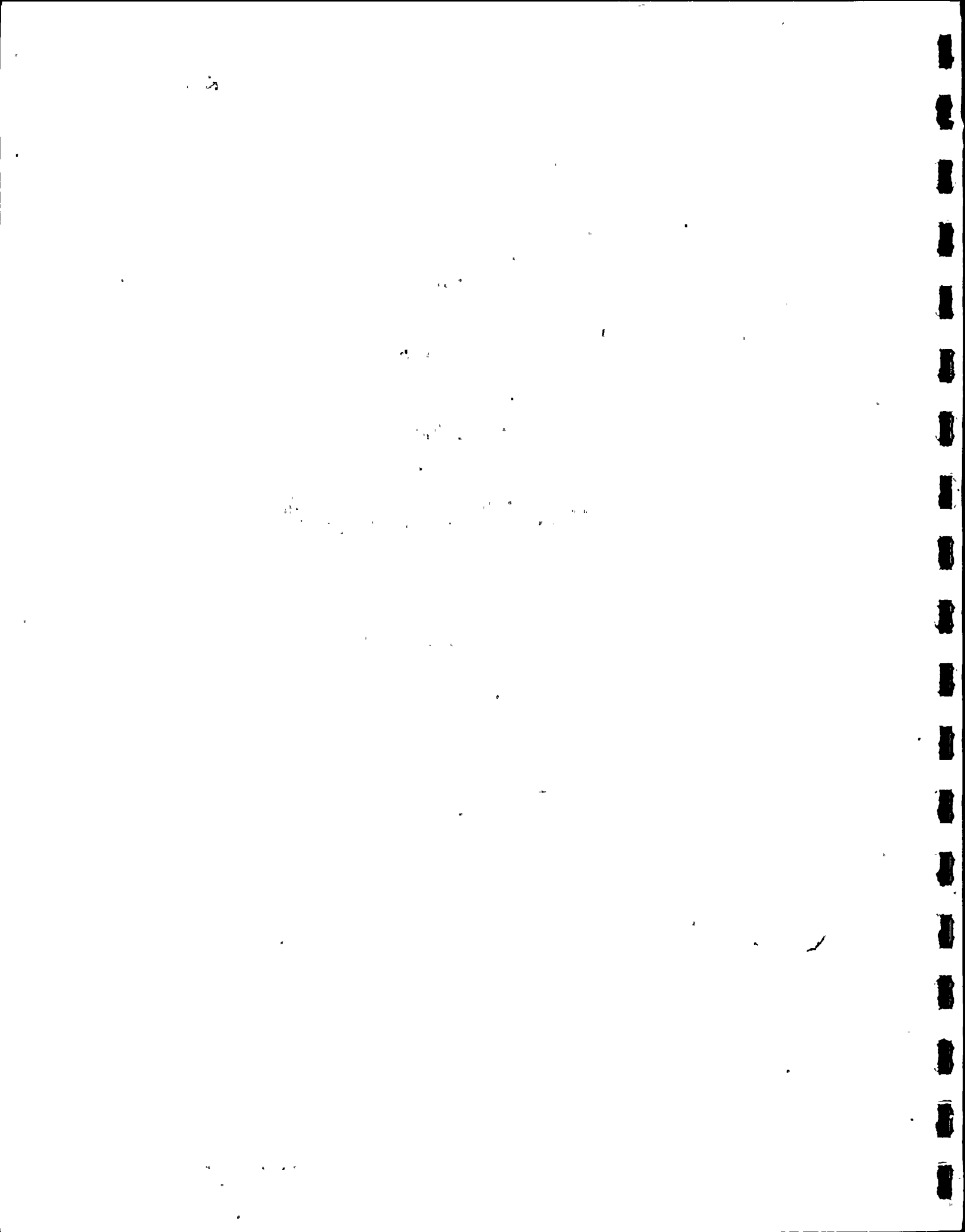
**RCS  
ASYMMETRIC LOADS  
EVALUATION**

**ST. LUCIE 1**

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RCS

ASYMMETRIC LOADS

EVALUATION

ECCS ANALYSIS APPROACH WITH REDUCED AREA  
COOLANT CHANNELS IN PERIPHERAL ASSEMBLIES

Prepared by

COMBUSTION ENGINEERING, INC.

for

St. Lucie 1

July 31, 1980

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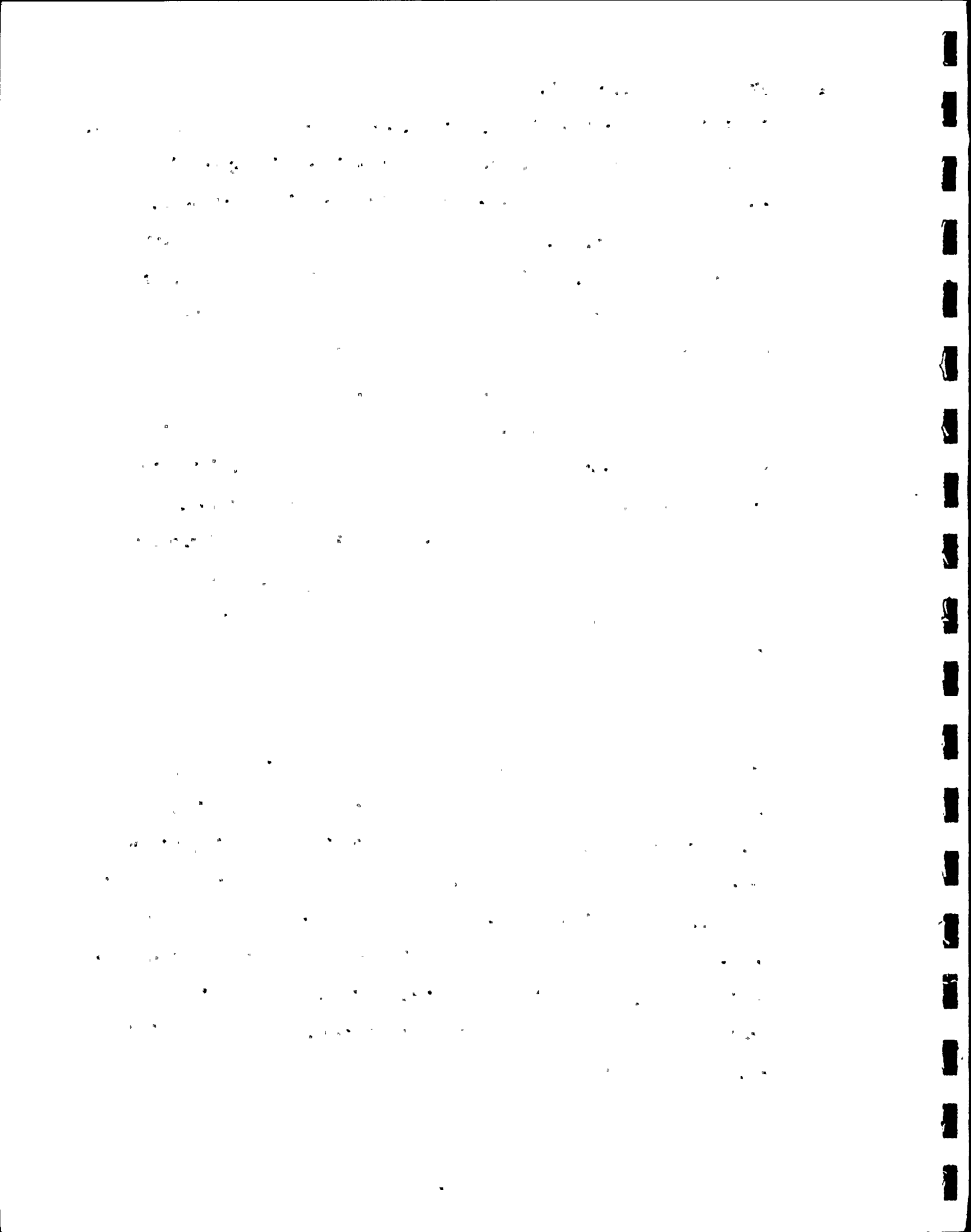
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#### 8.1.0 INTRODUCTION AND SUMMARY

The ECCS performance evaluation demonstrating conformance with 10CFR50.46, which presents the NRC Acceptance Criteria for Emergency Core Cooling Systems for Light Water Cooled Reactors<sup>(1)</sup>, are presented in References 2, 3, and 4. These references provide analyses for Calvert Cliffs Units 1 & 2, and St. Lucie Unit 1. The purpose of this supplementary analysis is to demonstrate acceptable ECCS performance with reduced area coolant channels assumed in the peripheral fuel assemblies. While demonstrating acceptable ECCS performance, the intent of this analysis is to also show that the current licensing analysis, pertaining to the hottest fuel rod in the core, is more limiting than that for the hottest rod in a peripheral assembly with reduced area coolant channels. Since this evaluation is to apply to the above plants, a generic analysis was performed. The method of the analysis is discussed in the following sections.

#### B.2.0 METHOD OF ANALYSIS

In the C-E ECCS evaluation model<sup>(5,6)</sup>, the CEFLASH-4A<sup>(7)</sup> computer program is used to determine the primary system thermal hydraulic behavior during the blowdown period, and the COMPERC-II<sup>(8)</sup> program is used to describe the system behavior during the refill and reflood periods. The resulting transient parameters from these computer programs, describing the thermal and hydraulic behavior of the primary system, supply the input to the STRIKIN-II<sup>(9)</sup> program which is used to calculate the hot rod peak clad temperature and peak local clad oxidation percentage.

1. The first part of the report deals with the general situation of the country and the progress of the work during the year. It is a summary of the work done by the various departments and a statement of the results achieved. It is a general statement of the work done by the various departments and a statement of the results achieved.

2. The second part of the report deals with the work done by the various departments during the year. It is a detailed statement of the work done by the various departments and a statement of the results achieved. It is a detailed statement of the work done by the various departments and a statement of the results achieved.

