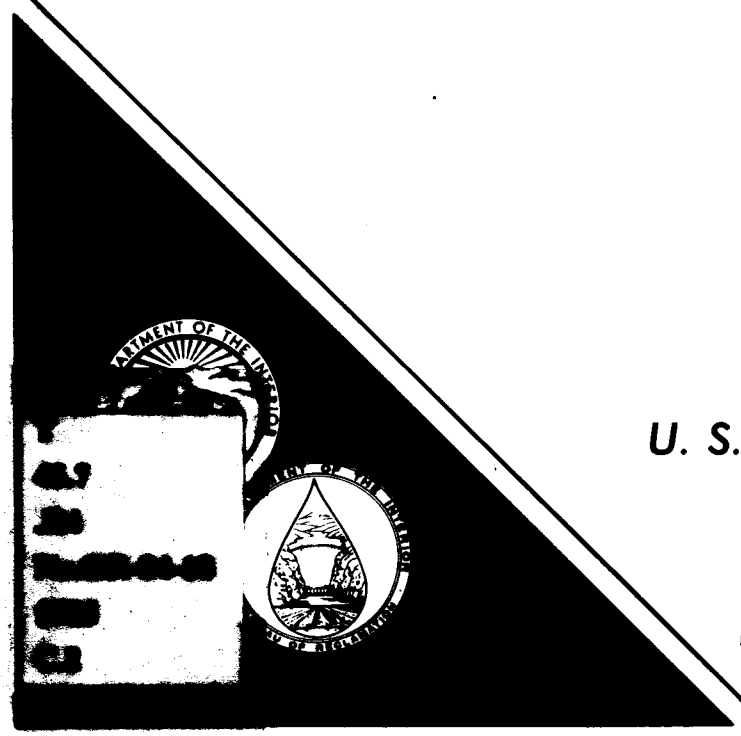
GR-84-18

# CORONA RELATED INSULATION TESTING AND EVALUATION OF PALISADES GENERATOR NO. 2

February 1985
Engineering and Research Center



U. S. Department of the Interior
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16. ABSTRACT

Palisades Unit 2 generator has a long history of slot discharge, corona activity, and ozone related problems. This report documents the history of the unit, the testing performed to evaluate the insulation system, and the recommended solutions to correct the stator winding insulation deficiencies.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS-- /rotating machines /stators /insulation /hydroelectric generators /groundwall insulation /slot discharge /partial discharge /corona

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# CORONA RELATED INSULATION TESTING AND EVALUATION OF PALISADES GENERATOR NO. 2

by

**R. C. Arbour**

Power and Instrumentation Branch
Division of Research and Laboratory Services
Engineering and Research Center

Denver, Colorado

February 1985

UNITED STATES DEPARTMENT OF THE INTERIOR ★ BUREAU OF RECLAMATION

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## TABLES



## FIGURES

# INTRODUCTION

The existing stator winding in unit 2 at Palisades Powerplant was furnished by Oerlikon-Pacific in 1970. The winding was initially installed without side filler in the slots. The unit was dismantled in 1972, the wedges removed, and side filler installed. This resulted in greatly reduced corona probe readings. The corona probe data presented in table 1 document the improvement in readings. Test 1 was performed before repairs, test 2 after installing filler, and tests 3 and 4 after rewedging.

In May 1981, high-voltage d-c ramp tests were performed on this unit. The V-I curves indicated that the grading paint was not operating effectively. The unit also had a history of excessive ozone

Table 1. — Palisades Powerplant unit 2 stator repairs corona test.

