CONNECTICUT YANKEE ATOMIC POWER COMPANY

BERLIN, CONNECTICUT
P. O. BOX 270 HARTFORD, CONNECTICUT 06101

TELEPHONE
203-666-6911

March 29, 1978

Docket No. 50-213

Director of Nuclear Reactor Regulation
Attn: Mr. D. L. Ziemann, Chief
Operating Reactors Branch #2
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

References: (1) D. C. Switzer letters to B. H. Grier (NRC - I&E Region I), dated December 8, 1977 and January 13, 1978.
(2) W. T. Russell (NRC) Summary of Meeting Held on January 29, 1978, dated January 30, 1978.
(3) R. H. Graves (CYAPCO) letter to B. Grier dated March 23, 1978.

Gentlemen:

Haddam Neck Plant
Environmental Qualification of Terminal Blocks/Boxes

In Reference (1), Connecticut Yankee Atomic Power Company (CYAPCO) described its actions with respect to the replacement of four electrical connectors inside containment of the Haddam Neck Plant with terminal blocks mounted inside junction boxes ("terminal block/box combination"). This replacement was deemed prudent by CYAPCO solely in light of the fact that the original electrical connectors at the Haddam Neck Plant did not have specific documentation available regarding environmental qualifications. As described in Reference (1), the terminal block/box combination was judged to be environmentally qualified by material analyses; CYAPCO also stated therein that testing would be initiated to document the environmental qualification.

In response to that commitment, the following information is hereby provided.

Environmental qualification testing of the terminal block/box combination in use at the Haddam Neck Plant was initiated prior to January 30, 1978 with the successful completion of Phase I (screening) tests, performed under pressure, temperature, and humidity conditions which conservatively represented the postulated post-accident environment inside containment. The results of these tests were discussed in detail with the NRC Staff, as documented in Reference (2).

The Phase I tests were followed by Phase II tests during which two terminal block/box combinations* were subjected to temperature and radiation environ-

*General Electric (GE) terminal block inside a steel junction box and a GE terminal block inside an aluminum junction box prototypes.

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ments simulating normal operation, prior to being subjected to the postulated post-accident environment. After exposure to the normal operating environment and shortly after the commencement of the postulated post-accident environment sequence, electrical degradation at one point on one of the terminal blocks being tested was observed; this observation was made on the General Electric terminal block Model EB-25 inside the aluminum box. Upon completion of the test sequence on March 22, 1978, the test vessel was opened and that terminal point was determined to have failed. It should be noted that the latter stages of the Phase II testing program were witnessed by a member of the NRC Staff. This terminal point failure was reported to the NRC Staff in Reference (3).

A description of the Phase II environmental qualification test program and pertinent preliminary test results, based on the report of a Northeast Utilities Service Company (NUSCO) representative, is provided in the Attachment.

Although CYAPCO and the NUSCO technical staff believe that the terminal block would have performed its intended function since the other terminal points on the block were operable throughout the duration of the test, it was nevertheless deemed prudent to replace the two aluminum boxes having one-inch vent holes housing the General Electric terminal blocks with steel boxes with 1/4-inch vent holes. This action was based upon test results which verified the fact that the same model General Electric terminal block enclosed in a similarly configured steel box performed acceptably during the same Phase II environmental qualification test program. These tests and their results, provided positive indications that the failure of the single terminal point on the GE block was due to the interface with the aluminum box. Further, the tests indicated that this situation was completely avoided using a steel box with improved block mounting and a 1/4-inch vent hole. This action and other pertinent considerations were discussed in detail with members of the NRC Staff at a meeting on March 23, 1978.

Review of this design change was performed, in accordance with Northeast Utilities Quality Assurance Procedures, by the Plant Operating Review Committee (PORC) and the NUSCO technical staff. Based on these reviews, the design of the block/steel box combination was determined to be technically acceptable in terms of performing its intended function in the core deluge valve circuits in the postulated post-accident environment. This determination was based, in part, on the results of the Phase II qualification tests, which were performed under temperature, pressure, radiation, humidity, and chemical conditions which conservatively simulated the post-accident containment environment at the Haddam Neck Plant; in addition, another evaluation concluded that the performance of the connections of the block box combination under seismic conditions would be acceptable. The pertinent environmental qualification data for the General Electric terminal block/steel box combination is summarized in the Attachment.

The Connecticut Yankee Nuclear Review Board (NRB) was also requested to review this design change. As a result of their review, the NRB concurred in the conclusions of the technical review discussed above and in the determination that the design of the block/box combination and the replacement and retest procedures did not constitute an unreviewed safety question within the context of 10CFR 50.59; thus, the replacement was initiated on March 23, 1978 and completed on March 23, 1978.