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The objective of the analysis is to demonstrate that the ECCS performance for a peripheral assembly with reduced area coolant channels is less limiting than a hot rod in a channel without any reduction in flow area. To accomplish this objective it is necessary to evaluate the performance of the limiting fuel rod in the peripheral assembly containing reduced area fuel channels. In evaluating the performance of the limiting fuel rod in the peripheral assembly, blowdown refill/reflood, and temperature calculations were performed using the computer programs described above based on a conservative set of input assumptions. The conservative assumptions are employed in the analysis so that the results will bound the response for Calvert Cliffs Units 1 & 2, and St. Lucie Unit 1 Plants. The details of these assumptions and the analytical methods employed in this analysis are discussed in the subsections below.

#### B.2.1 Blowdown Hydraulics

The blowdown portion of the transient was analyzed using the CEFLASH-4A computer program. In the CEFLASH-4A calculation, the peripheral assembly was explicitly represented with a 10% reduction in total assembly cross sectional flow area. This reduction in peripheral assembly flow area conservatively exceeds the maximum expected deformation since the testing program identified this maximum blockage to be 9%. This deformation was also assumed to occur along the entire length of the assembly to minimize the flow in this region. In addition, the power level of the peripheral assembly was conservatively assumed to be at the core average power level. This assumption is conservative since the peripheral assemblies are approximately 5% to 10% lower than that for the core average which results in maximizing the heat

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Figure 1. The effect of the number of trials on the number of correct responses. The number of correct responses was significantly higher for the 10 trials condition than for the 5 trials condition. Error bars represent the standard error of the mean.

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 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1

addition to this region.

In performing the blowdown calculation, the Calvert Cliffs plant, a representative 2700 Mwt class NSSS, is used. This plant was chosen since its' core power level is highest of all the plants considered in this evaluation.

#### B.2.2 Refill/Reflood Hydraulics

Since the containment pressure and core average reflood rates are unaffected by the flow area reduction in a single peripheral assembly, no new COMPERC-II calculations were necessary. As a consequence, the COMPERC-II refill/reflood hydraulics calculations from a representative 2700 Mwt class NSSS was chosen for use in this portion of the evaluation. This particular analysis was chosen since the evaluation resulted in the lowest containment pressure, the lowest reflood rate, and hence the lowest reflood heat transfer coefficients, for the plants considered in this report.

#### B.2.3 Temperature Analysis

The STRIKIN-II and PARCH<sup>(10)</sup> computer programs were used to evaluate the temperature transient and peak local clad oxidation percentage for the hottest rod in the peripheral assembly.

For conservatism, in modeling rod-to-rod thermal radiation, the power distribution surrounding the hot rod in the peripheral assembly was assumed to be a relatively flat distribution. As a consequence, the rods surrounding the hot rod in the peripheral assembly will be very nearly the same temperature as the hot rod during the entire .

1. The first part of the document is a letter from the President of the United States to the Congress, dated January 3, 1862. It is a very important document, as it contains the President's annual message to Congress. The letter is written in a very formal and dignified style, and it is one of the most important documents in the history of the United States.

2. The second part of the document is a report from the Secretary of the Treasury, dated January 3, 1862. It is a very important document, as it contains the Secretary's report on the state of the Treasury. The report is written in a very formal and dignified style, and it is one of the most important documents in the history of the United States.

3. The third part of the document is a report from the Secretary of the Interior, dated January 3, 1862. It is a very important document, as it contains the Secretary's report on the state of the Interior. The report is written in a very formal and dignified style, and it is one of the most important documents in the history of the United States.

transient thereby minimizing the benefits from rod-to-rod thermal radiation. This radiation enclosure is conservative since it bounds all power distributions encountered in all of the operating plants experienced to date.

In evaluating the response of the hottest rod in the peripheral assembly, the channel surrounding this rod was assumed to be reduced in flow area with percentage reductions in the range from 0 to 35% which covers the maximum expected flow area reduction of 34% obtained from the testing program. The results are presented as a curve of allowable linear heat rate, for a peripheral assembly, as a function of percent reduction in single channel flow area for the hottest pin in this assembly.

#### B.3.0 SUMMARY OF CONSERVATISMS

A summary of the conservatisms for this analysis is presented below:

1. The power level of 2754 Mwt (102% of 2700 Mwt) was assumed.
2. The peripheral assembly power level was assumed to be at the core average power level. The peripheral assembly power levels for all the plants considered in this evaluation are lower than the core average power levels.
3. The thermal radiation enclosure assumed a nearly uniform power distribution surrounding the hot rod to minimize radiation heat transfer during refill and reflood.
4. Radiation to the guide tubes was neglected. All of the hot rods in the peripheral assemblies for the plants considered herein are located near the guide tubes.

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5. The analysis was performed at the time-in-life of minimum gap conductance or maximum fuel stored energy.
6. The assembly and channel flow area reductions were applied along the entire length of the core. Actual deformations are expected to occur only near the core mid-plane.

Some of the significant parameters selected for use in this evaluation, compared with the more appropriate specific plant parameter, are listed in Table B.3.1.

#### B.4.0 RESULTS

The results of the analysis demonstrate acceptable ECCS performance for the plants considered for reductions in single channel flow area of 35% in a peripheral assembly. Figure B.4-1 illustrates the relationship between linear heat generation rate and reduction in single channel flow area for a peripheral assembly and demonstrate an acceptable linear heat generation rate of 14.9 kw/ft when the reduction in channel flow area is as high as 35%.

Table B.4.1 presents the results of three analysis considerations. In identifying an acceptable linear heat generation rate in a peripheral assembly for the various channel area reductions, the peak clad temperatures and peak local clad oxidation percentages were maintained below 2100°F and 15% respectively for additional conservatism.

Table B.4-2 lists the various parameters presented graphically for the three cases.

The results of this study show acceptable ECCS performance with a

[illegible]

Trial	Control (○)	MCI (●)	AD (■)
1	95	85	75
2	92	82	72
3	90	80	70
4	88	78	68
5	85	75	65

Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains.

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1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 2678, 26

Figure 1. The effect of the concentration of the  $\text{H}_2\text{O}_2$  solution on the amount of the released  $\text{H}_2$  gas from the  $\text{H}_2$  gas-generating system. The amount of the released  $\text{H}_2$  gas was measured at 25 °C for 10 min. The concentration of the  $\text{H}_2\text{O}_2$  solution was 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, and 1.0 M. The amount of the released  $\text{H}_2$  gas was measured at 25 °C for 10 min. The concentration of the  $\text{H}_2\text{O}_2$  solution was 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, and 1.0 M.

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Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The number of transformed cells was determined by the number of colonies obtained on the selective medium. The results are the mean of three independent experiments. Error bars represent the standard deviation.

Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains.

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$\frac{1}{n} \sum_{i=1}^n x_i = \bar{x}$

1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 2678, 26

$$0 \rightarrow \mathcal{O}_X(-1) \rightarrow \mathcal{O}_X \rightarrow \mathcal{O}_X(1) \rightarrow 0$$

1. *Journal of the American Medical Association*, 1990; 263: 1025-1028.

[illegible]

1. *Chlorophyll a* and *Chlorophyll b* were determined by the method of Lichtenthaler and Whistler (1973). The total chlorophyll content was determined by the method of Arar and Cook (1980). The carotenoid content was determined by the method of Lichtenthaler and Whistler (1973). The total carotenoid content was determined by the method of Arar and Cook (1980). The total protein content was determined by the method of Lowry et al. (1951). The total lipid content was determined by the method of Bligh and Dyer (1959). The total carbohydrate content was determined by the method of Dubois and Gilles (1950). The total nucleic acid content was determined by the method of Burton (1956). The total ash content was determined by the method of AOAC (1990). The total moisture content was determined by the method of AOAC (1990). The total dry matter content was determined by the method of AOAC (1990). The total organic acid content was determined by the method of AOAC (1990). The total alkaloid content was determined by the method of AOAC (1990). The total saponin content was determined by the method of AOAC (1990). The total tannin content was determined by the method of AOAC (1990). The total flavonoid content was determined by the method of AOAC (1990). The total phenolic content was determined by the method of AOAC (1990). The total terpenoid content was determined by the method of AOAC (1990). The total steroid content was determined by the method of AOAC (1990). The total glycoside content was determined by the method of AOAC (1990). The total alkaloid content was determined by the method of AOAC (1990). The total saponin content was determined by the method of AOAC (1990). The total tannin content was determined by the method of AOAC (1990). The total flavonoid content was determined by the method of AOAC (1990). The total phenolic content was determined by the method of AOAC (1990). The total terpenoid content was determined by the method of AOAC (1990). The total steroid content was determined by the method of AOAC (1990). The total glycoside content was determined by the method of AOAC (1990).

<sup>a</sup> Values are means ± SD.

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1.  $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$

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Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The number of transformed cells was determined by the number of colonies obtained after 10 days of growth on the selective medium. The results are the mean of three independent experiments. Error bars represent the standard deviation.

Trial	Control (n=10)	MCI (n=10)	AD (n=10)
1	95	85	75
2	95	85	75
3	95	80	70
4	95	75	65
5	95	75	65

Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The number of transformed cells was determined by the number of colonies obtained after plating on the selective medium. The results are the mean of three independent experiments. Error bars represent standard deviation.



maximum assembly flow area reduction of 10% and a maximum channel reduction of 35%.

#### E.5.0 EVALUATION OF RESULTS

Despite the many conservative assumptions inherent in this evaluation, the results were well below the Acceptance Criteria Limits<sup>(1)</sup>. The peak clad temperatures were calculated to occur during the late reflood period and were due to the very conservative assumptions in regard to the limited heat transfer imposed during this period. Without utilizing the conservative assumptions described in Section B.3.0, it is estimated that the resulting peak clad temperature would have been several hundred degrees lower than those reported herein.