| Coil No. | Slot No. | 10-18-83 Readings* | A Phase Test No. 1 | 2 | 3 | 4 | Slot No. | 10-18-83 Readings* | B Phase Test No. 1 | 2 | 3 | 4 | Slot No. | 10-18-83 Readings* | C Phase Test No. 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | †134 | 800 | 20.0 | 15.0 | 10.5 | 12.0 | 14 | | 8.7 | 7.5 | 6.5 | 9.0 | 74 | | 56.0 | 5.5 | 5.0 | 6.0 |
| 2 | 151 | | 7.0 | 6.8 | 9.5 | 10.0 | 31 | | 15.7 | 19.8 | 12.0 | 18.0 | 91 | | 56.0 | 10.0 | 10.5 | 13.2 |
| 3 | 167 | | • 3.0 | 60.0 | 12.0 | 10.5 | † 47 | 800 | 62.0 | 9.6 | 9.6 | 12.0 | †107 | 650 | 52.0 | 10.0 | 6.8 | 7.0 |
| 4 | †183 | I | 5.4 | 20.0 | 16.5 | 13.5 | 63 | | 15.6 | 5.0 | 4.0 | 5.8 | 123 | | ‡ 96.0 | 7.7 | 6.0 | 7.0 |
| 5 | 200 | | 4.5 | 9.6 | 12.0 | 12.0 | † 80 | 850 | 8.7 | 16.5 | 9.0 | 12.0 | 140 | | 42.0 | 9.7 | 12.0 | 13.5 |
| 6 | 216 | | 4.2 | 8.8 | 9.5 | 9.0 | 96 | | 11.5 | 9.8 | 8.5 | 10.0 | †156 | 400 | 53.0 | 13.5 | 8.2 | 9.4 |
| 7 | 233 | | 6.9 | 15.6 | 12.0 | 12.3 | 113 | | 19.8 | 19.2 | 21.0 | 24.0 | 173 | | ‡ 129.0 | 10.5 | 18.0 | 18.6 |
| 8 | 249 | | 8.7 | 8.2 | 7.0 | 7.0 | 129 | | 9.6 | 7.0 | 7.2 | 8.4 | 189 | | ‡ 165.0 | 12.0 | 18.6 | 20.4 |
| 9 | 265 | | 6.9 | 4.4 | 5.4 | 5.6 | 145 | | 7.7 | 9.1 | 7.0 | 7.2 | 205 | | ‡ 285.0 | 12.0 | 27.0 | 27.0 |
| 10 | 282 | | 3.6 | 5.4 | 7.5 | 7.5 | 162 | | 8.1 | 19.5 | 9.0 | 15.0 | 222 | | ‡ 120.0 | 15.0 | 21.0 | 23.0 |
| 11 | 298 | | 5.1 | 9.0 | 18.0 | 15.0 | 178 | | 7.5 | 9.0 | 6.4 | 6.5 | 238 | | 71.0 | 15.0 | 12.0 | 11.0 |
| 12 | 314 | | 18.6 | 11.4 | 18.0 | 22.5 | 194 | | 7.2 | 8.4 | 7.6 | 8.2 | †254 | 940 | 20.0 | 22.5 | 19.5 | 18.0 |
| 13 | 331 | | 10.5 | 33.0 | 18.0 | 19.5 | 211 | | 8.4 | 10.0 | 8.0 | 8.5 | †271 | 340 | 15.0 | 25.0 | 27.0 | 25.0 |
| 14 | 347 | | 4.5 | 24.6 | 21.0 | 5.5 | 227 | | 15.5 | 13.5 | 12.0 | 10.5 | †287 | 50 | 14.0 | 15.0 | 16.5 | 18.0 |
| 15 | 3 | | 4.2 | 8.0 | 5.2 | 8.2 | 243 | | 7.8 | 12.6 | 15.0 | 14.4 | 303 | | 15.0 | 13.5 | 10.5 | 10.5 |
| 16 | 20 | | 18.3 | 7.3 | 4.2 | 5.0 | 260 | | 6.5 | 8.0 | 10.5 | 10.5 | 320 | | 44.0 | 55.0 | 10.0 | 10.5 |
| 17 | 36 | | 14.1 | 3.0 | 1.8 | 2.0 | 276 | | 8.7 | 11.4 | 18.0 | 21.0 | 336 | | 10.5 | 9.0 | 6.8 | 7.5 |
| 18 | 53 | | 13.8 | 7.0 | 4.5 | 5.2 | 293 | | 7.9 | 25.5 | 30.0 | 35.0 | 353 | | 13.0 | 10.5 | 10.5 | 12.6 |
| 19 | 69 | | 22.9 | 8.0 | 13.5 | 13.5 | 309 | | 6.0 | 11.4 | 9.0 | 10.5 | 9 | | 8.7 | 5.0 | 2.8 | 5.0 |
| 20 | 85 | | 26.7 | 6.8 | 3.0 | 3.5 | 325 | | 7.1 | 11.4 | 4.4 | 5.0 | 25 | | 4.4 | 7.2 | 2.4 | 3.6 |
| 21 | 102 | | ‡105.0 | 7.5 | 8.2 | 9.6 | 342 | | 9.6 | 17.4 | 9.0 | 9.5 | 42 | | 9.4 | 12.6 | 7.5 | 9.8 |
