November 25, 1992

MEMORANDUM FOR: Ashok Thadani, Director
Division of Systems Safety and Analysis

FROM: Conrad McCracken, Chief
Plant Systems Branch
Division of Systems Safety and Analysis

SUBJECT: SUMMARY OF NOVEMBER 23, 1992, MEETING BETWEEN NRC STAFF, SANDIA NATIONAL LABORATORIES, AND THE OKONITE COMPANY

The NRC staff met with representatives of the Okonite Company and Sandia National Laboratories on November 23, 1992, to discuss the Sandia test results and Okonite's response to the test failures. NUMARC was also represented at the meeting. Enclosure 1 is a list of the attendees. A copy of the test plan and results presented by Sandia is given in Enclosure 2. Okonite supplied a list of customers (Enclosure 3) which indicates that their product is used in approximately 55 plants.

Sandia described the test program and the failures of the Okonite cables with bonded hypalon jackets. Okonite verified that they have not performed qualification tests of the cable with a bonded jacket, as used by Sandia. They agreed that the hypalon jacket ages more quickly than EPR insulation. Okonite has test data that show no chemical interaction exists between hypalon and EPR. However, the Sandia results indicate a mechanical failure of the insulation resulting from the embrittlement of the hypalon. Okonite stated that Sandia had applied a full accident radiation dose before any thermal aging, which in their opinion was extremely severe, and also that Sandia overaged the cable during thermal aging.

Original signed by

Conrad E. McCracken, Chief
Plant Systems Branch
Division of Systems Safety and Analysis

Enclosures:
As stated

DISTRIBUTION w/enclosures:
Central File
NRC PDR

w/o enclosures:

| | | |
|---|---|---|
| SPLB R/F | MVagins, RES | PShemanski |
| GHolahan | RTripathi | JLasky, Okonite |
| CMcCracken | HGarg | JCancelosi, Okonite |
| GHubbard | EMarinos | SCarfagno, Consultant |
| JTatum | SNewberry | MJacobus, Sandia |
| ADummer | BRogers | |

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| | | | | |
|---|---|---|---|---|
| SPLB:DSSA | SPLB:DSSA | SPLB:DSSA | DD:DSSA | D:DSSA |
| ADummer | GHubbard | CMcCracken | GHolahan | AThadani |
| 11/24/92 | 11/24/92 | 11/24/92 | 11/25/92 | 11/ /92 |

[G:\okosumry.amd]

RETURN TO REGULATORY CENTRAL FILES

Okonite Meeting 11/23/92

List of Attendees

| NAME | Company | Title |
|---|---|---|
| James Tatum | USNRC | Sr. Reactor Engineer |
| JACK S. LASKY | THE OKONITE CO | V.P. RESEARCH |
| JOHN R CANCELOSI | THE OKONITE CO | MAN. - Application Engineering |
| SAL P. CARFAGNO | Consultant | Consultant |
| Ann Dummer | NRC | Reactor Engineer |
| CURTIS MCCRACKEN | NRC | CHIEF, SPLB |
| Gary M Holahan | NRC/NRR/DSSA | Dep. Director DSSA |
| Milton Vagins | NRC/RES/DE/EMEB | Chief, EMEB |
| Alex Marion | NUMARC | Manager |
| MORRIS SCHREIM | NUMARC | SR. PROJECT MANAGER |
| Rajiv Tripathi | NRC/ OECD | Regional Coord (detailee |
| Hukam Garg | NRC/DRHC/S | Sr. Electrical Engineer |
| ANGELO MARINOS | " | Section Chief |
| Scott Newberry | NRC/DRCH | Chief HICB |
| Bill Rogers | NRC | Reactor Engineer |
| Paul Shemanski | NRC | Sr. Elec. Engr |
| Mark J. Jacobus | Sandia | SMTS |

# Acceptable Hi-Pot Test Voltages to Assess Cable Integrity

By

Ray A. Vigil
Sandia National Laboratories
Albuquerque, New Mexico

Presented to

Annual USNRC/French CEA
Cooperative Research
Program Meeting
Albuquerque, New Mexico
October 26-27, 1992

Sandia National Laboratories

# Objectives

- Determine if high potential testing (240 Vdc/mil) causes damage to selected cables.
- Determine the minimum insulation thickness to establish a nominal qualified life of 40/60 years.
- Ascertain the voltage level necessary to detect damage beyond the minimum qualified thickness.
- Assess whether the new voltage levels cause damage to selected cables.
- Examine the effect of cable length on dc breakdown voltage.

# Test Specimens

- Okonite Okolon single conductor cable with a FR-EPDM insulation and a bonded CSPE (Hypalon) jacket.

- Rockbestos SR single conductor cable insulated with silicone rubber and jacketed with fiberglass braid.

- Brand Rex stranded single conductor with 30 mils of XLPE insulation.

# Test Phases

- **Phase 1: Assess Damage Induced by 240 Vdc/mil Testing.**
- **Phase 2: Determine Minimum Thickness for 40/60 year Nominal Qualified Life and the Corresponding Detection Voltages.**
- **Phase 3: Determine Damaging Effects of New Detection Voltages.**

# Phase 2

**Determination of minimum insulation thickness necessary to establish a nominal qualified life of 40/60 years.**

General Information

- **Ten samples of each of the 3 types of cables were tested.**
- **Samples were milled to varying amounts of remaining insulation thickness.**
- **Cables were wrapped on a mandrel inside a test chamber for aging and accident simulation.**
- **Desired conditions were simulated using sequential exposures to radiation followed by thermal aging.**

# Phase 2 (cont'd)

Radiation Exposure

- Accident radiation exposure was included with aging radiation exposure.
- The nominal plant radiation condition simulated was 20 Mrads total aging dose.
- The accident radiation exposure consisted of 110 Mrads at a rate of 300 kRads/hr for 433 hours.

# Phase 2 (cont'd)

Thermal Aging

- Aging time was 336 hours at 158 °C.