In the analysis, the Calvert Cliffs plant, representative of the 2700 Mwt class of plants, was used since it's power level is highest of all the plants considered. In addition, this particular plant was used since the response during the reflood portion of the transient results in the lowest containment pressure, the lowest reflood rate, and hence the lowest reflood heat transfer coefficients of the plants considered in the evaluation. Table B.3.1 presents some of the major parameters used in the analysis and demonstrates that the parameters used in the evaluation bound those for the plants considered in this report.

Table B.3.1 presents the peak linear heat generation rate for the hottest fuel rod in the core and for the hottest fuel rod in a peripheral assembly for all the plants considered in this evaluation. Since the difference in power level between the hottest core fuel rod and the hottest fuel rod in a peripheral assembly varies throughout the cycle



for all plants, the values presented for these linear heat rates correspond to the time in life wherein the separation in power, between these two locations, is at a minimum. This evaluation is therefore conservative since during the cycle, the separation in power between the hottest peripheral fuel rod and the hottest rod in the core is much greater than that assumed in the analysis. Inspection of Table B.3.1 demonstrates that the Calvert Cliffs Unit II plant produces the highest linear heat rate, for a fuel rod in a peripheral assembly, of 14.3 kw/ft when the hottest fuel rod in the core is at 15.5 kw/ft at the most limiting time-in-life. Furthermore, with a 35% reduction in channel flow area for the hottest peripheral fuel rod, the ECCS performance is less limiting than that for the hottest fuel rod in the core with no channel deformation.

It should also be mentioned that the results of this analysis apply equally to those plants listed in Table B.3.1 so that, in effect, the linear heat rate of the hottest rod in a Combustion Engineering peripheral assembly can be as high as 14.9 kw/ft for each of these plants regardless of whatever the core peak linear heat rate is.

The peak linear heat generation rate in a peripheral assembly in St. Lucie Unit 1 is 13.9 kw/ft. Therefore, even with a 35% reduction in channel flow area in the hottest load rod in a peripheral assembly, the limiting rod will remain the hottest rod in the core with the peak linear heat rate of 15.0 kw/ft.

It is also of particular importance to note that the analysis of the peripheral fuel rod contained in this report includes the various

1. The first part of the document is a list of names and addresses of the members of the committee. The names are listed in alphabetical order, and the addresses are given in full. The list is as follows:

2. The second part of the document is a list of the names and addresses of the members of the committee who have been elected to the office of the Secretary. The names are listed in alphabetical order, and the addresses are given in full. The list is as follows:

3. The third part of the document is a list of the names and addresses of the members of the committee who have been elected to the office of the Treasurer. The names are listed in alphabetical order, and the addresses are given in full. The list is as follows:

uncertainties and associated engineering factors associated and applied to the hottest fuel rod in the core. With this factor also applied to the peripheral fuel rod, the evaluation still demonstrated that the limiting fuel rod remains the hottest rod in the core so that application of the factors to the peripheral fuel rod represents considerable additional conservatism.

#### B.6.0 CONCLUSIONS

The results of this analysis demonstrate an acceptable linear heat generation rate of 14.9 kw/ft for a reduction in channel flow area of 35% in a peripheral assembly. In Table B.3.1 the peak linear heat generation rate in the peripheral assemblies for the plants considered in this evaluation are presented to demonstrate the difference in power between the hottest rod in the core and the hottest rod in a peripheral assembly. As identified in Table B.3.1 of the plants considered, the highest power level of a pin in a peripheral assembly is 14.3 kw/ft when the limiting rod in the hot assembly is operating at 15.5 kw/ft. Since the results of this evaluation demonstrate acceptable ECCS performance at the linear heat rate of 14.9 kw/ft, there is no impact on the present peak linear heat generation rate for the plants considered in this evaluation so that the analysis results reported in References 2, 3, and 4 remain limiting.

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#### B.7.0 COMPUTER CODE VERSION IDENTIFICATION

The following NRC approved versions of Combustion Engineering ECCS Evaluation Model computer codes were used in this analysis:

CEFLASH-4A:   Version No. 76041

STRIKIN-II:   Version No. 77036

PARCH       :   Version No. 77004

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for transparency and accountability, particularly in financial matters.

2. The second part outlines the various methods and tools used to collect and analyze data. This includes both traditional manual techniques and modern digital solutions, highlighting the advantages of each approach.

3. The third section focuses on the challenges faced during the data collection process. It addresses issues such as data quality, consistency, and the potential for bias, offering strategies to mitigate these risks.

4. The fourth part describes the importance of data security and privacy. It discusses the need to implement robust safeguards to protect sensitive information from unauthorized access and breaches.

5. The fifth section explores the role of data in decision-making. It explains how analyzed data can provide valuable insights that inform strategic planning and operational improvements.

6. The sixth part discusses the ethical considerations surrounding data collection and analysis. It touches upon issues like informed consent, data ownership, and the potential for misuse of information.

7. The seventh section provides a summary of the key findings and conclusions drawn from the study. It reiterates the significance of a systematic and ethical approach to data management.

8. The final part of the document offers recommendations for future research and practice. It suggests areas where further exploration is needed and provides guidance on best practices for implementing the discussed concepts.



#### B.8.0 REFERENCES

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3. BG&E Letter, A. E. Lundwall Jr. to A. Giambusso, dated 7/17/71.
4. FP&L Letter to NRC L-79-42, dated February 22, 1979
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CENPD-132, Supplement 1, "Updated Calculative Methods for the CE Large Break LOCA Evaluation Model", December 1974 (Proprietary).
6. CENPD-132, Supplement 2, "Calculational Methods for the CE Large Break LOCA Evaluation Model", July 1975 (Proprietary).
7. CENPD-133, "CEFLASH-4A, A FORTRAN IV Digital Computer Program for Reactor Blowdown Analysis", April 1974 (Proprietary).  
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8. CENPD-134, "COMPERC-II, A Program for Emergency Refill-Reflood of the Core", April 1974 (Proprietary).  
CENPD-134, Supplement 1, "COMPERC-II, A Program for Emergency Refill-Reflood of the Core (Modification)", December 1974 (Proprietary).
9. CENPD-135, "STRIKIN; A Cylindrical Geometry Fuel Rod Heat Transfer Program", April 1974 (Proprietary).  
CENPD-135, Supplement 2, "STRIKIN-II, A Cylindrical Geomegry Fuel Rod Heat Transfer Program (Modification)", February 1975.  
CENPD-135, Supplement 4, "STRIKIN-II, A Cylindrical Geometry Fuel Rod Heat Transfer Program", August 1976 (Proprietary).

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CENPD-135, Supplement 5-P, "STRIKIN-II, A Cylindrical Geometry Fuel Rod Heat Transfer Program", April 1977 (Proprietary).

10. CENPD-138, and Supplement 1; "PARCH, A FORTRAN IV Digital Program to Evaluate Pool Boiling, Axial Rod and Coolant Heatup", February 1975 (Proprietary).



TABLE B.3-1

PARAMETERS USED IN DEFORMED ASSEMBLY ANALYSIS

<u>PARAMETER</u>	<u>ANALYSIS ASSUMPTION</u>	<u>CALVERT CLIFFS UNIT I</u>	<u>PLANT</u>	
			<u>CALVERT CLIFFS UNIT II</u>	<u>ST. LUCIE 1</u>
Total Reactor Power (Mwt)	2754	2754	2754	2754
PLHGT (kw/ft)	15.6	14.2	15.5	15.0
PLHGR In Peripheral Assembly (kw/ft)	*	12.2	14.3	13.9
Average LHR (kw/ft)	6.548	6.333	6.52	6.427
Fuel Average Tem- perature at PLHGR (°F)	2300	2151	2233	2203

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\*Varies with channel deformation (15.6 - 14.9 kw/ft)



TABLE B.4-1

RESULTS OF DEFORMED ASSEMBLY ANALYSIS

<u>CASE</u>	<u>PLHGR (kw/ft)</u>	<u>PEAK CLAD TEMPERATURE (°F)</u>	<u>PEAK LOCAL CLAD OXIDATION (%)</u>
Undeformed Assembly	15.6	2053	< 15.0
20% Deformation	15.2	1940	< 6.0
35% Deformation	14.9	2036	< 14.5





TABLE B.4-2

VARIABLES PLOTTED AS A FUNCTION OF TIME

<u>VARIABLE</u>	<u>FIGURE DESIGNATION</u>
Assembly Flow Rate	B.4-2
Undeformed Case:	
Peak Clad Temperature	B.4-3
Local Clad Oxidation	B.4-4
20% Reduction Case	
Peak Clad Temperature	B.4-5
Local Clad Oxidation	B.4-6
30% Reduction Case:	
Peak Clad Temperature	B.4-7
Local Clad Oxidation	B.4-8