Very truly yours,

CONNECTICUT YANKEE ATOMIC POWER COMPANY

D. C. Switzer
President

Attachment

DOCKET NO. 50-213

ATTACHMENT

HADDAM NECK PLANT

SUMMARY OF ENVIRONMENTAL QUALIFICATION TEST PROGRAM

TERMINAL BLOCK/BOX COMBINATIONS

MARCH, 1978

INTRODUCTION

In accordance with commitments made in a January 13, 1978 letter and at a meeting on January 29, 1978, CYAPCO engaged the Franklin Institute to perform full series environmental qualification testing of a General Electric terminal block type EB-25 enclosed in two different types of junction boxes (aluminum and steel) representative of those utilized in the core deluge valve motor operator circuits inside containment at the Haddam Neck Plant. Two block/aluminum box combinations are located in the reactor vessel head region while two block/steel box combinations are located on the charging floor inside containment. As discussed at the January 29, 1978 meeting, a block/box combination had already successfully undergone screening tests (Phase I tests), under pressure, temperature, and humidity conditions which conservatively simulated the post-accident environment inside containment.

The following information summarizes the full series test program (Phase II tests), including the test setup, procedures, and pertinent preliminary test results related to qualification of the block/box combinations.

DESCRIPTION OF TESTED COMPONENTS

As noted on the attached figure, for the purposes of simulating the installed equipment at the Haddam Neck Plant, one General Electric type EB-25, eight-point terminal block was mounted vertically in an aluminum junction box, and a second EB-25, eight-point terminal block was mounted horizontally in a steel junction box. In addition, a number of other terminal blocks were installed in these two junction boxes and a third junction box for the purpose of gaining additional test data; in one of these combinations, a GE terminal block was mounted vertically in a steel box.

The GE terminal block tested was made of a wood flour-filled phenolic material and its marking strips were removed prior to testing, as installed at the Haddam Neck Plant.

The steel box measured 12 x 10 x 4 inches (height, width, and depth) and was 1/16 of an inch in thickness. The aluminum box measured 12 x 12 x 6 inches and was 1/8 of an inch in thickness. Both boxes were somewhat larger than those originally installed in the core deluge circuits. The steel box utilized a terminal block mounting panel on standoffs from the back of its enclosure.

One of the two steel boxes, and the aluminum box, were mounted vertically in the autoclave. The terminal blocks within these enclosures were also vertically oriented. The second steel box was mounted horizontally, with the cover up, in the autoclave. The vertically oriented steel box had a 1/4-inch vent/drain hole in the center of the bottom of the box. The vertically oriented aluminum box had a 1/4 inch drain hole in the bottom of the box and a 1-inch diameter vent hole in the center of the cover of the box. The 1-inch vent hole was covered with 2 x 2 inch splash plate approximately 3/4 of an inch away from (outside) the surface of the cover. The horizontally oriented steel box had a 1-inch diameter vent/drain hole in the center of the bottom of the box behind the component mounting panel.

It should be noted that the aluminum box and the horizontal steel box were fabricated and oriented in a manner to duplicate the two boxes, with their General Electric type EB-25 terminal blocks, in each of the core deluge valve circuits at the Haddam Neck Plant. In fact, the horizontally oriented steel box which was tested, was identical to the two boxes which were installed in the core deluge circuits in November, 1977, in response to IE Bulletin 77-05. It was also identical to the EB-25 terminal block/junction box tested at Franklin Institute in January, 1978, as part of a screening test.

PRECONDITIONING OF TEST SPECIMENS

Prior to being put into the autoclave, the test specimens were thermally aged and irradiated. The thermal aging was based on an Arrhenius plot for flexural strength of a 1/4-inch sample of wood flour-filled phenolic. Aging at 150°C (302°F) for 171 hours is equivalent to a 40-year exposure to a temperature of about 70°C; the 70°C figure was used as representative of the ambient temperature to simulate the terminal blocks located on the head of the reactor vessel. Since the terminal blocks on the charging floor operate in a cooler ambient temperature, they were effectively aged to an equivalent life much greater than 40 years.

The radiation exposure considered the cumulative dose due to both the normal operating and postulated post-Loss-of-Coolant Accident (LOCA) environments. The test specimens were exposed to a total of 5×10^6 rads (gamma).

Both the thermal aging and irradiation were deemed to conservatively represent the normal operating and post-LOCA environment taking into account the actual location of the block/box combinations inside containment, and the actual expected years of service. Additional conservatisms exist when consideration is given to a more realistic assessment of postulated post-LOCA doses (see March 6, 1978 CYAPCO letter) and the actual environmental conditions during the required functional time of the core deluge valves.

ENVIRONMENTAL TEST SEQUENCE AND TEST PARAMETERS

The environmental qualification test sequence called for a rise from initial conditions of 120°F and 0 psig to 286°F and 40 psig within eight seconds to conservatively simulate the initial phase of a LOCA. Again, this transient is felt to conservatively bound the limiting environmental condition inside containment following a postulated LOCA.