| 22 | 118 | | 67.0 | 5.0 | 7.5 | 8.0 | 358 | | 3.2 | 9.5 | 2.8 | 2.8 | 58 | | 15.5 | 21.3 | 16.5 | 21.0 |
| 23 | 135 | | 30.0 | 14.4 | 15.0 | 15.0 | 15 | | 6.4 | 2.3 | 2.0 | 3.0 | 75 | | 22.0 | 13.5 | 10.5 | 11.0 |
| 24 | 152 | | 68.0 | 17.4 | 7.2 | 7.0 | 32 | | 6.8 | 3.5 | 4.0 | 6.0 | 92 | | 20.6 | 6.2 | 4.1 | 4.8 |
| 25 | 168 | | 3.0 | 4.5 | 2.6 | 2.5 | 48 | | 18.0 | 3.8 | 5.0 | 6.0 | 108 | | 24.0 | 11.4 | 15.0 | 18.6 |
| 26 | 184 | | 6.9 | 8.3 | 7.5 | 5.6 | 64 | | 9.3 | 5.2 | 6.9 | 8.0 | 124 | | 34.0 | 38.0 | 50.0 | 75.0 |
| 27 | 201 | | 18.6 | 12.9 | 8.8 | 9.0 | 81 | | 5.7 | 12.9 | 9.0 | 9.2 | 141 | | 59.0 | 27.6 | 21.0 | 27.0 |
| 28 | †217 | 970 | 18.9 | 41.0 | 30.0 | 27.0 | 97 | | 6.8 | 44.0 | 18.0 | 16.5 | †157 | 500 | ‡ 91.0 | 12.0 | 10.5 | 12.0 |
| 29 | 234 | | 12.0 | 21.3 | 19.5 | 16.5 | 114 | | 15.3 | 15.0 | 8.2 | 10.0 | 174 | | ‡ 186.0 | 16.5 | 22.5 | 21.6 |
| 30 | 250 | | 7.5 | 18.0 | 10.5 | 10.5 | 130 | | 15.0 | 11.4 | 18.0 | 18.0 | 190 | | ‡1000.0 | 60.0 | 90.0 | 90.0 |
| 31 | 266 | | 11.4 | 8.1 | 8.0 | 8.0 | 146 | | 23.0 | 25.5 | 24.0 | 28.5 | 206 | | ‡ 790.0 | 65.0 | 50.0 | 52.0 |
| 32 | 283 | | 3.9 | 3.5 | 5.2 | 4.5 | †163 | I | 13.2 | 18.0 | 15.0 | 15.0 | 223 | | ‡ 210.0 | 50.0 | 28.5 | 36.0 |
| 33 | 299 | | 6.3 | 3.3 | 6.0 | 5.0 | 179 | | 8.3 | 24.0 | 15.0 | 12.6 | 239 | | ‡ 114.0 | 22.5 | 16.5 | 17.0 |
| 34 | 315 | | 13.2 | 5.8 | 8.5 | 9.6 | †195 | 35 | 5.9 | 52.0 | 24.0 | 25.5 | 255 | | 62.0 | 18.0 | 9.5 | 9.5 |
| 35 | 332 | | 22.5 | 8.6 | 6.5 | 7.0 | 212 | | 5.0 | 14.4 | 12.0 | 15.0 | 272 | | 72.0 | 50.0 | 18.0 | 18.0 |
| 36 | 348 | | 7.2 | 6.8 | 7.2 | 7.0 | 228 | | 8.2 | 37.0 | 28.5 | 35.0 | 288 | | 44.0 | 13.5 | 9.5 | 9.8 |
| 37 | 4 | | 9.9 | 5.6 | 4.0 | 5.5 | 244 | | 16.2 | 24.6 | 27.0 | 25.5 | 304 | | 15.0 | 25.0 | 32.0 | 35.0 |
| 38 | 21 | | 15.0 | 7.5 | 9.0 | 8.5 | 261 | | 18.6 | 13.5 | 13.5 | 21.0 | 321 | | 50.0 | 60.0 | 15.0 | 15.0 |
| 39 | 37 | | 19.2 | 5.4 | 12.0 | 12.0 | 277 | | 38.0 | 24.0 | 30.0 | 30.0 | 337 | | 27.5 | 19.5 | 22.5 | 27.0 |
| 40 | 54 | | 30.0 | 15.0 | 9.8 | 10.5 | 294 | | 8.5 | 7.6 | 8.0 | 8.0 | 354 | | 52.0 | 27.0 | 10.5 | 15.0 |
| 41 | 70 | | 53.0 | 6.6 | 5.0 | 4.0 | 310 | | 6.6 | 12.0 | 5.0 | 5.5 | 10 | | 12.3 | 5.4 | 3.9 | 8.2 |
| 42 | 86 | | ‡144.0 | 8.1 | 2.8 | 3.0 | 326 | | 8.4 | 10.8 | 4.3 | 4.2 | 26 | | 9.4 | 7.5 | 3.2 | 3.3 |
| 43 | 103 | | ‡228.0 | 16.8 | 8.3 | 9.0 | 343 | | 10.2 | 18.0 | 4.2 | 4.0 | 43 | | 32.0 | 16.2 | 2.7 | 3.5 |
| 44 | 119 | | ‡800.0 | 9.3 | 10.5 | 10.5 | 359 | | 32.0 | 32.0 | 21.0 | 18.0 | 59 | | 56.0 | 60.0 | 8.0 | 8.0 |
| 45 | 111 | | ‡276.0 | 31.0 | 12.0 | 13.8 | 351 | | 22.0 | 37.0 | 15.0 | 13.5 | 51 | | 27.3 | 50.0 | 7.0 | 8.2 |