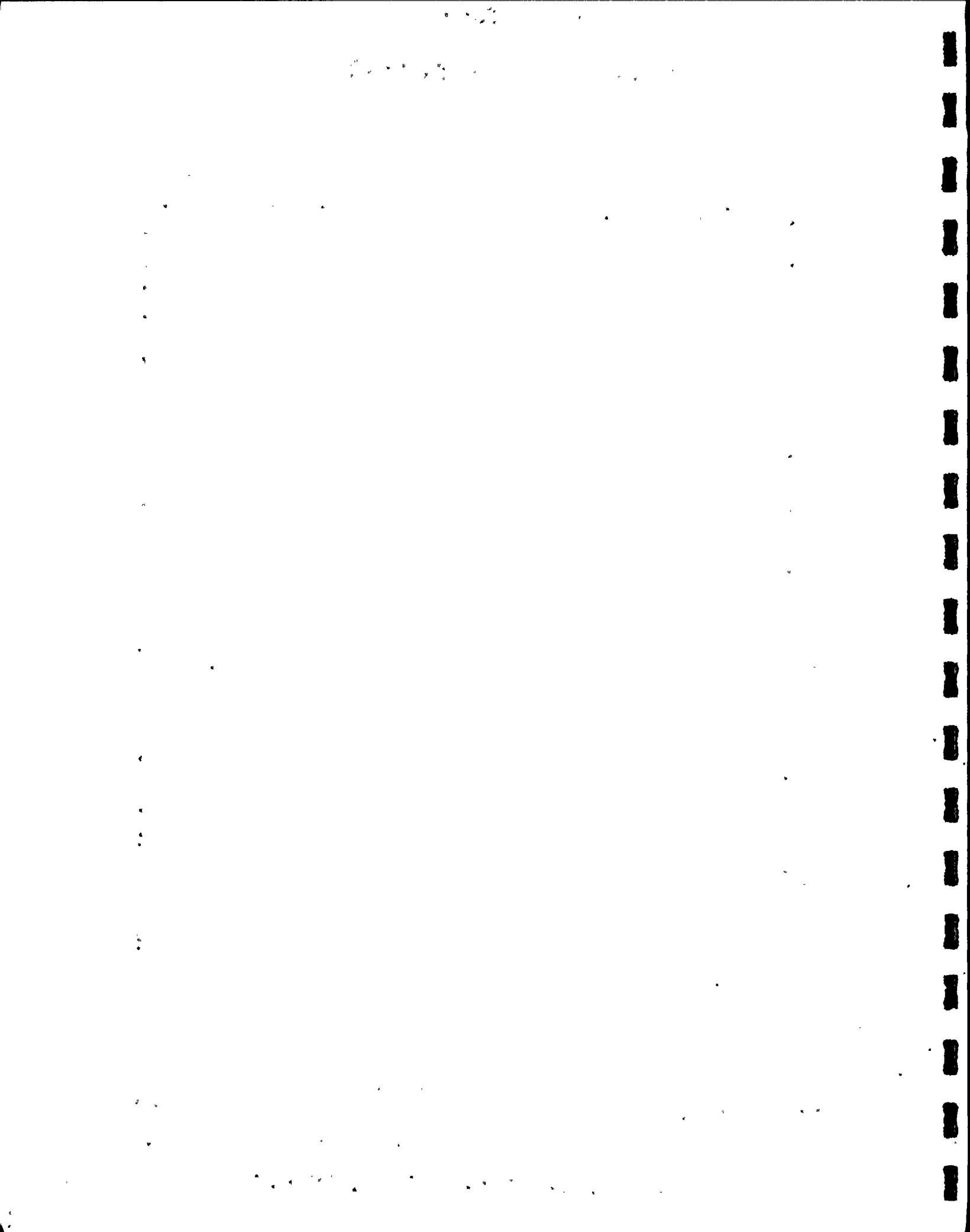


FIGURE B.4-1

PLHGR vs FLOW AREA REDUCTION

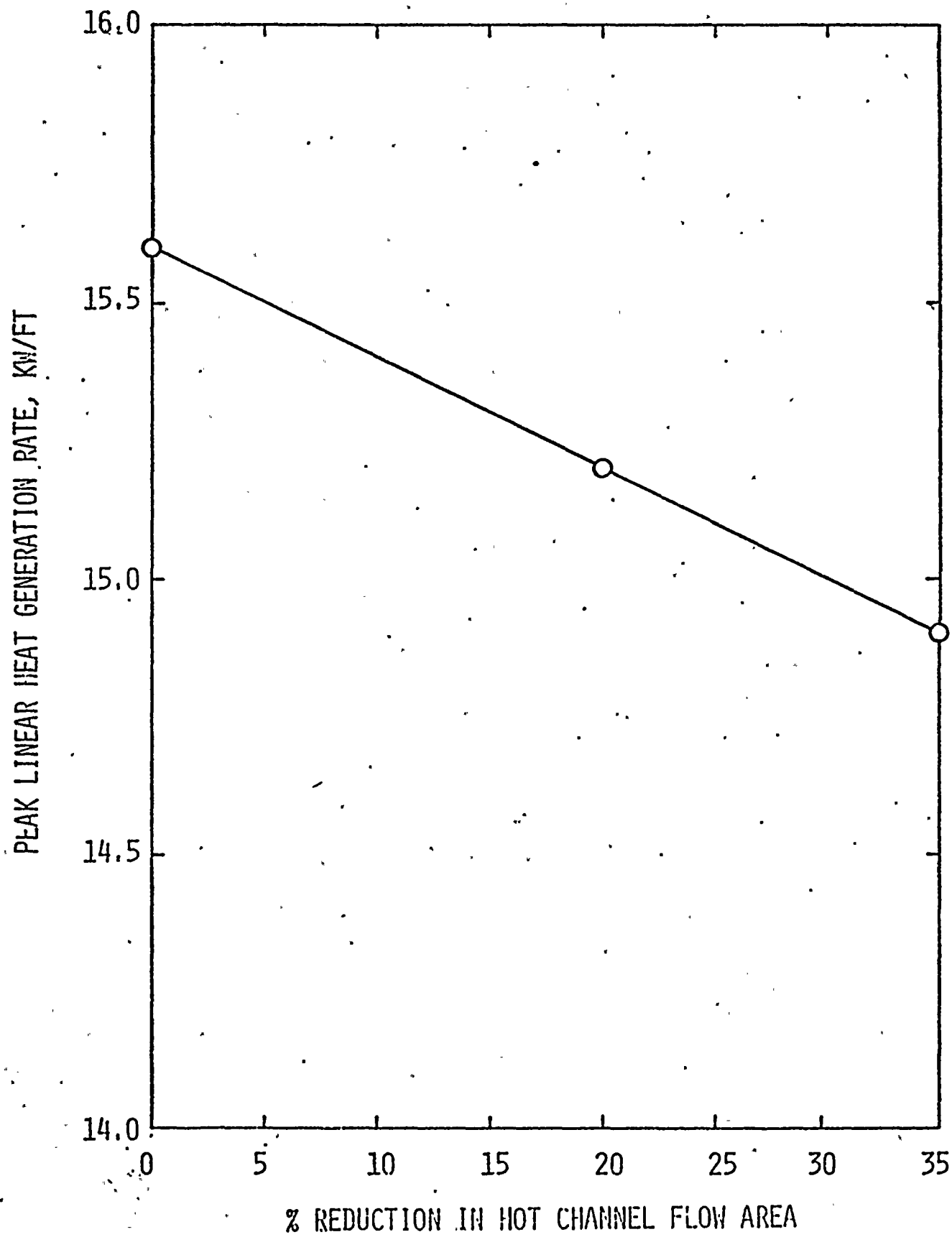
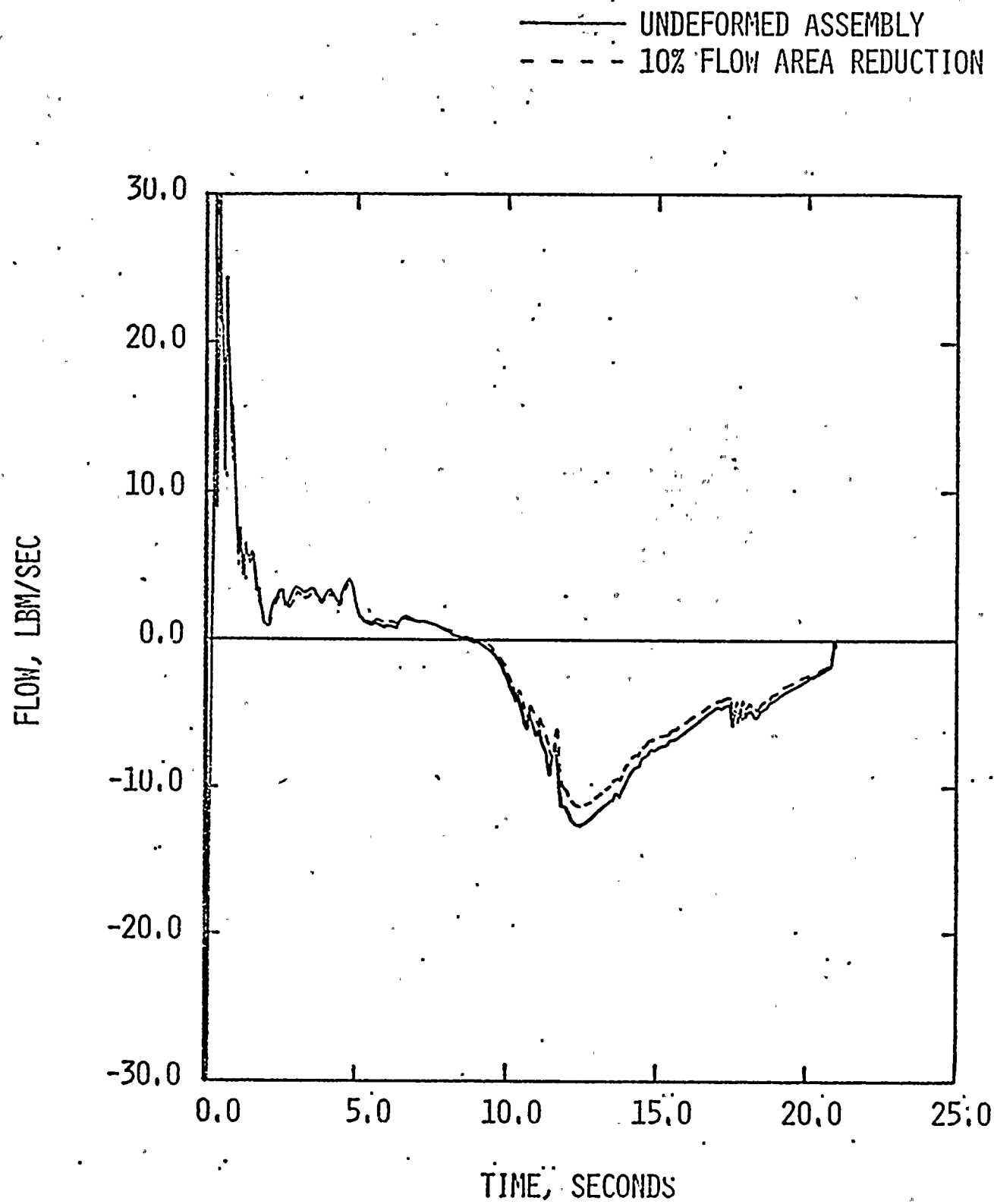