Five minutes into the test, a chemical spray of borated, demineralized water was introduced into the autoclave. One spray nozzle was directed toward each of the three boxes in the autoclave, with a nozzle spray angle of 120°. The spray nozzles were oriented such that they sprayed directly onto the covers of the two steel boxes and onto the back side of the aluminum box. The borated water was mixed to form a solution of 2640 ppm boric acid; which again conservatively represented expected concentrations of chemicals which could spray the block/box combinations, considering its actual location in containment and expected refueling water storage tank values. It is important to note that additional conservatism has been introduced into the qualification test sequence by virtue of the fact that the major source of spray, the containment spray system, is not expected to be utilized following the postulated LOCA.

Spray at the original boron concentration was continued for 17.1 hours. After 17.1 hours, the spray was taken from the sump of the autoclave in a recirculation mode; thereby, dilution of the boric acid concentration occurred. The spray was terminated after 24 hours.

After the initial temperature and pressure transients, the test conditions of 286°F and 40 psig were held constant until 15 minutes into the test sequence. At that time, a 4 psig pressure dip was induced to simulate the start of the recirculation phase of the postulated LOCA. The pressure was lowered to 35 psig in 10 seconds. This value was then held constant for 60 seconds, after which the autoclave temperature and pressure were again raised to 286°F and 40 psig, respectively, in 10 seconds. The autoclave conditions were then held constant at 286°F and 40 psig until 30.95 hours into the test.

After about 31 hours at 286°F and 40 psig, the temperature and pressure were brought down to 232°F and 7 psig, respectively, in 6 uniform steps over a 3-hour period. These new conditions were then held constant for approximately 101 hours. At that time, it was determined that conditions had stabilized to the point where no additional, meaningful data could be expected to be obtained. Because of this and because the test had run sufficiently long to qualify the terminal block/box combinations for the core deluge system, the test was terminated.

TEST ELECTRICAL PARAMETERS

The extreme terminal points on both ends of each of the terminal blocks under test were energized to 525 volts. The terminal points immediately adjacent to these energized point were grounded. All other terminal points on each block were wired in series into a low-voltage, 20-ampere current source. The two 525-volt terminal points on each terminal board were connected to their power supply by a double-pole knife switch, allowing for quick isolation of a given terminal block. Further isolation of a given terminal point was possible by open circuiting the wiring between one pole of the knife switch and the terminal point in question. The power supplies for the 525-volt energized terminal points were protected by one-ampere circuit breakers. To conservatively represent the 480 volt plant electrical system, 525 volts was used as the test voltage. The 20-ampere current circuits were designed to conservatively present the 17 ampere locked rotor current of the core deluge valves. The terminal blocks were energized with voltage and current continuously throughout the test period, except when certain terminal points were isolated, for short periods, while Insulation Resistance (IR) readings were taken.

It should be recognized that this test setup conservatively simulated the dielectric paths to ground, when compared to the normal three-phase electrical system at the plant. During normal plant operation, the dielectric paths to ground would only be stressed at approximately 277 volts, instead of 525 volts.