Table 1. — Palisades Powerplant
unit 2 stator repair corona test — Continued

| Coil No. | Slot No. | A Phase Test No. 1 | 2 | 3 | 4 | Slot No. | 10-18-83 Readings* | B Phase Test No. 1 | 2 | 3 | 4 | Slot No. | C Phase Test No. 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 46 | 94 | ‡147.0 | 33.0 | 10.5 | 10.5 | 334 | | 12.4 | 12.6 | 7.5 | 7.0 | 34 | 20.7 | 22.2 | 2.6 | 4.2 |
| 47 | 78 | 78.0 | 10.0 | 6.5 | 8.0 | 318 | | 34.0 | 68.0 | 15.0 | 15.0 | 18 | 8.4 | 9.8 | 0.8 | 1.4 |
| 48 | 61 | 28.5 | 45.0 | 5.5 | 6.5 | 301 | | 13.8 | 22.5 | 8.0 | 7.5 | 1 | 9.3 | 2.7 | 1.5 | 4.0 |
| 49 | 45 | 19.5 | 12.0 | 7.5 | 9.0 | 285 | | 5.5 | 10.8 | 8.0 | 6.5 | 345 | 20.0 | 15.0 | 6.5 | 7.5 |
| 50 | 29 | ‡ 77.0 | 18.9 | 9.0 | 9.0 | 269 | | 8.8 | 9.3 | 12.0 | 12.0 | 329 | 24.0 | 13.5 | 7.5 | 3.5 |
| 51 | 12 | 29.8 | 6.8 | 6.0 | 5.4 | 252 | | 9.8 | 7.4 | 3.5 | 4.2 | 312 | 13.0 | 15.0 | 9.5 | 9.2 |
| 52 | 356 | 9.6 | 12.9 | 10.5 | 9.5 | 236 | | 41.0 | 60.0 | 15.0 | 15.0 | 296 | 31.0 | 50.0 | 52.0 | 55.0 |
| 53 | 340 | 19.5 | 13.2 | 12.0 | 12.0 | 220 | | 22.0 | 15.6 | 10.0 | 10.0 | 280 | 65.0 | 21.0 | 21.0 | 21.0 |
| 54 | 323 | 87.0 | 19.5 | 4.5 | 6.0 | 203 | | 8.6 | 7.9 | 4.2 | 4.2 | 263 | 73.0 | 65.0 | 2.5 | 10.0 |
| 55 | 307 | 31.0 | 6.7 | 10.5 | 9.5 | 187 | | 15.6 | 11.4 | 9.8 | 9.8 | 247 | 36.0 | 19.5 | 6.5 | 6.5 |
| 56 | 290 | 9.0 | 3.3 | 3.0 | 3.2 | 170 | | 12.0 | 6.0 | 4.2 | 5.0 | 230 | 17.4 | 10.0 | 6.2 | 7.0 |
| 57 | 292 | 5.1 | 3.0 | 3.0 | 3.0 | 172 | | 28.0 | 15.0 | 10.0 | 7.0 | 232 | 20.0 | 15.0 | 8.5 | 8.6 |
| 58 | 275 | 15.6 | 13.5 | 12.0 | 12.6 | 155 | | 15.0 | 10.0 | 9.4 | 10.5 | 215 | ‡ 95.0 | 19.5 | 12.6 | 15.0 |
| 59 | 259 | 60.0 | 18.0 | 8.1 | 7.2 | †139 | 810 | 58.0 | 25.5 | 15.0 | 12.6 | 199 | ‡920.0 | 50.0 | 82.0 | 85.0 |
| 60 | 242 | 30.0 | 19.8 | 8.0 | 7.0 | 122 | | 70.0 | 21.9 | 9.0 | 10.5 | 182 | ‡128.0 | 8.5 | 11.4 | 12.0 |
| 61 | 226 | 32.0 | 12.6 | 16.5 | 18.0 | 106 | | 25.0 | 8.8 | 8.5 | 9.0 | 166 | ‡ 68.0 | 7.5 | 10.0 | 10.5 |
| 62 | 210 | 28.0 | 10.0 | 8.5 | 7.5 | 90 | | 9.2 | 9.8 | 6.0 | 6.0 | 150 | 46.0 | 10.5 | 9.5 | 11.5 |
| 63 | 193 | 5.1 | 12.0 | 9.0 | 8.6 | 73 | | 8.4 | 5.1 | 5.0 | 4.5 | 133 | ‡ 63.0 | 9.4 | 9.5 | 10.5 |
| 64 | 177 | 15.6 | 6.6 | 6.0 | 5.5 | 57 | | 7.8 | 2.2 | 1.5 | 2.2 | 117 | 31.0 | 8.8 | 9.0 | 12.6 |
| 65 | 161 | 7.0 | 8.0 | 2.8 | 3.1 | 41 | | 6.6 | 3.2 | 3.5 | 5.0 | 101 | 11.6 | 5.6 | 6.2 | 9.0 |
| 66 | 144 | 22.0 | 5.8 | 4.0 | 4.6 | 24 | | 8.0 | 7.5 | 4.6 | 6.6 | 84 | 54.0 | 4.0 | 5.0 | 5.8 |