FIGURE B.4-2

REDUCED FLOW AREA IN PERIPHERAL ASSEMBLY  
ASSEMBLY FLOW RATE



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LAND OFFICE

FOR THE YEAR 1900

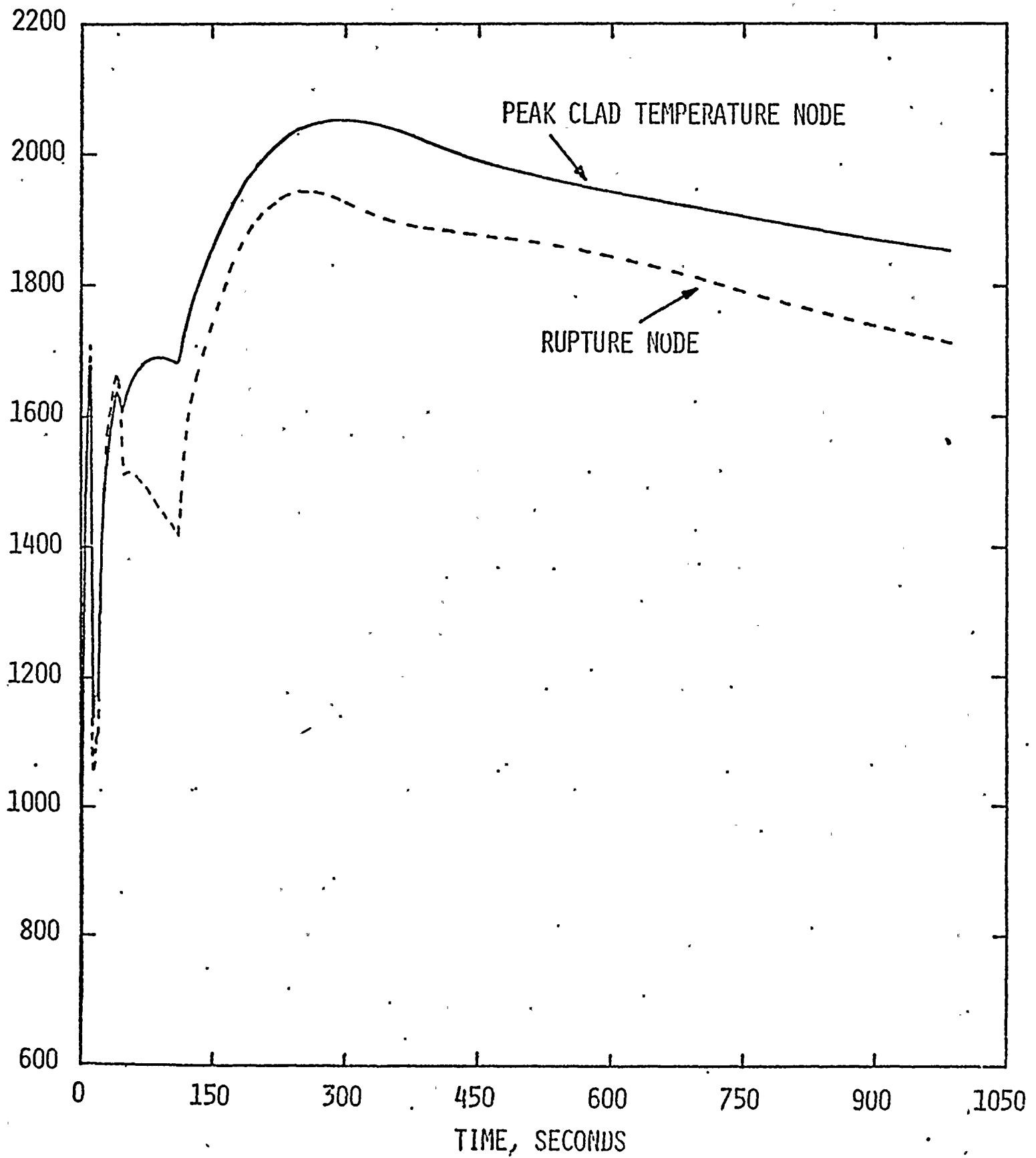
IN THE STATE OF ALABAMA

ALBANY, N. Y.  
1901

ALBANY, N. Y.  
1901

FIGURE B.4-3

REDUCED FLOW AREA IN PERIPHERAL ASSEMBLY  
UNDEFORMED ASSEMBLY  
PEAK CLAD TEMPERATURE



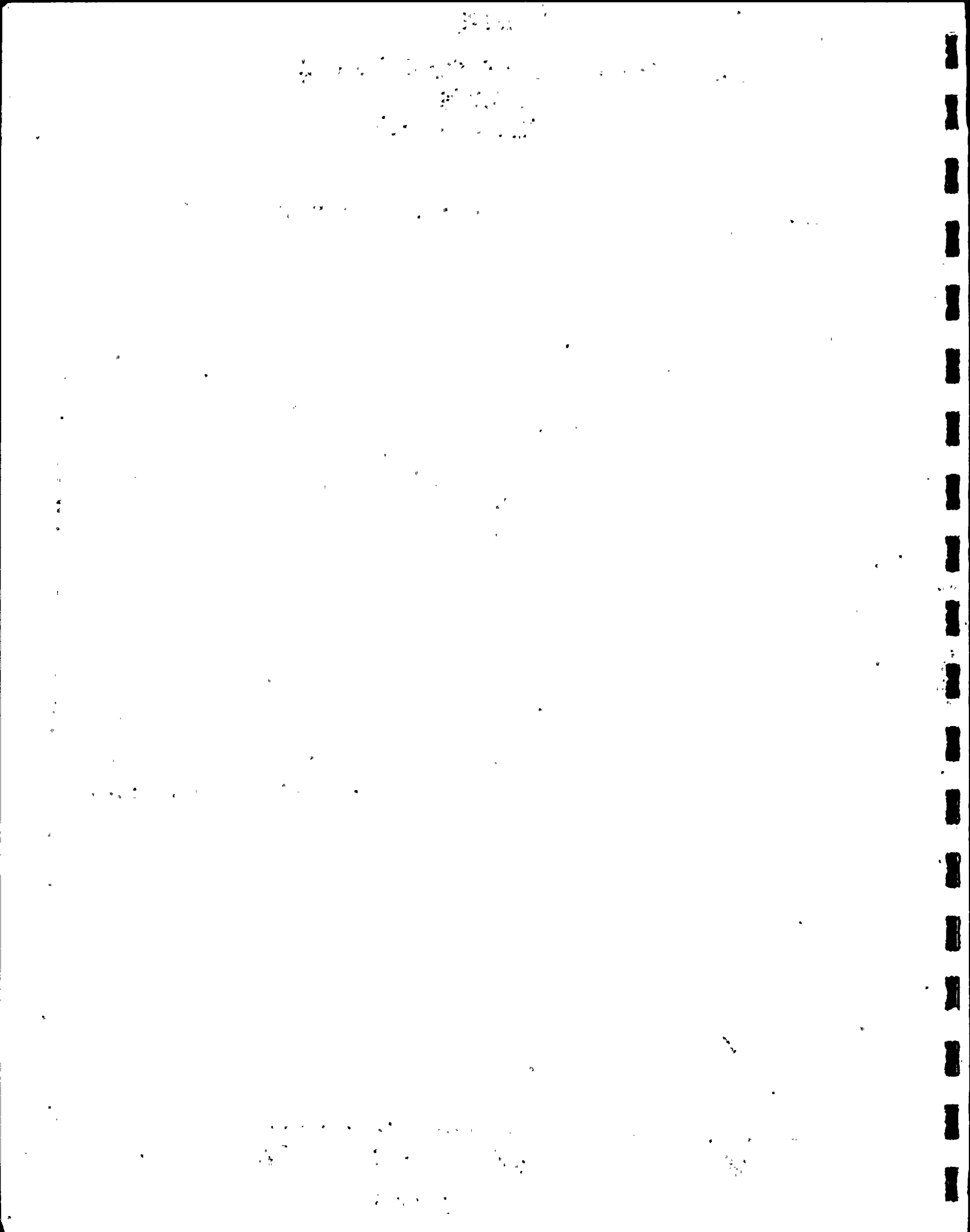
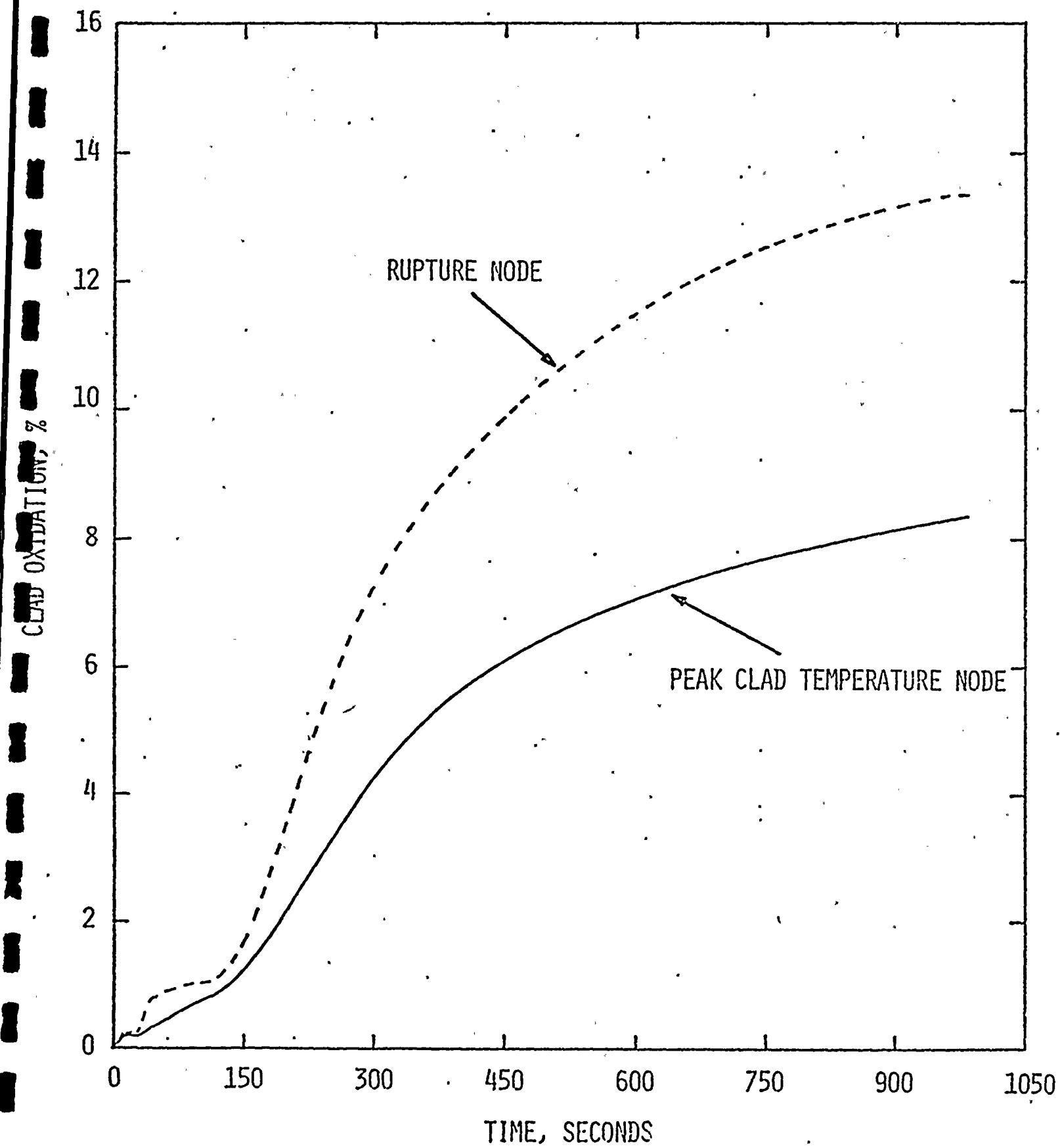