- Plant ambient temperatures simulated depend on cable type as follows:

| Cable Type | Activation Energy | 40 YR Ambient Temp (°C) | 60 YR Ambient Temp (°C) |
|---|---|---|---|
| Okonite Hypalon | 1.00 | 69 | 65 |
| Okonite EPR | 1.10 | 76 | 72 |
| Brand Rex | 1.37 | 89 | 86 |
| Rockbestos SiR | 2.55 | 118 | 116 |

# Phase 2 (cont'd)

LOCA Exposure

- After completion of the aging exposures, the samples were exposed to a LOCA simulation.

- The LOCA exposure followed the IEEE 323-1974 temperature and pressure profiles for the first four days. Six additional days at constant temperature and pressure were used to accelerate the post-accident conditions.

- Results of LOCA test will indicate the thickness of insulation needed for accident functionality ("critical" thickness).

# Phase 2 (cont'd)

Post-Accident Assessment

- Following the accident test, surviving cables will be subjected to dielectric tests as follows:

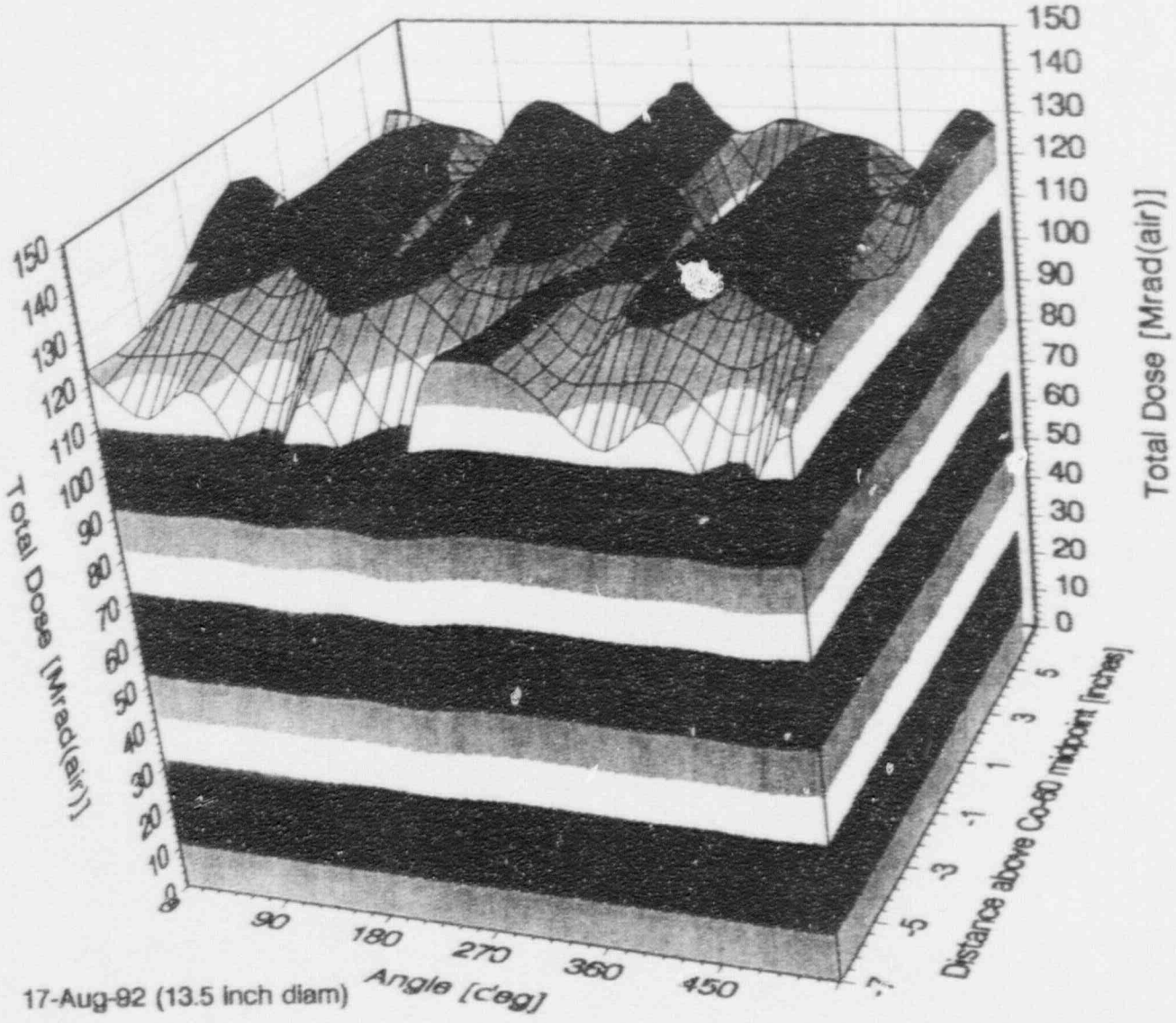
  a) 240 Vdc/mil for 5 minutes based on lowest remaining amount of insulation.