| 67 | 128 | ‡ 44.0 | 5.8 | 5.5 | 5.4 | 8 | | 4.1 | 2.2 | 1.5 | 2.2 | 68 | 8.1 | 10.0 | 9.8 | 10.5 |
| 68 | 112 | ‡261.0 | 16.5 | 4.5 | 4.6 | 352 | | 8.8 | 4.4 | 3.5 | 3.8 | 52 | 15.6 | 14.4 | 1.6 | 2.2 |
| 69 | 95 | ‡ 66.0 | 5.4 | 3.0 | 3.0 | 335 | | 6.1 | 9.5 | 3.8 | 3.5 | 35 | 6.9 | 14.1 | 1.8 | 2.8 |
| 70 | 79 | 58.0 | 6.3 | 2.5 | 2.6 | 319 | | 7.7 | 24.6 | 15.0 | 6.0 | 19 | 9.5 | 6.0 | 0.6 | 1.6 |
| 71 | 62 | 12.3 | 14.7 | 3.8 | 4.2 | 302 | | 4.2 | 14.4 | 13.5 | 12.6 | 2 | 10.2 | 4.4 | 3.5 | 5.5 |
| 72 | 46 | 9.6 | 8,5 | 2.0 | 1.6 | †286 | 900 | 6.2 | 9.6 | 12.0 | 12.0 | 346 | 10.5 | 8.5 | 7.8 | 9.2 |
| 73 | 30 | 26.0 | 6.0 | 4.0 | 4.6 | 270 | | 11.4 | 9.4 | 9.0 | 10.0 | 330 | 7.2 | 18.0 | 7.0 | 7.8 |
| 74 | 13 | 15.3 | 4.0 | 2.5 | 2.8 | 253 | | 10.2 | 7.6 | 15.0 | 9.5 | 313 | 17.0 | 9.5 | 9.5 | 9.2 |
| 75 | 357 | 8.4 | 2.4 | 2.8 | 3.0 | 237 | | 15.0 | 16.5 | 18.0 | 21.0 | 297 | 16.0 | 21.0 | 21.0 | 21.0 |
| 76 | 341 | 12.3 | 5.0 | 4.8 | 5.0 | 221 | | 11.5 | 10.0 | 10.5 | 12.0 | 281 | 45.0 | 16.5 | 12.0 | 12.0 |
| 77 | 324 | 29.1 | 8.5 | 9.0 | 12.0 | 204 | | 6.3 | 5.3 | 5.5 | 5.0 | 264 | 25.0 | 15.0 | 3.0 | 10.0 |
| 78 | 308 | 13.0 | 3.3 | 5.5 | 6.5 | 188 | | 21.0 | 13.2 | 9.0 | 9.5 | 248 | 28.0 | 15.0 | 5.7 | 5.4 |
| 79 | 291 | 6.9 | 3.3 | 5.0 | 5.6 | 171 | | 6.2 | 9.1 | 5.5 | 5.0 | 231 | 9.5 | 8.5 | 12.0 | 14.5 |
| 80 | 274 | 3.6 | 4.4 | 4.4 | 4.5 | 154 | | 6.4 | 8.5 | 8.5 | 7.0 | 214 | ‡ 86.0 | 12.0 | 12.0 | 12.6 |
| 81 | 258 | 17.7 | 4.9 | 4.2 | 4.0 | 138 | | 15.0 | 10.0 | 8.6 | 8.0 | 198 | ‡168.0 | 13.5 | 30.0 | 30.0 |
| 82 | 241 | 6.6 | 8.0 | 6.2 | 6.4 | 121 | | 14.8 | 6.8 | 5.2 | 5.5 | 181 | ‡114.0 | 6.5 | 12.0 | 12.0 |
| 83 | 225 | 11.4 | 9.5 | 9.5 | 7.8 | 105 | | 6.3 | 9.0 | 9.5 | 10.5 | 165 | 28.0 | 10.5 | 7.8 | 8.0 |
| 84 | 209 | 4.5 | 6.4 | 10.0 | 9.0 | 89 | | 6.7 | 6.4 | 7.5 | 9.0 | 149 | 27.5 | 6.5 | 5.4 | 7.0 |
| 85 | 192 | 9.9 | 5.5 | 4.5 | 4.0 | 72 | | 5.1 | 2.9 | 3.3 | 2.4 | 132 | 19.5 | 9.5 | 6.0 | 8.4 |
| 86 | 176 | 5.4 | 10.5 | 9.5 | 8.8 | 56 | | 34.0 | 6.9 | 6.4 | 8.8 | 116 | 51.0 | 6.1 | 5.4 | 7.0 |
| 87 | 160 | 8.0 | 8.6 | 7.5 | 6.6 | 40 | | 13.5 | 11.4 | 9.0 | 10.5 | 100 | 18.6 | 7.5 | 9.0 | 10.5 |
| 88 | 143 | 6.0 | 4.0 | 2.1 | 2.4 | 23 | | 4.0 | 1.7 | 1.6 | 4.2 | 83 | 11.4 | 1.8 | 1.3 | 2.0 |
| 89 | 127 | ‡ 70.0 | 5.0 | 3.5 | 4.0 | 7 | | 5.1 | 1.9 | 0.8 | 1.2 | 67 | 9.2 | 5.0 | 3.5 | 4.6 |
| 90 | 110 | ‡165.0 | 5.3 | 3.1 | 3.5 | 350 | | 6.5 | 9.8 | 3.0 | 2.6 | 50 | 9.8 | 18.0 | 3.8 | 5.0 |
| | Avg. | 42.3 | 11.2 | 8.0 | 7.95 | | | 13.6 | 14.1 | 10.0 | 10.6 | | 75.7 | 15.9 | 13.4 | 15.0 |