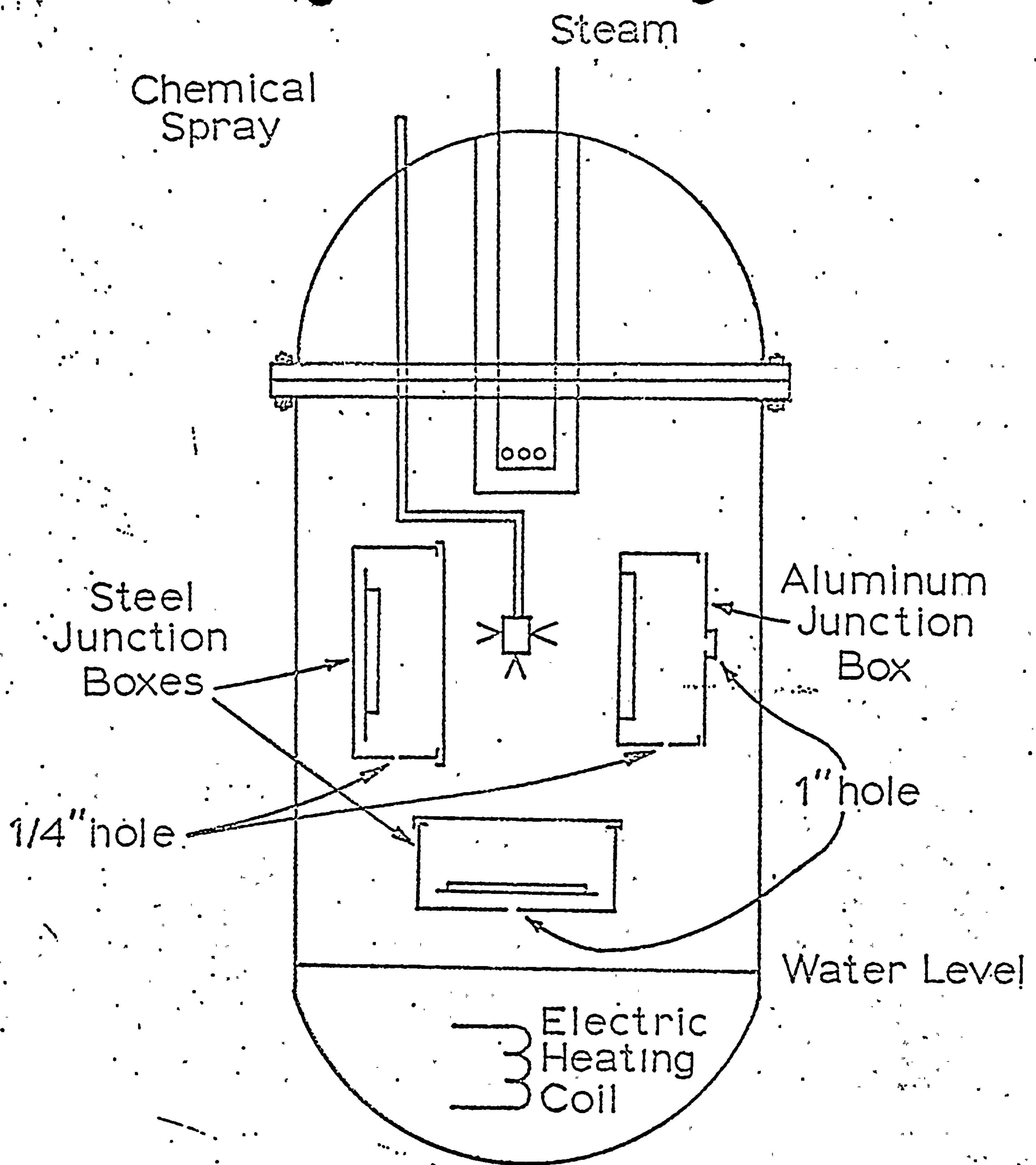
TEST PASS/FAIL CRITERIA

A failure of the terminal point under test was defined as the inability of that point to continuously support the applied test voltage or current. Any other indications associated with test connections, autoclave penetrations, power supplies, etc., would not be defined as a failure of a test specimen(s).

CONCLUSIONS

Insofar as a single point on the GE terminal block located in the aluminum box failed to its adjacent grounded terminal 30 minutes after initiation of the LOCA test sequence defined, its performance was not deemed acceptable under the acceptance criteria of the test, although it is still believed that the terminal block would have performed its intended function in actual service.

No failures occurred of the GE blocks mounted in steel boxes, and their performance was acceptable for the steel junction boxes oriented in both the horizontal or vertical positions. The IR data taken on the blocks in the steel boxes during the test confirmed that these block/box combinations would perform their intended function under the environmental conditions postulated for a LOCA and conservatively simulated in the test autoclave. It is, therefore, concluded that the GE block/steel box combinations are fully qualified for use in safety related circuits inside containment at the Haddam Neck Plant.



Environmental Qualification Test Setup Schematic

QUALIFICATION OF FIREWALL® III

CLASS 1E ELECTRIC CABLES

THE ROCKBESTOS COMPANY
New Haven, Conn. 06504

February 1, 1977

TABLE OF CONTENTS

PURPOSE

The purpose of this test program is to demonstrate that Firewall® III electric cables will function during a loss of coolant accident (LOCA) postulated to occur at any time during 40 years of operation under conditions as prescribed by IEEE 383-1974.

TEST SAMPLE DESCRIPTIONS

Instrumentation Cable

Single Conductor #16 AWG, 300 volt , 20 mils of flame retardant XLPE insulation identified as Rockbestos Firewall® III.

*Control Cable

Single Conductor #12 AWG, 600 volt, 30 mils of flame retardant XLPE insulation identified as Rockbestos Firewall® III.

Power Cable

Single Conductor #6 AWG, 600 volt, 45 mils of flame retardant XLPE insulation identified as Rockbestos Firewall® III.

* Also qualifies Firewall SIS (NEC Type SIS).

PROCEDURE

I. Reference IEEE 383 Paragraph 2.3.3.1

Three samples ("A," "B" and "C") each made up of two 10 ft. pieces of cable, were prepared for Firewall III instrumentation, control and power cables described on Page 1. All samples were formed into test coils.

II. Reference IEEE 383 Paragraph 2.3.3.2

The "A" and "B" samples were thermally aged in a circulating air oven for 1300 hours at 150°C in order to simulate 40 year installed life at a continuous operating temperature of 90°C. This simulation was based on the attached Arrhenius data. Exposure time of 850 hours dictated by the Arrhenius slope was adjusted to 1300 hours to provide an adequate margin over specified service temperature, as required in IEEE 323, Section 6.3.1.5.

III. Reference IEEE 383 Paragraph 2.3.3.3

The "A" and "B" samples were subsequently subjected in air to gamma radiation from a cobalt 60 source at a rate of 1×10^6 rads per hour to a cumulative dosage of 5×10^7 rads.