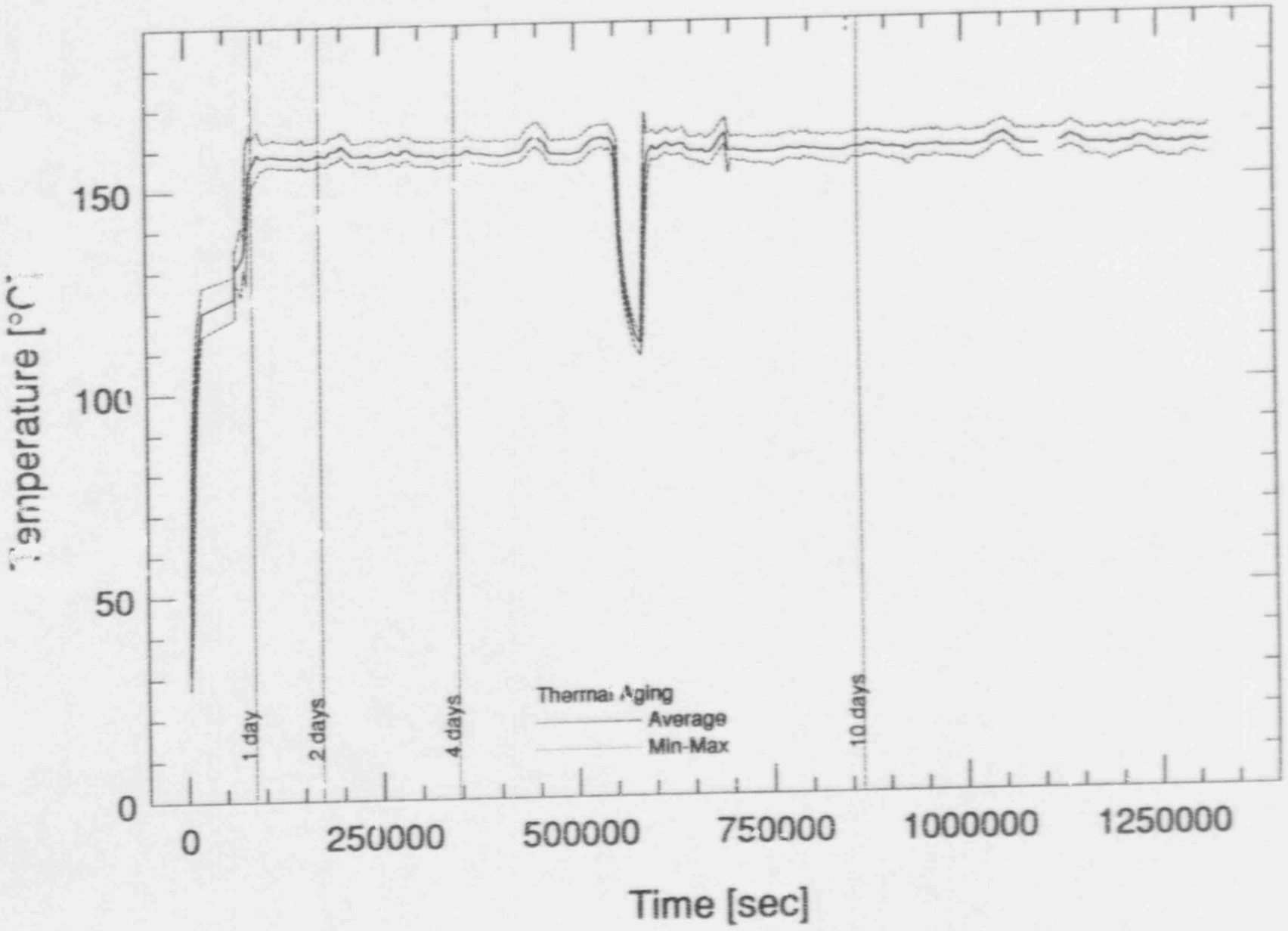
  b) 240 Vdc/mil for 5 minutes based on the nominal cable insulation thickness.

  c) ultimate breakdown strength.

- New samples will be artificially damaged and tested to determine the voltage levels needed to detect when the thickness of insulation is less than or equal to the "critical" thickness.