Key Code for Table 1

Test No. 1 – 11/08/72: Energized at 4 kV with one phase hot, two phases floating; Test made after rotor removed.

Test No. 2 – 2/20/73-2/23/73: Energized at 4 kV with one phase hot, two phases floating; Test made after side filler installed.

Test No. 3 – 3/26/73: Energized at 4 kv with one phase hot, two phases floating; Test made after wedging.

Test No. 4 – 3/27/73: Energized at 4 kV with one phase hot, two phases grounded.

I – Inconsistent
* – Corona probe readings on 10-18-83.
† – Slots with high readings on 10-18-83.
‡ – Slots with readings above 50 on 11-8-72.

production. The levels of ozone concentration were high enough to cause corrosion of the heat exchanger cooling coils. A visual examination of the stator winding revealed evidence of thermal and/or corona related damage at the junction point of the conductive slot paint and the semiconductive grading paint.

In an attempt to reduce the ozone concentration and prevent burning damage at the junction point of the two paints, it was recommended that grading paint repairs be made as soon as an outage could be scheduled.

Grading paint repairs were attempted in June 1983. The ozone concentration measurements obtained after the repairs indicated that the ozone generation process was unaffected by the repair. As a direct result of this, a sample of the paint was sent to the E&R Center laboratory for testing. Test results indicated that the paint furnished by the manufacturer did not have the electrical properties of either conductive or grading point, thus reducing the repair efforts to an exercise in futility.

## TESTING AND EVALUATION

Scheduled turbine inspection of the unit in the fall of 1983 required complete disassembly of the rotating parts. This was an opportune time to perform blackout and corona probe tests on the stator winding. A blackout test consists of energizing the stator of the unit at operating voltage and visually inspecting for corona in the darkened core.

The blackout test was performed on October 18, 1983. Approximately 15 coils were found to be emitting high-energy discharges from the surface of the coil groundwall insulation to the groundplane of the stator core. On many coils, corona could be observed at the junction of the conductive paint and the semiconductive grading point. This was an example of inadequate grading paint resistivity and/or inadequate thermal characteristics. Corona was also observed where the edges of the coils intersected the surge rings. Corona probe tests conducted on October 19, 1983, confirmed that the electrical discharges in the 15 or so problem slots were very large in amplitude.