IV. Reference IEEE 383 Paragraph 2.3.3.4

In order to demonstrate the serviceability of Firewall III after normal 40 year service conditions, the "A" samples were straightened and recoiled with an inside diameter of 20 times their O.D.'s and immersed in tap water at room temperature. While still immersed, the samples were subjected to and passed a voltage withstand test for 5 minutes at a potential of 80 V/mil AC.

V. Reference IEEE 383 Paragraph 2.4

In order to demonstrate the serviceability of Firewall III during and after a LOCA occurring during the first days of installed life, the "C" samples were first subjected to a radiation dosage of 1.5×10^8 rads and then subjected to the LOCA profile of IEEE 323 for combined PWR/BWR while energized with rated voltage and current. Following this exposure, the samples were straightened and recoiled with an inside diameter of 40 times their O.D.'s and immersed in tap water at room temperature. While still immersed, the samples were subjected to and passed a voltage withstand test for 5 minutes at a potential of 80 V/Mil AC.

In order to demonstrate the serviceability of Firewall III during and after a LOCA occurring during the last days of 40 year installed life, the "B" samples were first subjected to an additional radiation dosage of 1.5×10^8 rads, bringing the total dosage to 2×10^8 rads, and then subjected to the LOCA profile of IEEE 323 for combined PWR/BWR while energized with rated voltage and current*. Following this exposure, the samples were straightened and recoiled with an inside diameter of 40 times their O.D.'s and immersed in tap water at room temperature. While still immersed, the samples were subjected to and passed a voltage withstand test for 5 minutes at a potential of 80 V/Mil AC.

* 6 AWG: 600 VAC, 70A
12 AWG: 600 VAC, 30A
16 AWG: 300 VAC, 22A

In order to further demonstrate the serviceability of Firewall III cables after a LOCA, the "B" samples, following the post LOCA simulation test described above, were exposed to a 100% RH 200 F environment for 100 days. Following this exposure, the samples were again straightened and recoiled with an inside diameter of 40 times their O.D.'s and immersed in tap water at room temperature. While still immersed, the samples were subjected to and passed a voltage withstand test for 5 minutes at a potential of 80 V/Mil AC.

(CERTIFIED) CONCLUSION

Having successfully withstood the conditions and tests as described in the preceding procedure, we certify that Firewall III cables will function for at least 40 years at a continuous operating temperature (conductor temperature) of 90°C and after a radiation exposure of 200 megarads and during a postulated Loss-of-Coolant-Accident (LOCA) occurring at any time during the 40 years.

George S. Buettner
Chief Engineer

James R. Marth
Cable Engineer

STATE OF CONNECTICUT, COUNTY OF NEW HAVEN:

Subscribed and sworn to before me this 1st day of February 1977.

Ernestine B. Natiello
Notary Public

My Commission Expires March 31, 1979

K•E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

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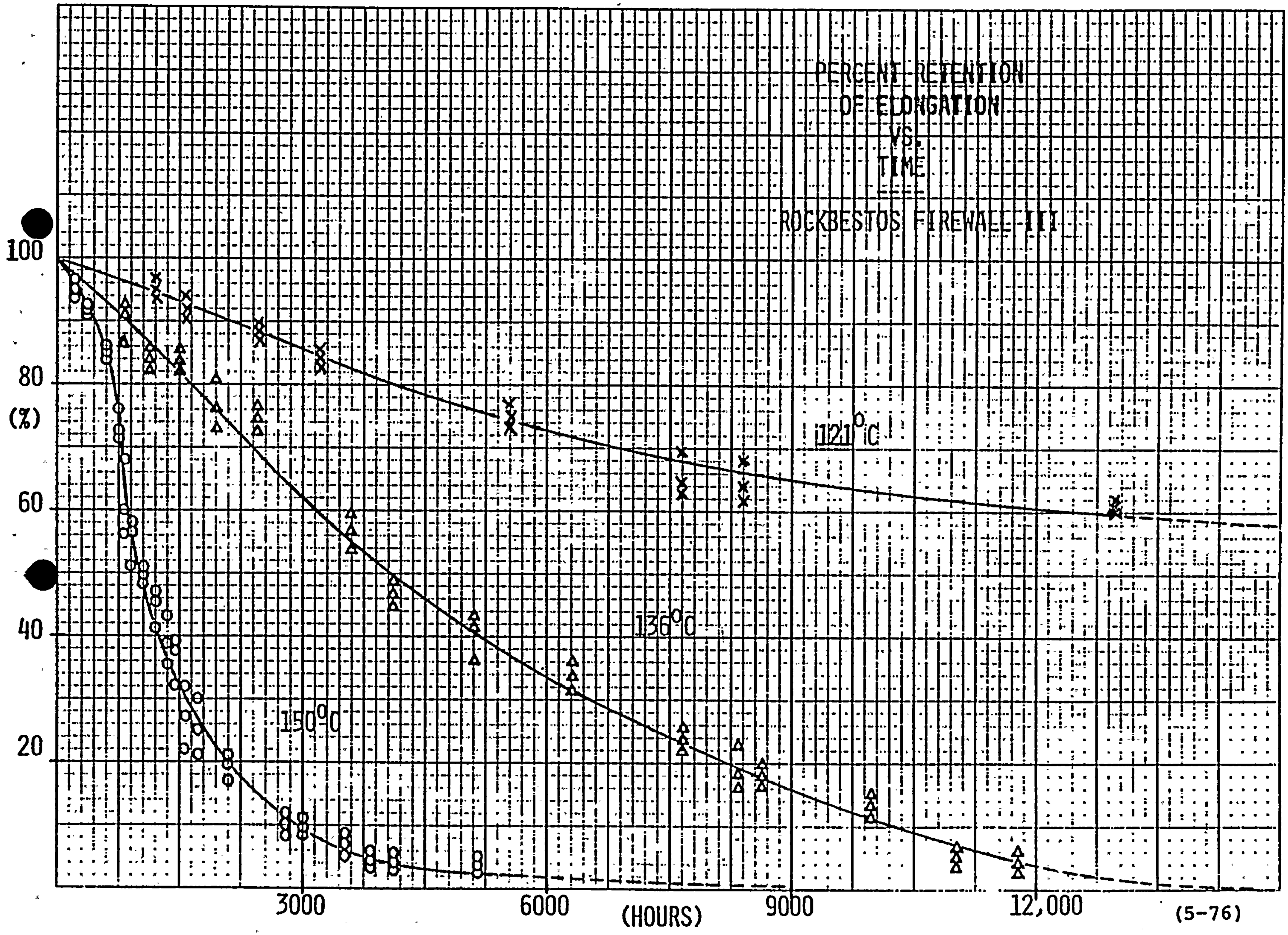