# Raw Dosimetry Data

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100
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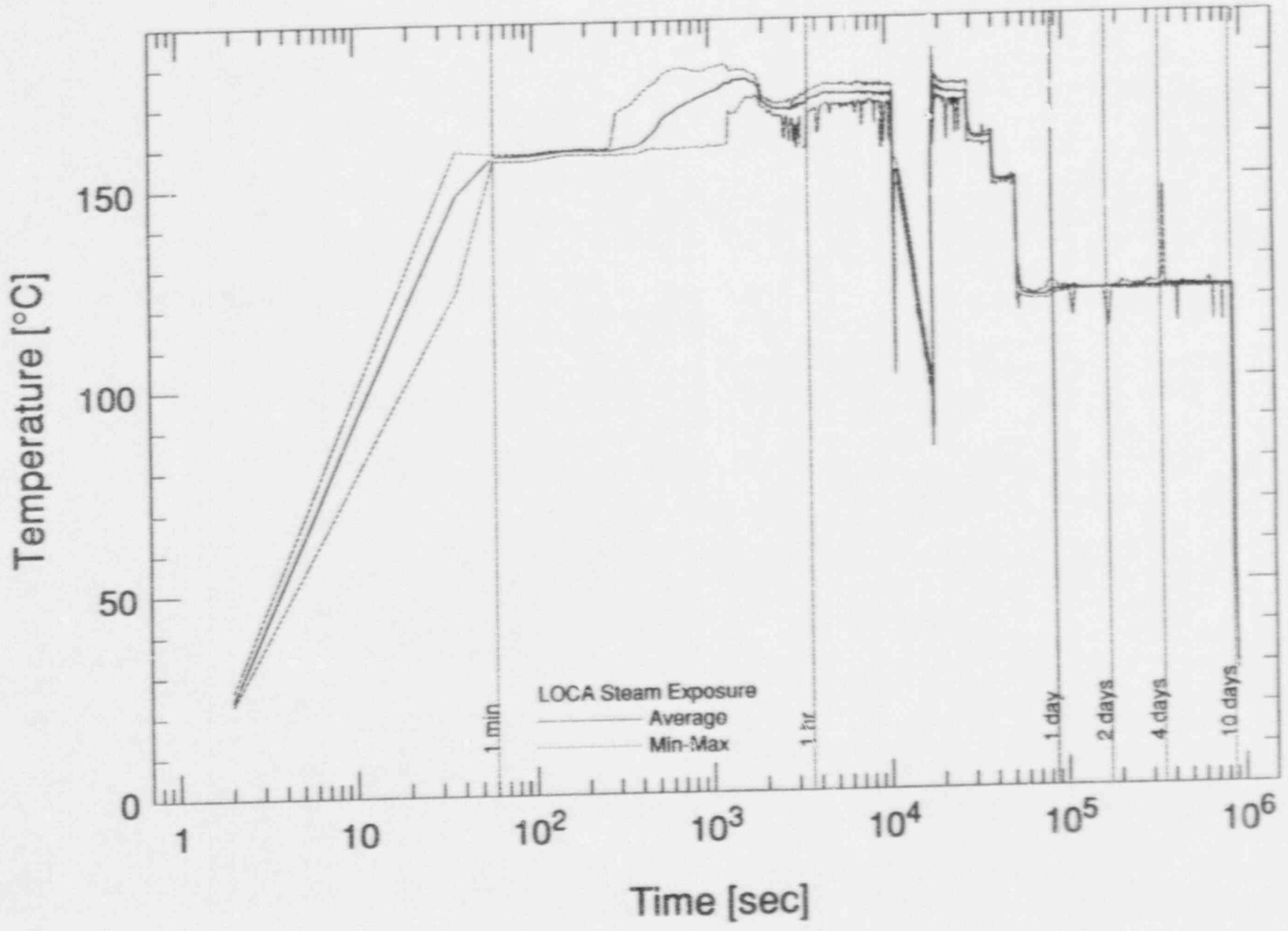
Time [sec]
1 day
2 days
4 days
10 days
Thermal Aging
Average