Discharges of this type and amplitude can cause erosion of the groundwall insulation system and lead to failure in a very short period of time. Table 2 is a listing of the slots exhibiting visual discharges and the associated corona probe readings.

The corona probe readings displayed in table 1 were obtained in 1972 using the original corona probe meter designed and built at Grand Coulee. The circuitry in this meter utilized transistor

Table 2. – Palisades Powerplant corona probe readings on 10-18-83

| Slot No. | Phase and Position in String* | Corona Probe Readings | | |
|---|---|---|---|---|
| | | PEAK | AVERAGE | ENVELOPE |
| 47 | B-3 | 800 | 600 | 0 |
| 80 | B-5 | 850 | 640 | 0 |
| 107 | C-3 | 650 | 500 | 20 |
| 134 | A-1 | 800 | 650 | 4 |
| 139 | B-59 | 810 | 700 | 5 |
| 156 | C-6 | 400 | 300 | 15 |
| 157 | C-28 | 500 | 400 | 18 |
| 163 | B-32 | Inconsistent | (comes and | goes) |
| 183 | A-4 | Inconsistent | (comes and | goes) |
| 195 | B-34 | 35 | 20 | 5 |
| 217 | A-28 | 970 | 850 | 20 |
| 254 | C-12 | 940 | 820 | 0 |
| 271 | C-13 | 340 | 300 | 5 |
| 286 | B-72 | 900 | 650 | 5 |
| 287 | C-14 | 50 | 30 | 0 |

*Position in string
1 – Line end
90 – Neutral end

technology. The readings in table 2 were obtained using a new corona probe meter designed and built at the E&R Center. The new meter utilizes state-of-the-art integrated circuit technology. For comparison purposes, measurements in the "PEAK" reading mode on the new meter corresponds and are equivalent to measurements obtained with the Grand Coulee meter. The "AVERAGE" function on the new meter produces an indication of how many large pulses are occurring each cycle by means of an averaging circuit. The "ENVELOPE" function of the meter measures the envelope of the energy bursts that occur at a repetition rate of 120 Hz. It has been found that this type of signal is related to some degree to the smaller discharges that are usually associated with corona.

The slots listed in table 2 were marked during the blackout tests as having visible discharges. All of the slots listed in table 2 had considerably higher corona probe readings than in 1972-1973.

The inconsistent readings in slots 163 and 183 indicate the existence of intermittent discharges. This phenomena has been encountered on other units.

Based on past experience, a corona probe peak reading above 150 is indicative of a discharge intensity level that may be damaging to the groundwall insulation system.

The new corona probe meter also has output terminals that can be monitored with an oscilloscope for observing the actual wave shape and amplitude of the signals detected by the probe. Figure 1 shows a series of wave shapes observed on the oscilloscope monitor along with the associated slot number and meter readings in the left-hand margin.

A visual examination of the unit revealed numerous low-intensity girth burns at the junction of the conductive paint and the semiconductive grading paint. Burned areas were also found in the rubber covering on the surge rings where the edges of the coils intersect the surge ring.

## RECOMMENDED METHOD OF REPAIR

Reduction of the high-energy discharges in the slots is of primary concern. To accomplish this reduction, electrical contact between the outer surface of the coil and the groundplane of the stator must be reestablished. To reestablish this contact, the wedges must be removed and the existing side filler should be replaced with conductive-type side filler. If the existing side filler cannot be removed without damaging the surface of the coil, conductive RTV (room temperature vulcanizing silicone rubber) or conductive paint should be injected in an attempt to reestablish contact between the surface of the coil and the groundplane of the stator core.

The corona at the junction of the conductive and semiconductive grading paint is due to high electrical and/or thermal gradients resulting from abnormally high grading paint resistance and/or inadequate thermal characteristics. The corona itself is not cause for alarm, except that it produces ozone and can eventually lead to girth burns and will result in the loss of contact between the two paints. This condition may or may not be detrimental to the groundwall insulation system. To repair this area, contact must be reestablished from the stator iron groundplane to the coil with conductive paint. New grading paint can then be applied and must overlap the conductive paint to provide a discharge path to ground. The reestablishment of the groundplane with conductive paint is necessary due to the existence of a nonconductive protecting paint that is normally applied over the grading and conductive paints.

If contact to the groundplane cannot be maintained with conductive paint, then a bead of conductive RTV should be laid at the junction of the coil side and the stator core in an attempt to reestablish groundplane contact.

The glow-type corona at the intersection of the coils and the surge rings is generating ozone which in turn is decomposing the rubber on the surface of the surge ring. Repair of this area could possibly be accomplished by injecting nonconducting RTV between the edge of the coils and the surge ring rubber coating. This repair should be tested and the potential of the repair method evaluated with another blackout test. If the repair method works, then all of the surge ring-coil boundaries can be treated.