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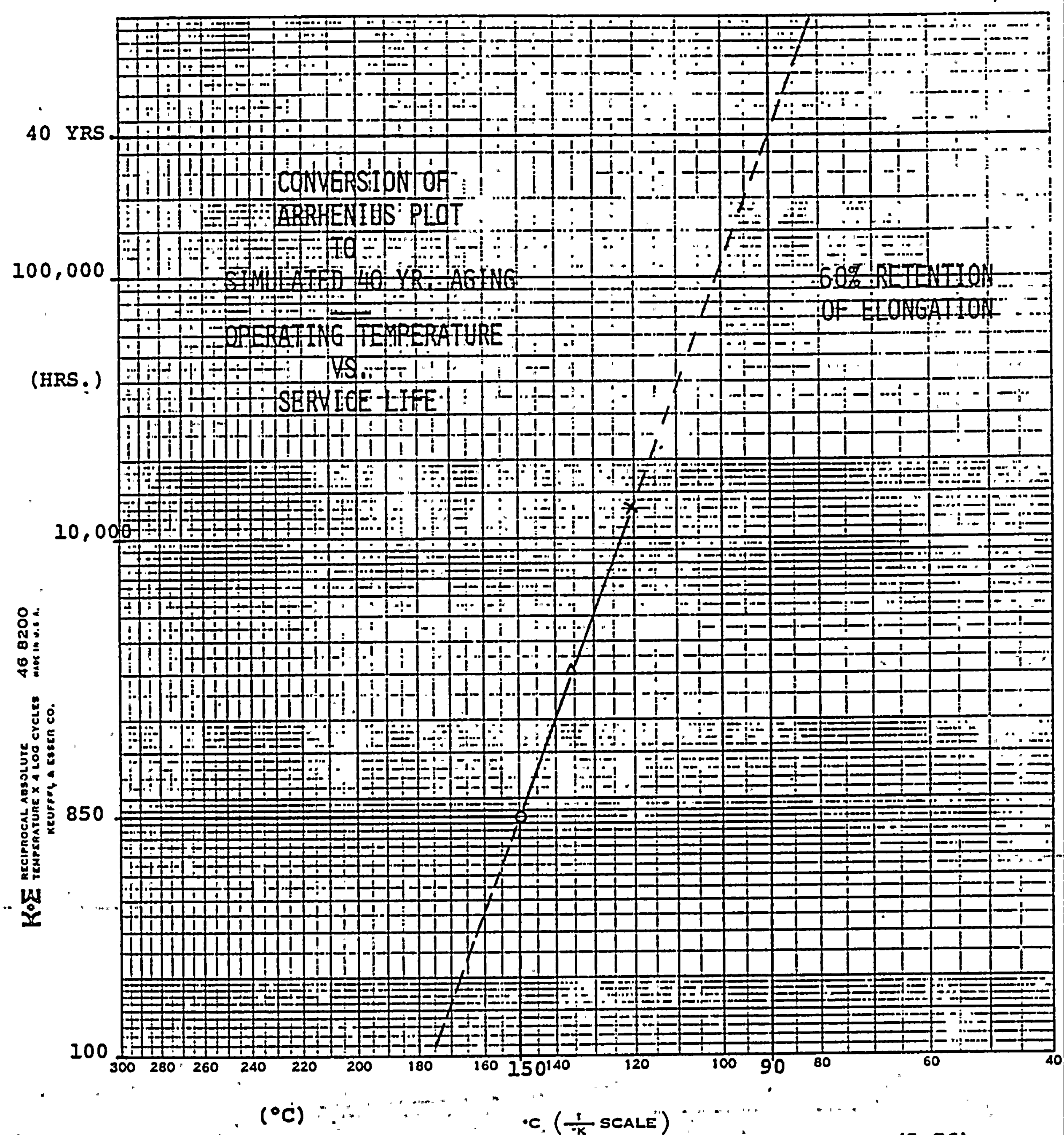
ROCKBESTOS FIREWALL III