Min-Max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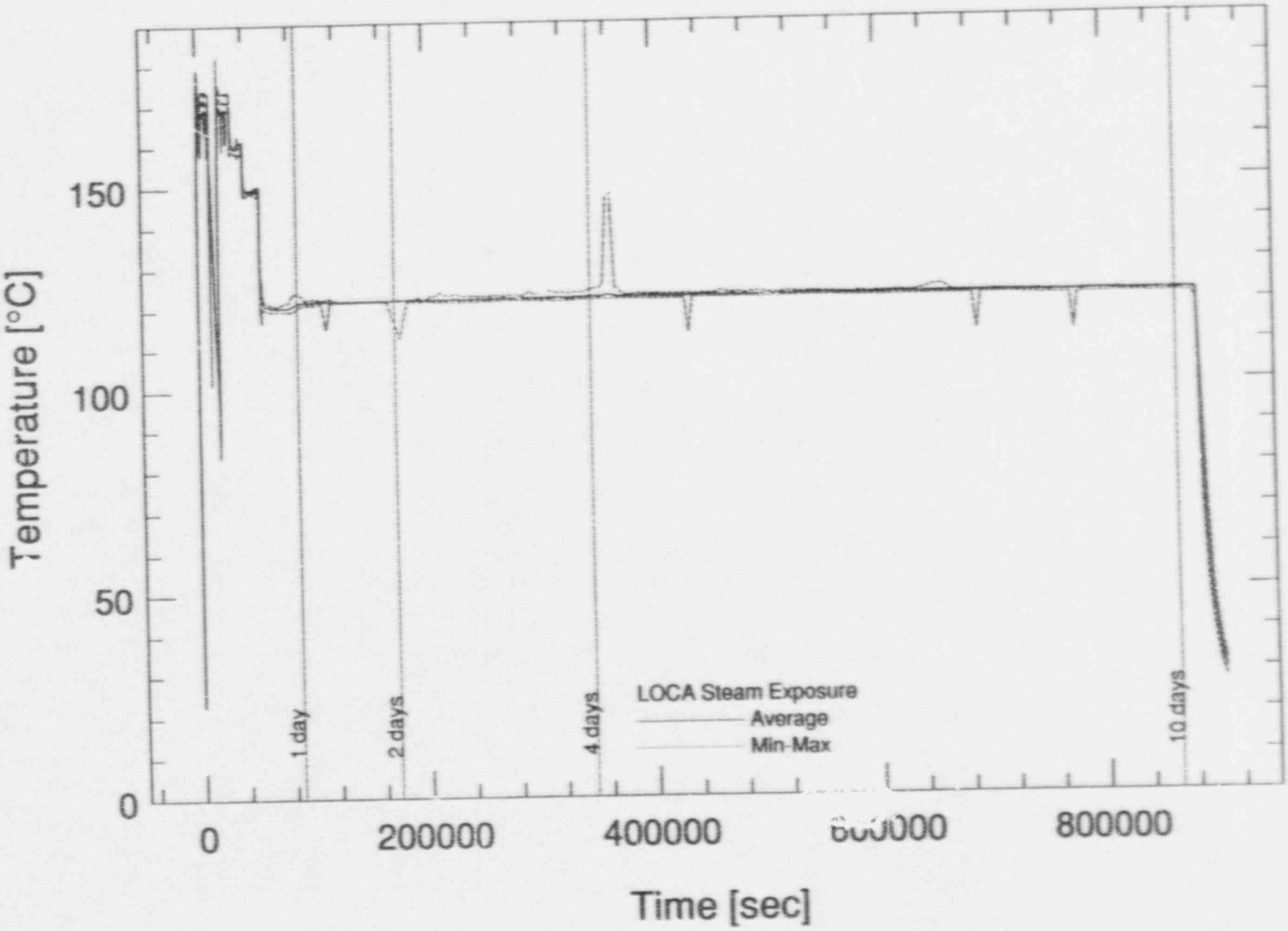
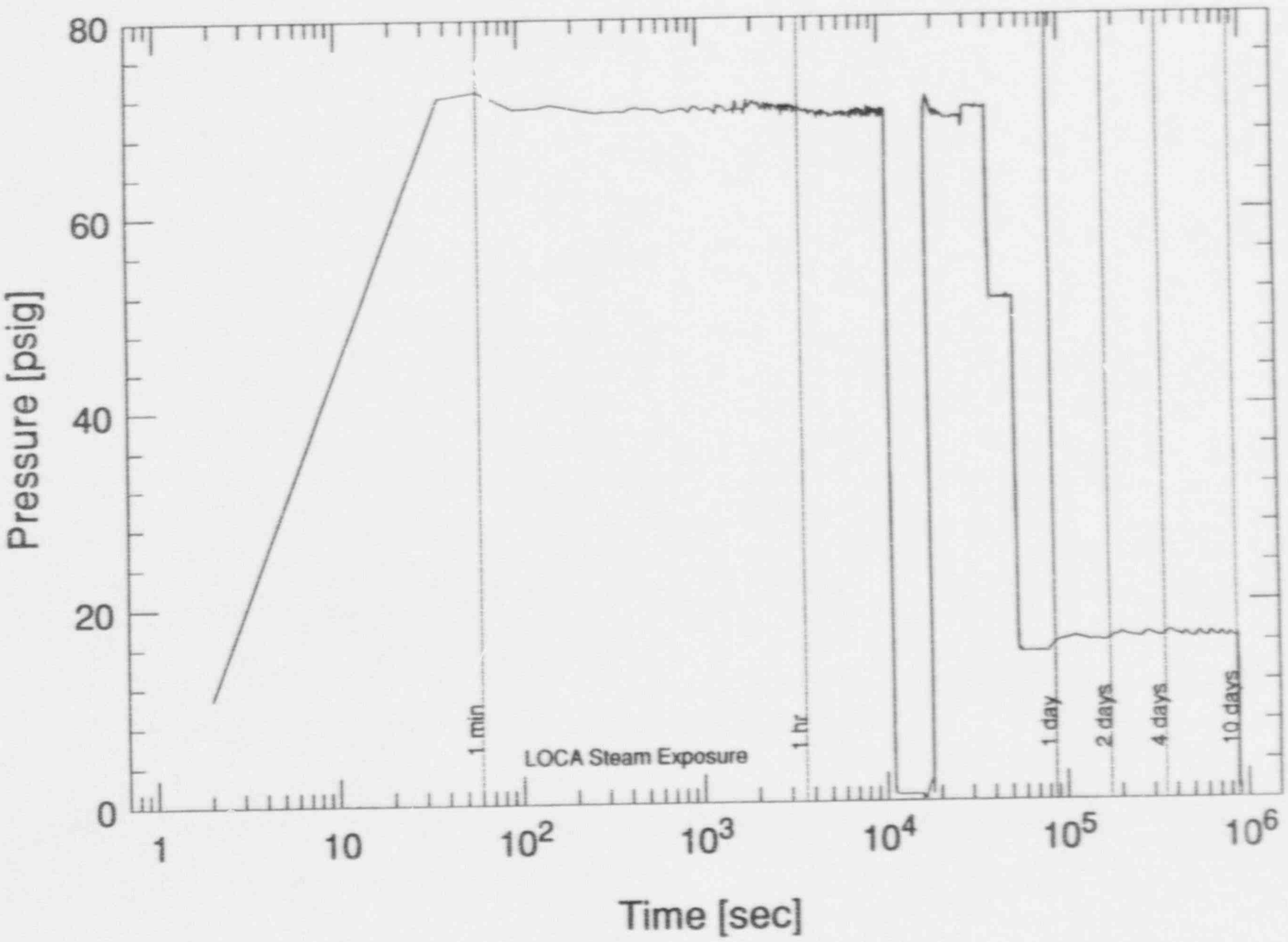
100
50
0
1
10
$10^2$
$10^3$
$10^4$
$10^5$
$10^6$
Time [sec]
LOCA Steam Exposure
Average
Min-Max
1 min
1 hr
1 day
2 days
4 days
10 days