It should be noted that the Palisades experience will have a major impact in establishing standard practices for repairing many of the Bureau generators with similar problems.

In the case of unit 2 at Palisades Powerplant, the Project has already opted to install active charcoal filtration systems on the generators. This is a highly effective way to remove the ozone and the problems caused by the ozone, as has been proved by the success at Morrow Point Powerplant. However, this method treats the symptom and not the cause.

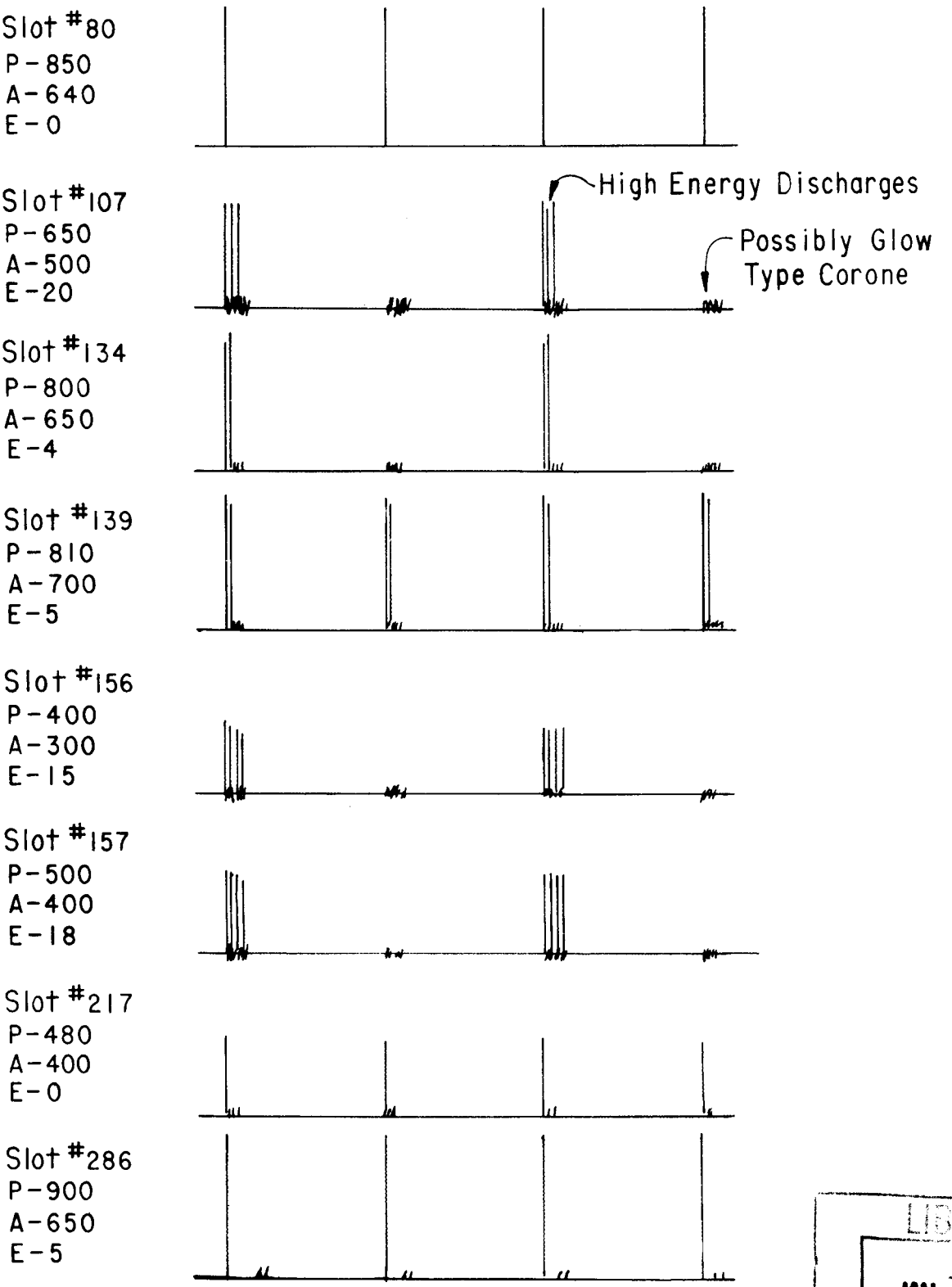


Figure 1. – Oscilloscope waveshapes, Palisades Powerplant corona test, 10-18-83.





GPO 846-029

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