FIGURE B.4-4

REDUCED FLOW AREA IN PERIPHERAL ASSEMBLY  
UNDEFORMED ASSEMBLY  
PEAK LOCAL CLAD OXIDATION



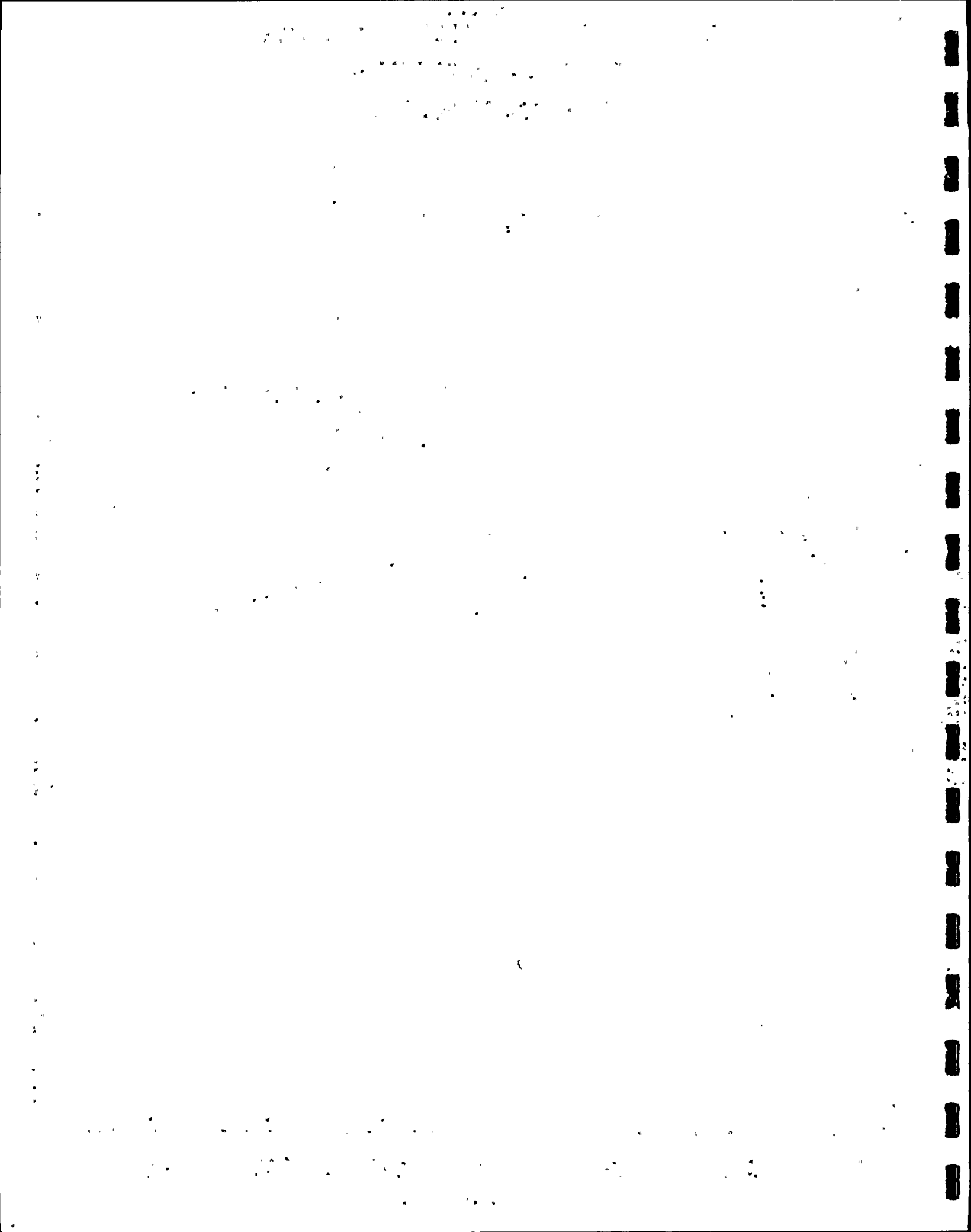
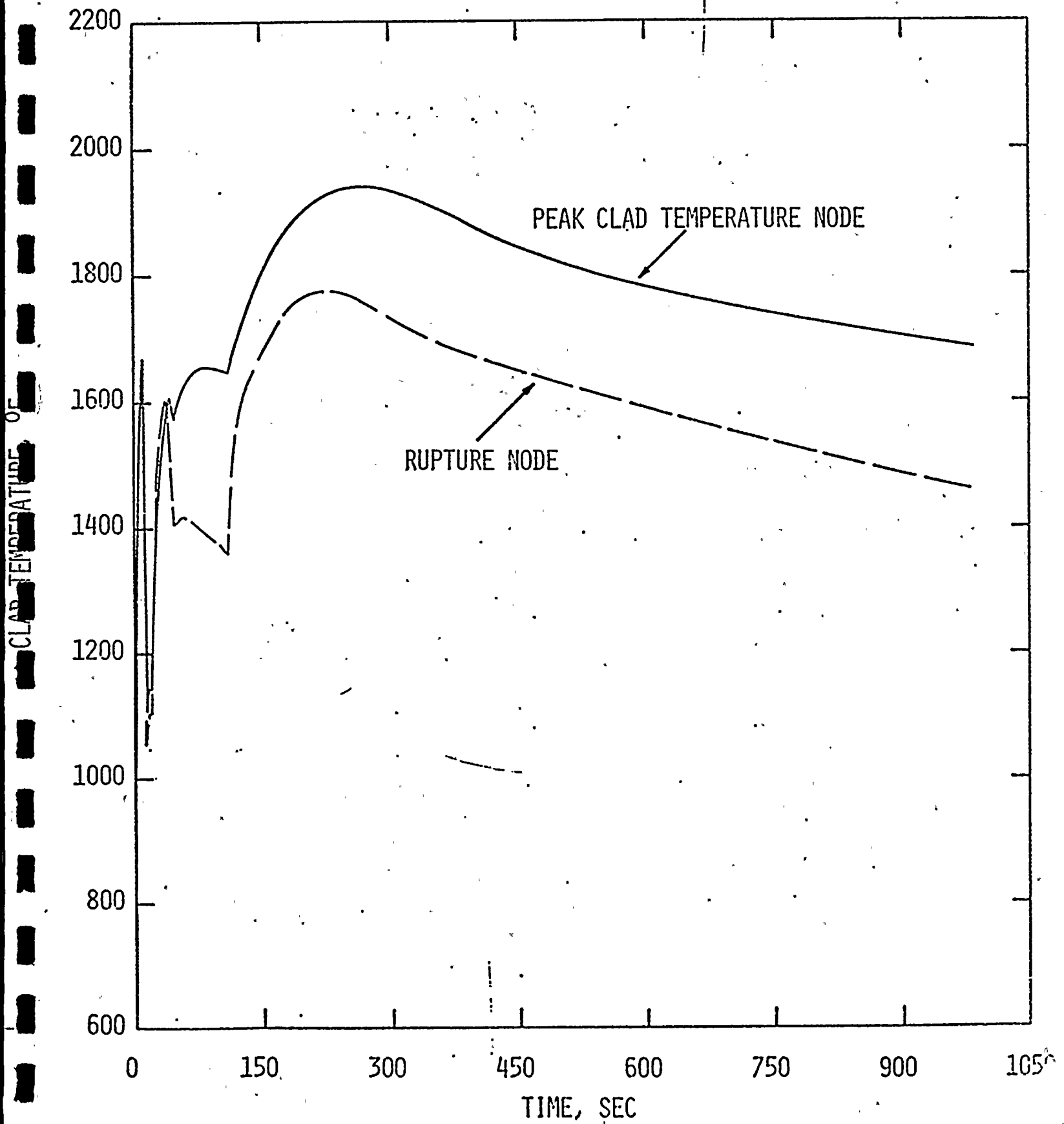