Temperature [°C]
150
100
50
0
0
200000
400000
800000
Time [sec]
1 day
2 days
4 days
10 days
LOCA Steam Exposure
Average
Min-Max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60
40
20
0
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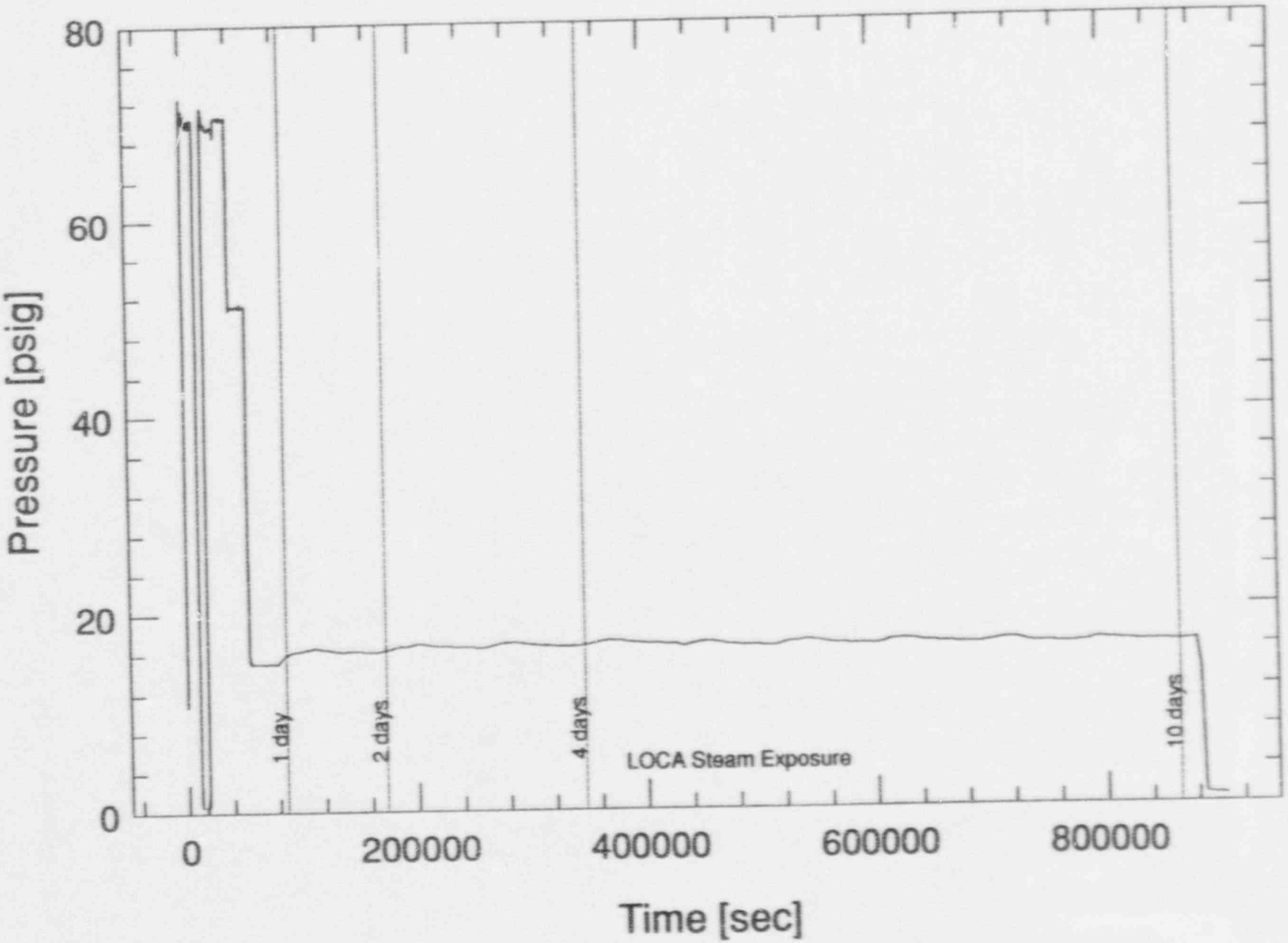
1
10
$10^2$
$10^3$
$10^4$
$10^5$
$10^6$
Time [sec]
1 min
1 hr
1 day
2 days
4 days
10 days
LOCA Steam Exposure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40
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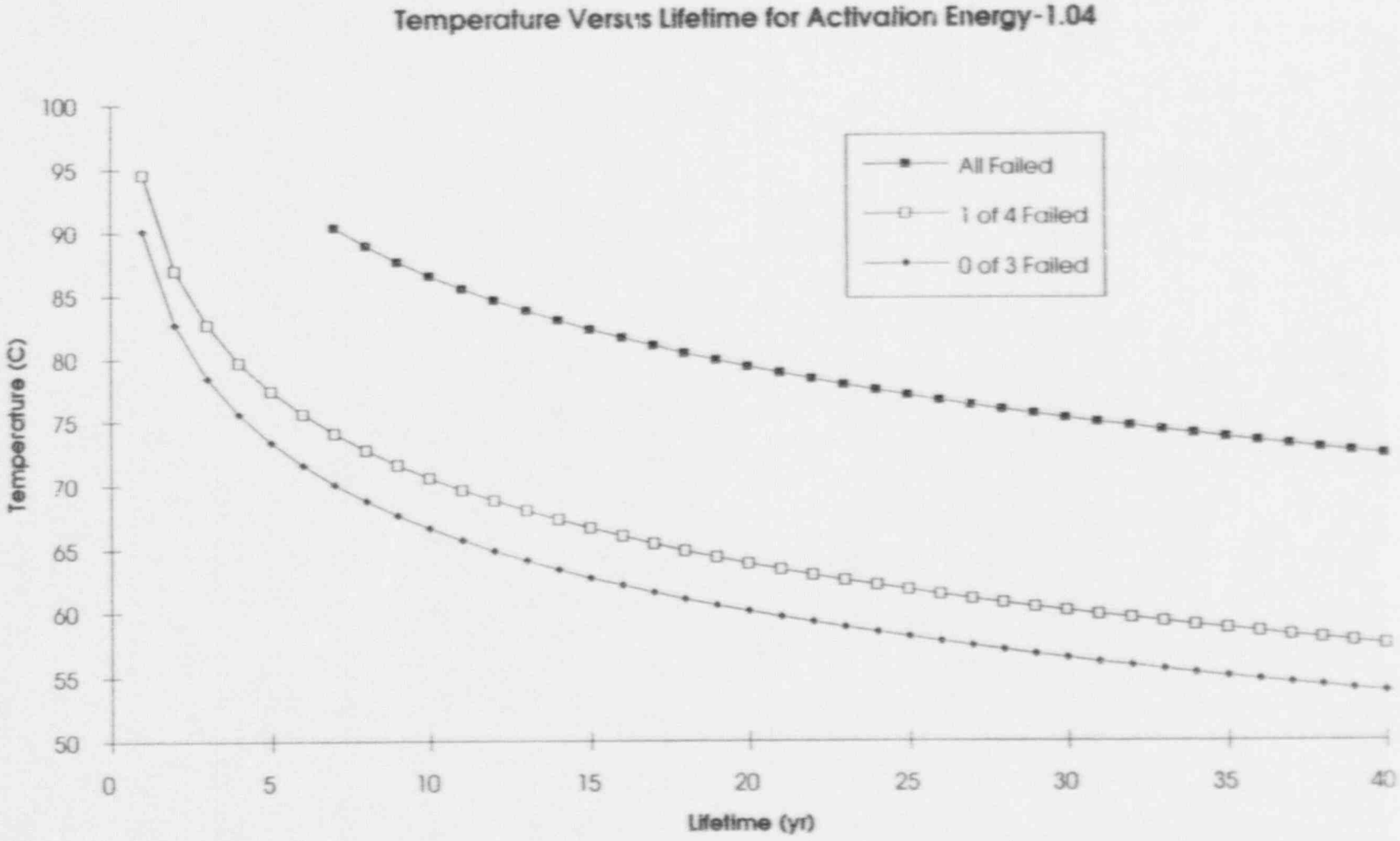
Time [sec]
1 day
2 days
4 days
10 days
LOCA Steam Exposure