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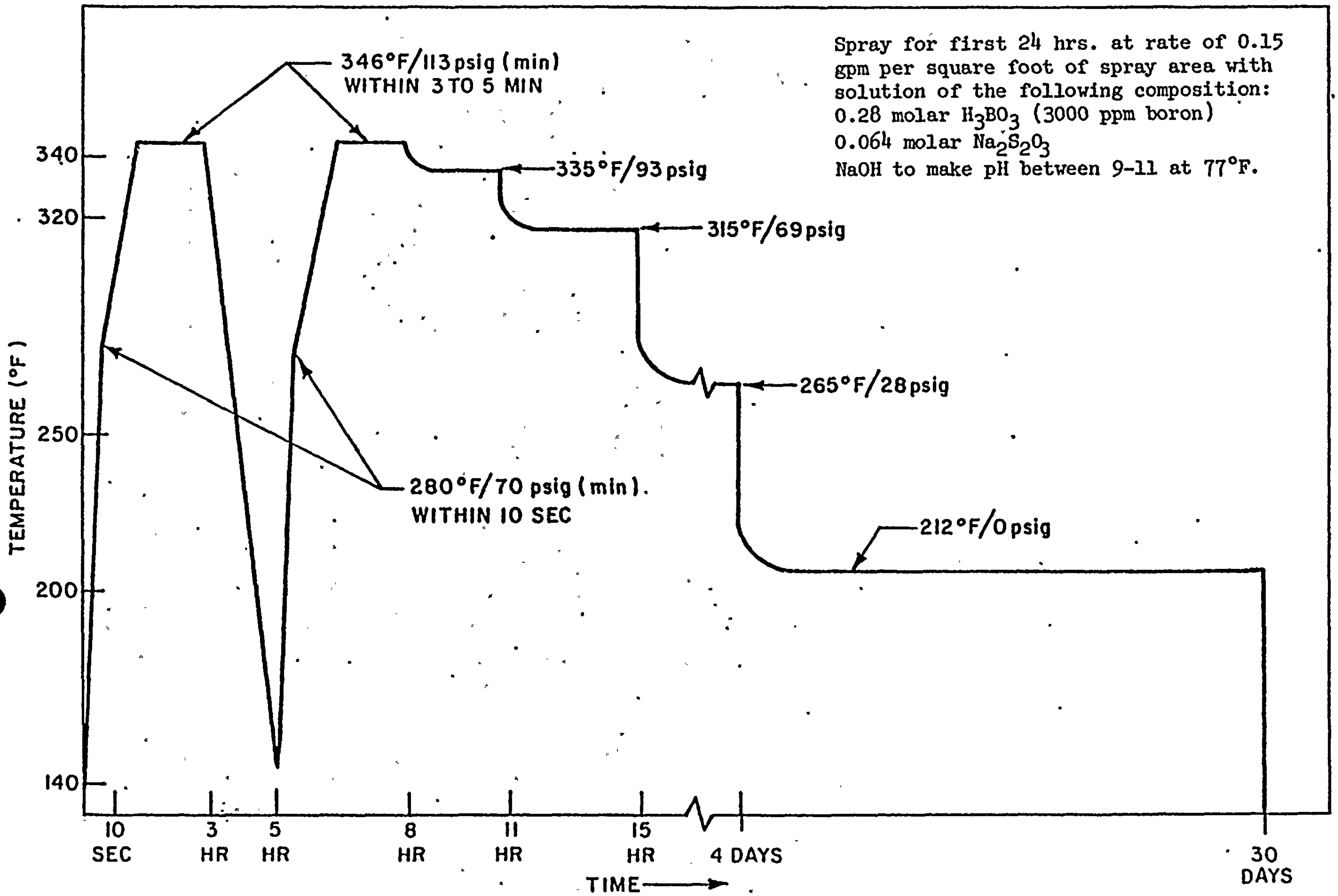
LOCA Profile



LOCA PROFILE

ISOMEDIX

August 19, 1975

Mr. J. R. Marth
Cerro Wire & Cable Co.
P.O. Box 1102
New Haven, Connecticut 06504

Dear Mr. Marth:

This will summarize parameters pertinent to the irradiation of a mandrel of cable samples per your order 70572, dated July 18, 1975.