FIGURE B.4-5  
REDUCED FLOW AREA IN PERIPHERAL ASSEMBLY  
20% FLOW AREA REDUCTION  
PEAK CLAD TEMPERATURE



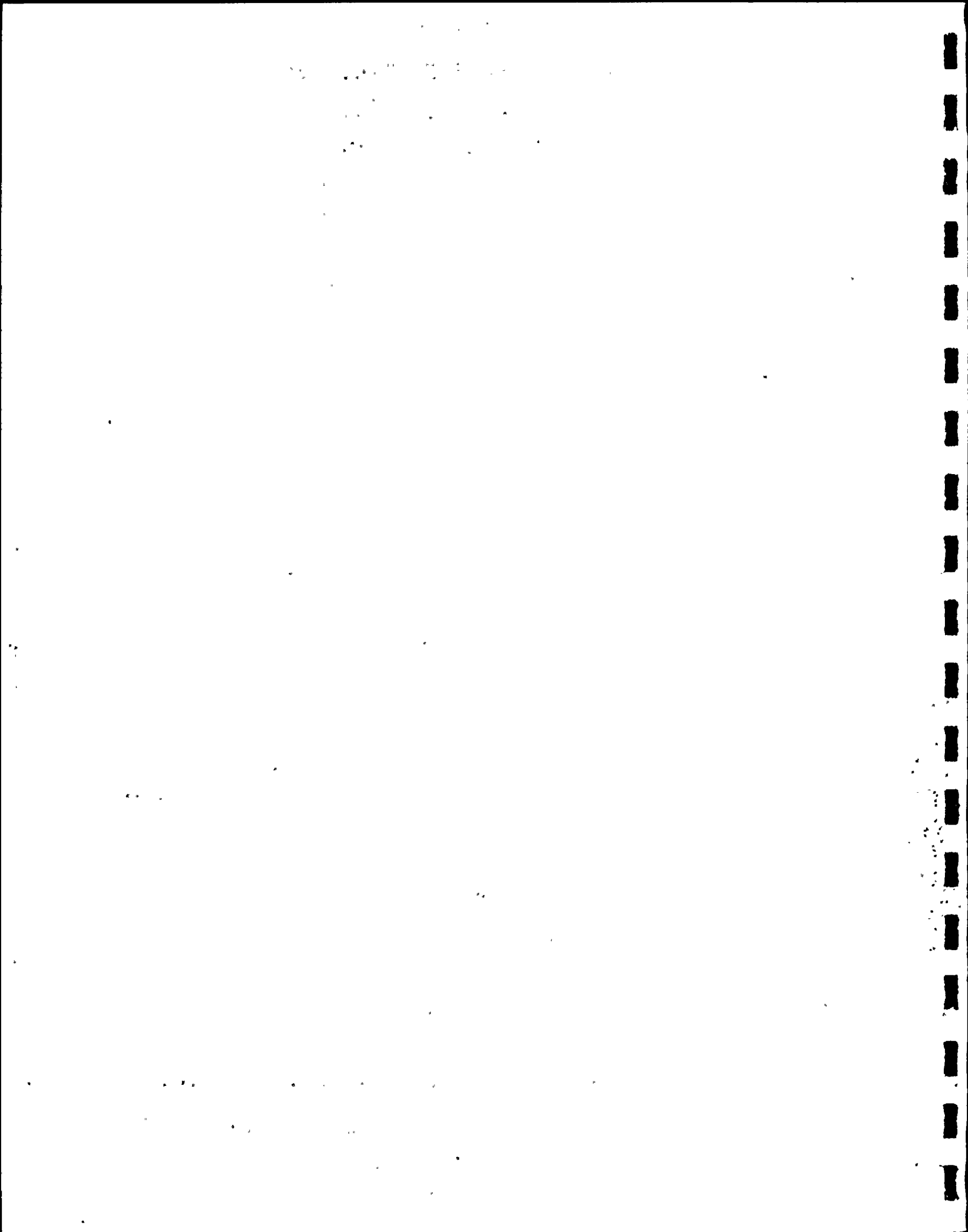
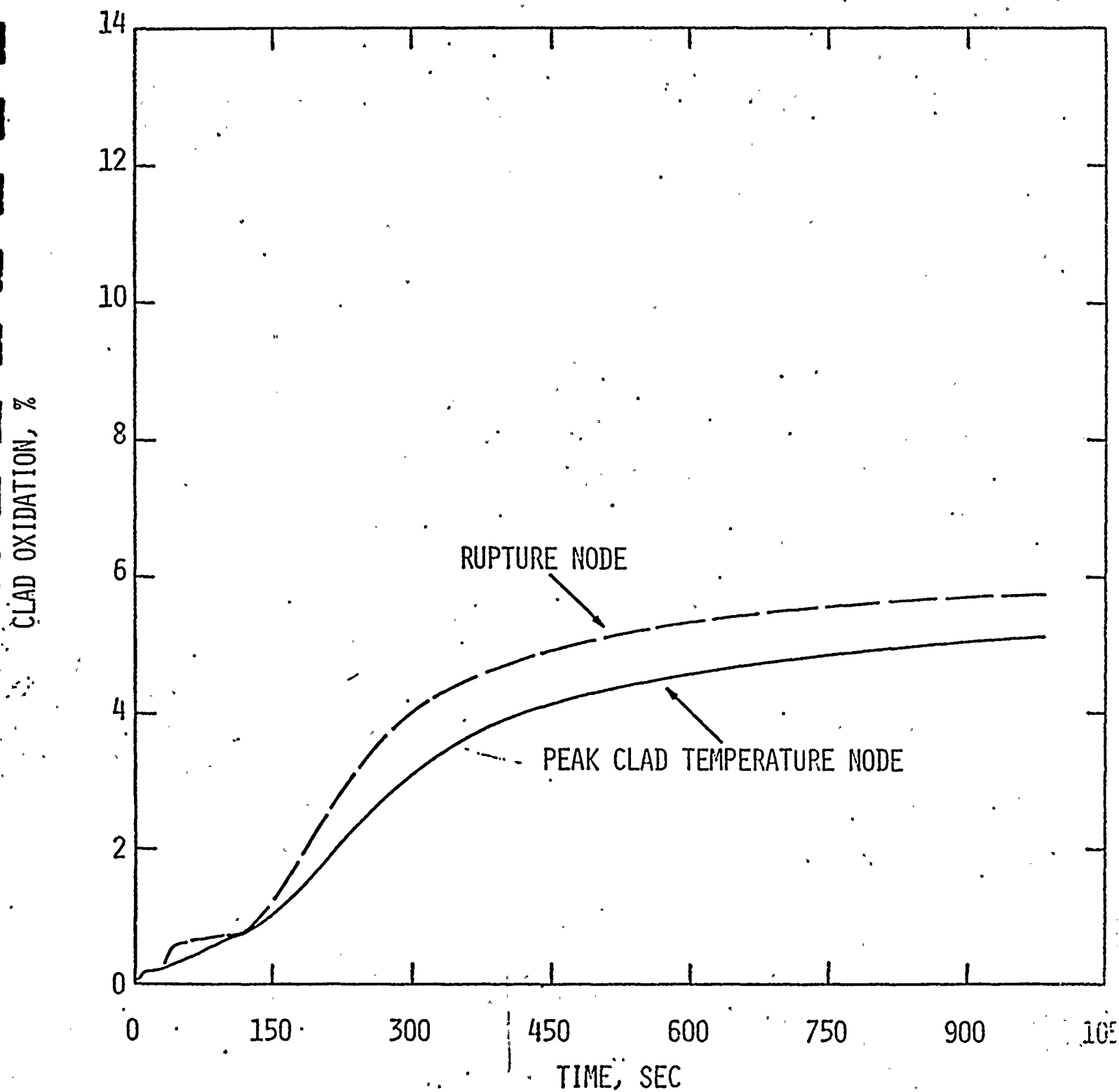