Temperature Versus Lifetime for Activation Energy-1.04
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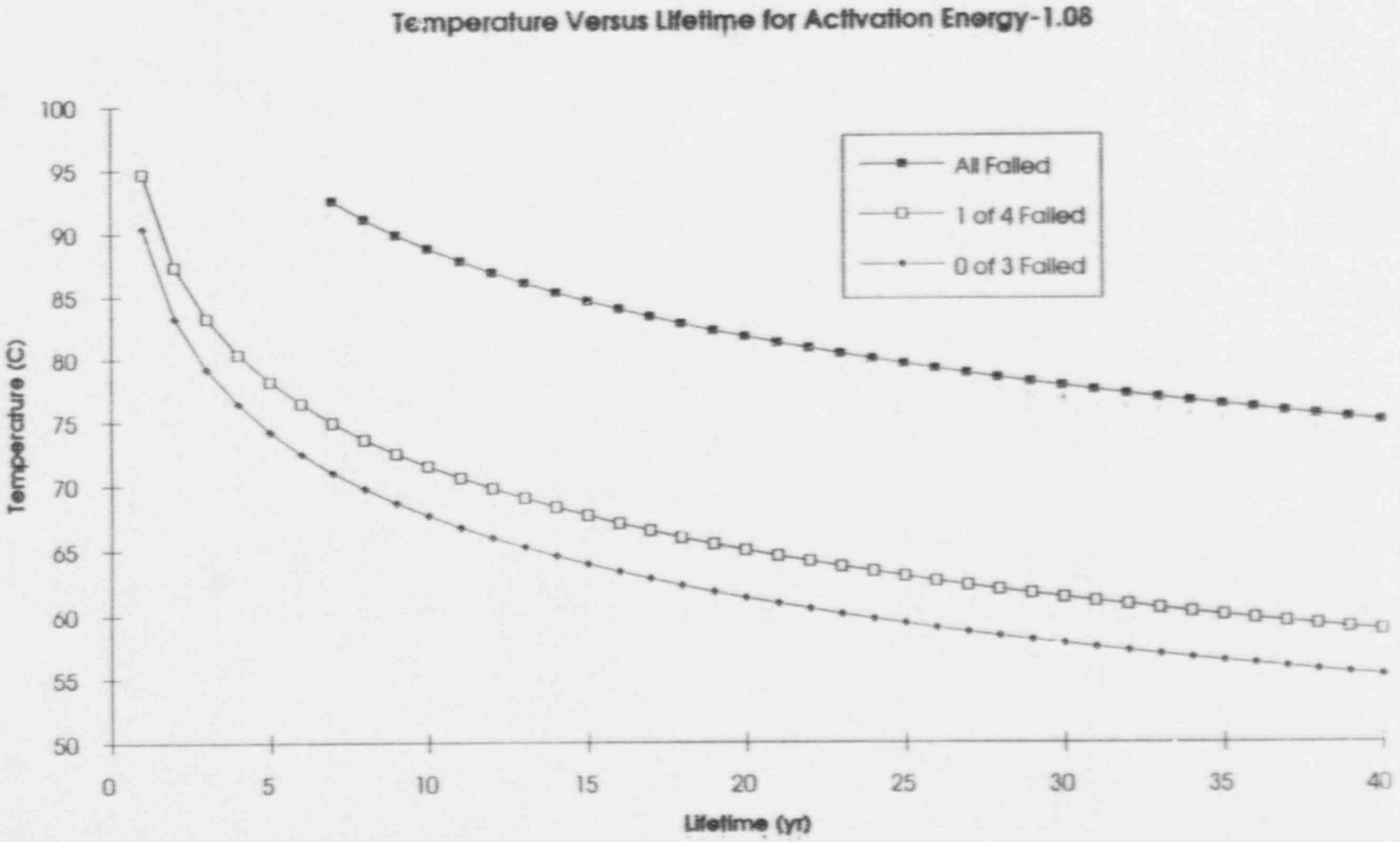
1 of 4 Failed
0 of 3 Failed
Temperature (C)
100
95
90
85
80
75
70
65
60
55
50
0
5
10
15
20
25
30
35
40
Lifetime (yr)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1 of 4 Failed
0 of 3 Failed
Temperature (C)
100
95
90
85
80
75
70
65
60
55
50
0
5
10
15
20
25
30
35
40
Lifetime (yr)