FIGURE B.4-6

REDUCED FLOW AREA IN PERIPHERAL ASSEMBLY

20% FLOW AREA REDUCTION

PEAK LOCAL CLAD OXIDATION



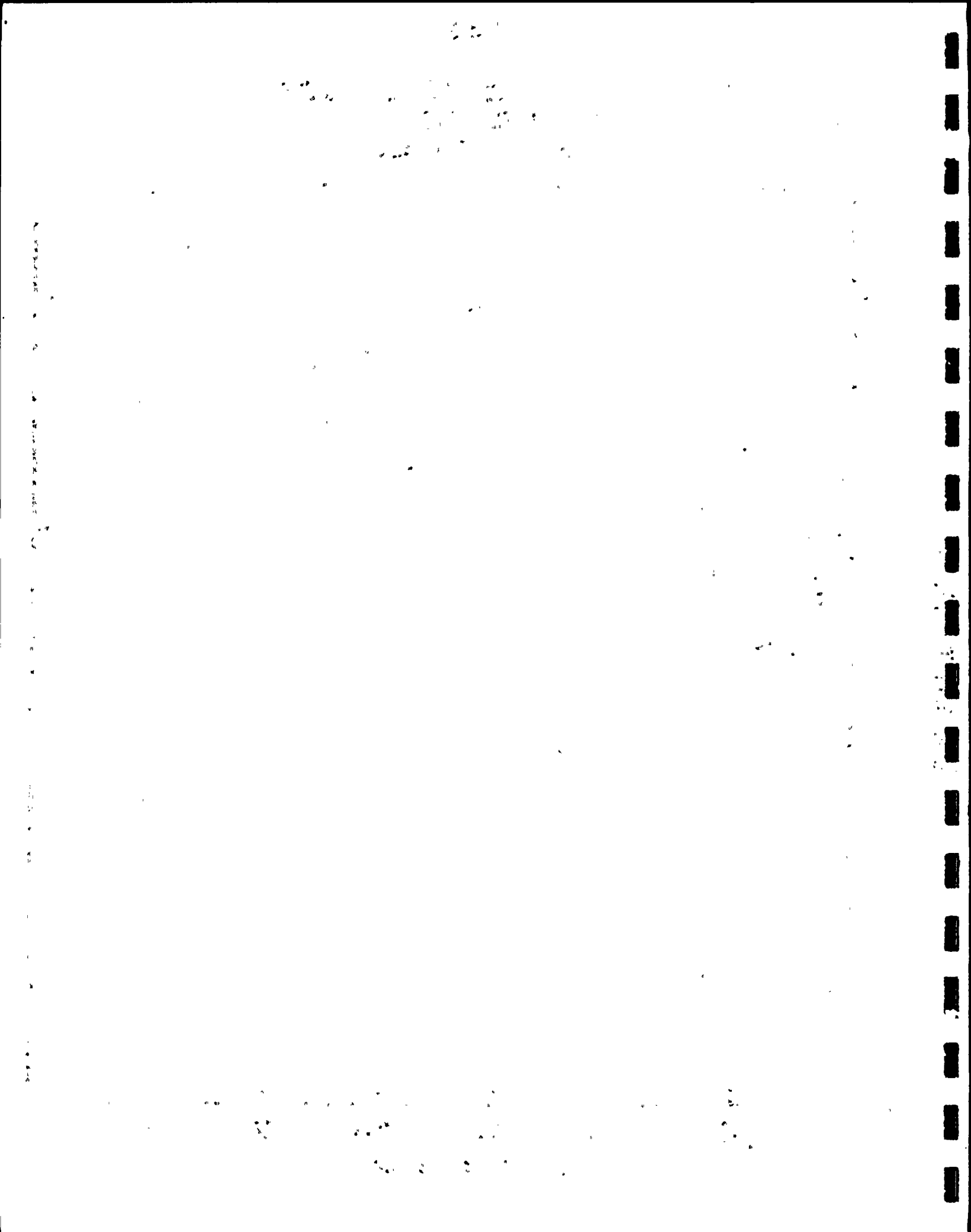
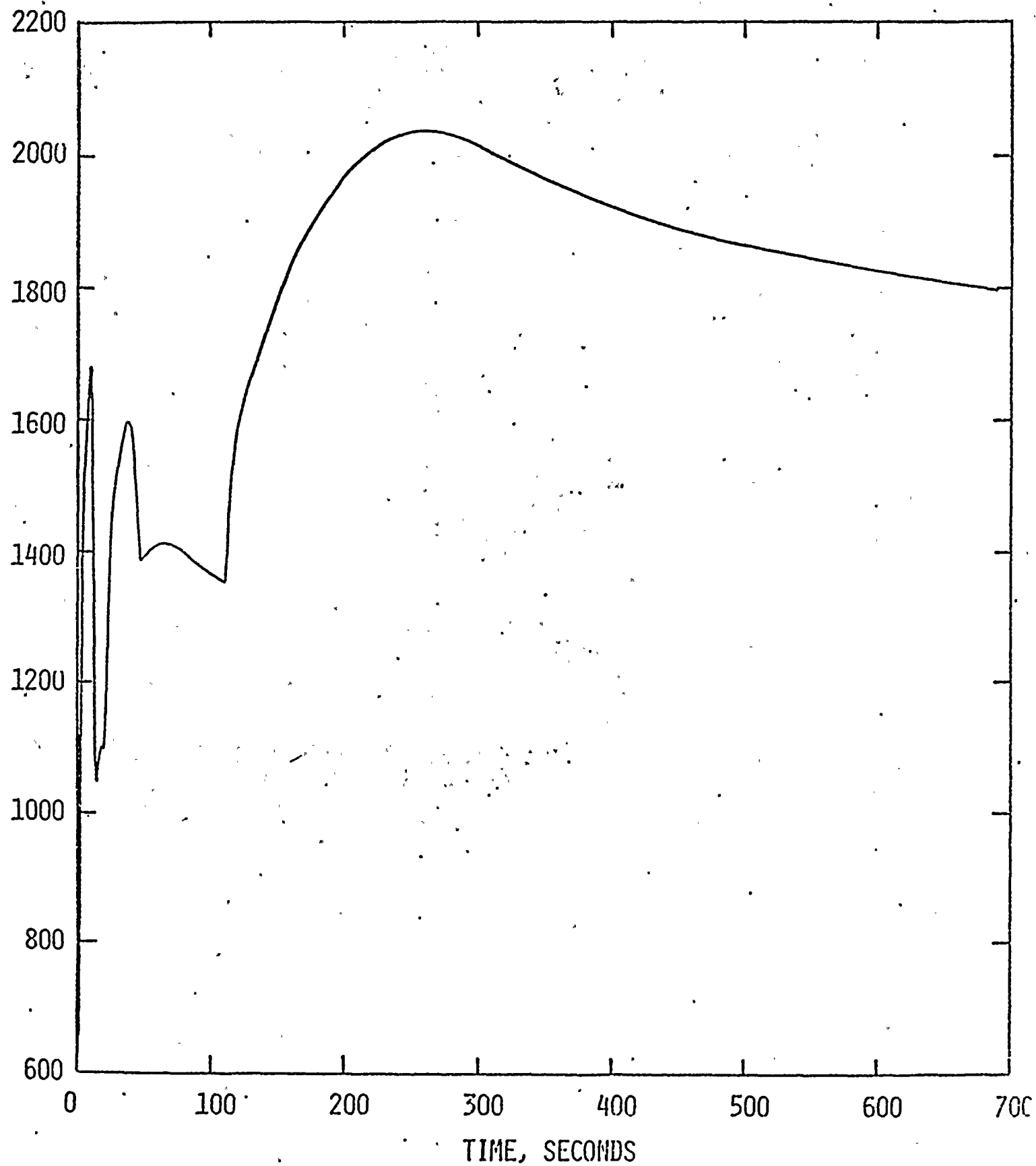


FIGURE B.4-7

REDUCED FLOW AREA IN PERIPHERAL ASSEMBLY  
35% FLOW AREA REDUCTION  
PEAK CLAD TEMPERATURE NODE



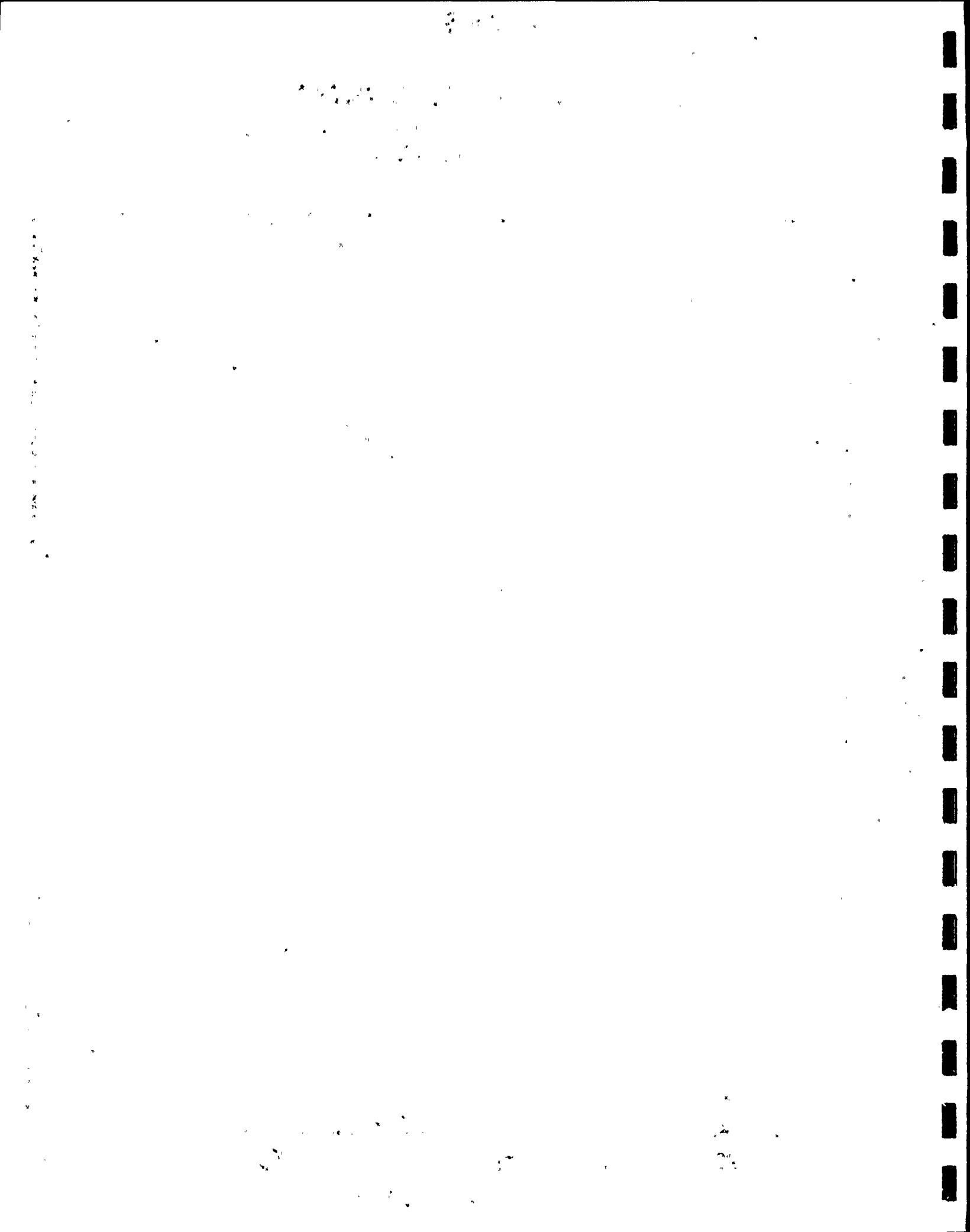




FIGURE B.4-8

REDUCED FLOW AREA IN PERIPHERAL ASSEMBLY  
35% FLOW AREA REDUCTION  
PEAK LOCAL CLAD OXIDATION NODE