# Marketing Notes

Section 14:005 Date July 25, 1984

Subject Central Station Participation List

Attached is the Central Station Participation List which shows the electric generating stations who have used a substantial amount of Okonite Power & Control Cable.

TYPE OF CABLE - Legend

H - High Voltage Cable (Okoguard)

L - Low Voltage Cable (Okonite, Okonite-FMR or X-Olene FMR)

C - Control Cable (Okonite, Okonite-FMR or X-Olene FMR)

I - Instrumentation (Okonite, Okonite-FMR, X-Olene FMR or Okozel)

S - Special

R. A. Guba

RAG/rtp

attachment

THE OKONITE COMPANY

Post Office Box 340
Ramsey, New Jersey 07446
201-825-0300/Cable Okonite

## CENTRAL STATION PARTICIPATION LIST

Each electric generating station listed respresents the use of a a substantial amount of OKONITE Power & Control Cable.

## TYPE OF CABLE - Legend

H - High Voltage Cable (Okoguard)
L - Low Voltage Cable (Okonite, Okonite-FMR or X-Olene FMR)
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I - Instrumentation (Okonite, Okonite-FMR, XOOlene FMR or Okozel)
S - Special

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CENTRAL STATIONS - Fossil-Fueled and Hydro (1970-1984)

| UTILITY | STATION & UNIT | TYPE OF CABLE |
|---|---|---|
| Alabama Power Company | Gaston 5 | H L C |
| | Gorgas 10 | H L C I |
| | J. Miller 1 & 2 | H L S |
| Allegheny Power Company | Harrison 1, 2, 3 | C |
| | Hatfield 3 | H L C |
| Baltimore Gas & Electric Company | Brandon Shores 1, 2 | L |
| Buckeye Rural Elec. Co-op, Inc. | Cardinal 3 | L |
| Canal Electric Company | Canal 2 | H L |
| Central Illinois Light Company | Duck Creek 1 | H L C |
| Central Illinois Public Service Co. | Newton 1 | H C |
| Central South West | Oklaunion | L |
| Cincinnati Gas & Electric Company | Miami Fort 8 | L C |
| | East Bend 2 | H |
| City Utilities Co. | South West Power | H C |
| Colorado UTE | Yampa 1, 2 | H L C |
| Commonwealth Edison Company | Collins 1, 2 3 | H L |
| | State Line | L |
| Consolidated Edison Co. of NY, Inc. | Astoria 6 | H L |
| Consumers Power Company | Ludington (Hydro) | H |
| | Karn 3, 4 | L |
| Dallas Power & Light Company | Monticello 1, 2 | H |
| Dayton Power & Light Company | Stuart 1, 2, 3, 4 | H |
| Delmarva Power & Light Company | Edgemoor 5 | L |
| | Indian River 4 | H L |
| Detroit Edison Company | Monroe 1, 2, 3, 4 | H L C I |
| | Greenwood 1 | L C |
| Duke Power Company | Belews Creek 1, 2 | L C |
| | Cliffside 5 | H L C I |
| | Jocassee 1, 2, 3, 4 (Hydro) | H L C I |
| | Riverbend | C |

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CENTRAL STATIONS - Fossil-Fueled and Hydro (1970-1984) Continued...Page #3

| UTILITY | STATION & UNIT | CABLE TYPE |
|---|---|---|
| Nevada Power Corporation | MOAPA Station | L C |
| Northern States Power Company | Blue Lake | C |
| | French Island | L C |
| | Inver Hills | L C |
| Omaha Public Power District | North Omaha | H L C |
| | Nebraska City Station | H L I |
| Otter Tail Power Company | Bigstone 1 | L C |
| Pacific Power & Light Company | Jim Bridger | C |
| | Wyodak | H L |
| | Centralia 2 | H |
| Pennsylvania Power Company | Bruce Mansfield | H L C |
| Pennsylvania Power & Light Co. | Martins Creek 3 | L C |
| Power Authority State of New York | Astoria | H L |
| Potomac Electric Power Company | Benning 1, 6 | H L C |
| | Dickerson 4, 5 | L |
| Public Service of Colorado | Comanche 2 | C |
| Public Service of New Hampshire | Newington | H L |
| | Seabrook | H |
| Public Service of New Mexico | San Juan 1, 2, 3, 4 | H L |
| | Scrubber 1, 2 | L C I |
| Salt River Project | Navajo 1, 2, 3 | H L |
| San Antonio Public Service | Sommers 2 | C I |
| | Calaveras | H L C I |
| San Diego Gas & Electric Company | Encina 4, 5 | H L |
| Savannah Electric & Power Company | Effingham | H |
| Seminole Electric Co-op | Units 1 & 2 | L C |
| South Carolina Electric & Gas Co. | Williams | H L C I |
| | Fairfield 1 through 8 | H L C |
| Santee-Cooper | Cross Generating Sta. 2 | H L C |
| Southern Indiana Gas & Electric | Culley | C |
| Southwest Electric Power Company | Welch | H L I |
| | Lee 5 | H |

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## CENTRAL STATIONS - Nuclear-Fueled (1970-1984)

| UTILITY | STATION & UNIT | CABLE TYPE |
|---|---|---|
| Alabama Power Company | Farley 1, 2 | H L C |
| Arkansas Power & Light Company | Russellville | L C |
| Baltimore Gas & Electric | Calvert Cliffs | L |
| Boston Edison Company | Pilgrim 1 | L C |
| Carolina Power & Light Company | Brunswick 1, 2 | H L |
| | Robinson | L |
| Central Maine Power | Maine Yankee | H L |
| Cincinnati Gas & Electric Company | Zimmer 1 | L C |
| Cleveland Electric Illuminating Co. | Perry 1, 2 | C |
| Commonwealth Edison Company | La Salle 1, 2 | L C |
| | Byron 1, 2 | H L C |
| | Braidwood 1, 2 | H L C |
| | Dresdan 1, 2, 3 | H L C |
| | Zion | L C |
| | Quad Cities | I |
| Detroit Edison Company | Fermi 2 | L C |
| Duke Power Company | Oconee 1, 2, 3 | H L C I |
| | McGuire 1, 2 | H L C I |
| | Catawba 1, 2 | H L C I |
| | Cherokee 1 | |
| Duquesne Lighting Company | Beaver Valley 1 | L C |
| | Beaver Valley 2 | L C I |
| Florida Power & Light Company | Turkey Point 3, 4 | H L C I |
| | St. Luci 2 | H |
| | Manatee 1, 2 | H L C |
| Georgia Power Company | Hatch 1, 2 | H L C |
| | Vogtle 1, 2 | H L C |
| Gulf State Utilities Company | River Bend 1, 2 | L C |
| Houston Lighting & Power Company | South Texas Project | H L C |
| Illinois Power Company | Clinton 1, 2 | H L C I |
| Indiana & Michigan | Cook 1, 2 | H L |
| Iowa Electric Light & Power Co. | Arnold | L C |
| Korea Electric Company | Korea Nuclear Units 5, 6, 7, 8 | H L C I |

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CENTRAL STATIONS - Nuclear-Fueled (1970-1984)

| UTILITY | STATION & UNIT | CABLE TYPE |
|---|---|---|
| Texas Utilities Generating Company | Comanche Peak 1, 2 | H L |
| Toledo Edison Company | Davis Besse 1 | H L |
| Virginia Electric & Power Company | North Anna 1, 2, 3, 4<br>Surry 1, 2 | H L<br>C |
| Washington Public Power Supply System | Nuclear Project 1, 2, 3 | H |
| Wisconsin Michigan Power | Point Beach | H L |
| Wisconsin Public Service | Kewaunee 1 | L |
| Westinghous Electric Corporation | Krsko Nuclear (Yugoslavia) | H L C |

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