The mandrel was placed in a cobalt-60 gamma field in an upright position, which paralleled the long axis of the radiation source. The mandrel was exposed at each of 4 quadrents, as marked with tape on its top. By integrating the dose rate at any point on the mandrel during its 4-position exposure, an average dose rate was obtained which, when multiplied by the total exposure time, yields total dose.

Phase I of the test required that the cables be exposed to 50 Mrad. They were exposed for a total of 78 hours at an average dose rate of 0.65 Mrad for a total dose of 50.7 Mrad. At this point (July 21) the mandrel was removed from the irradiator, and Cerro representatives removed several cables.

Phase II consisted of the mandrel and remaining cables being exposed to an additional 150 Mrad. Using the same procedure, they were exposed for 188 hours at an average dose rate of 0.8 Mrad per hour, for a total dose of 150.4 Mrad.

Irradiation was conducted in air at ambient temperature and pressure. Radiant heat from the source heated the samples somewhat, but the temperature did not exceed 110^{o}f, as indicated by previous measurements on an oil solution in the same relative position.

Isomedix Inc. • 25 Eastmans Road, Parsippany, New Jersey (201) 887-4700
Mailing Address: Post Office Box 177, Parsippany, New Jersey 07054

CHICAGO DIVISION • 7828 Nagle Ave., Morton Grove, Illinois 60053 (312) 966-1160

Dosimetry was performed using a Victoreen Model 555 Integrating Dose Rate Meter and Probe. The unit was calibrated on January 15, 1974 by the Victoreen Instrument Company, using cobalt-60 and cesium-137 sources whose calibrations are traceable to the U.S. National Bureau of Standards. A copy of the calibration certificate is available. Backup dosimetry using a Red Perspex system confirmed the Victoreen readings.

Irradiation was completed on August 1, 1975, and the mandrel was picked up by your personnel.

Very truly yours,

George R. Dietz

George R. Dietz
Manager, Radiation Services

GRD:km

THE ROCKBESTOS CO.
14 SOUTH ST.
SUITE 8
WESTBORO, MASS. 01581

QUALIFICATION OF FIREWALL® III
CLASS 1E ELECTRIC CABLES

THE ROCKBESTOS COMPANY
New Haven, Conn. 06504

July 7, 1977

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The "A" and "B" samples were subsequently subjected in air to gamma radiation from a cobalt 60 source at a rate of 1×10^6 rads per hour to a cumulative dosage of 5×10^7 rads.

IV. Reference IEEE 383 Paragraph 2.3.3.4

In order to demonstrate the serviceability of Firewall III after normal 40 year service conditions, the "A" samples were straightened and recoiled with an inside diameter of 20 times their O.D.'s and immersed in tap water at room temperature. While still immersed, the samples were subjected to and passed a voltage withstand test for 5 minutes at a potential of 80 V/mil AC.

V. Reference IEEE 383 Paragraph 2.4

In order to demonstrate the serviceability of Firewall III during and after a LOCA occurring during the first days of installed life, the "C" samples were first subjected to a radiation dosage of 1.5×10^8 rads and then subjected to the LOCA profile of IEEE 323 for combined PWR/BWR while energized with rated voltage and current. Following this exposure, the samples were straightened and recoiled with an inside diameter of 40 times their O.D.'s and immersed in tap water at room temperature. While still immersed, the samples were subjected to and passed a voltage withstand test for 5 minutes at a potential of 80 V/Mil AC.

In order to demonstrate the serviceability of Firewall III during and after a LOCA occurring during the last days of 40 year installed life, the "B" samples were first subjected to an additional radiation dosage of 1.5×10^8 rads, bringing the total dosage to 2×10^8 rads, and then subjected to the LOCA profile of IEEE 323 for combined PWR/BWR while energized with rated voltage and current*. Following this exposure, the samples were straightened and recoiled with an inside diameter of 40 times their O.D.'s and immersed in tap water at room temperature. While still immersed, the samples were subjected to and passed a voltage withstand test for 5 minutes at a potential of 80 V/Mil AC.

* 6 AWG: 600 VAC, 70A
12 AWG: 600 VAC, 30A
16 AWG: 300 VAC, 22A

In order to further demonstrate the serviceability of Firewall III cables after a LOCA, the "B" samples, following the post LOCA simulation test described above, were exposed to a 100% RH 200 F environment for 100 days. Following this exposure, the samples were again straightened and recoiled with an inside diameter of 40 times their O.D.'s and immersed in tap water at room temperature. While still immersed, the samples were subjected to and passed a voltage withstand test for 5 minutes at a potential of 80 V/Mil AC.

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Having successfully withstood the conditions and tests as described in the preceding procedure, we certify that Firewall III cables will function for at least 40 years at a continuous operating temperature (conductor temperature) of 90°C and after a radiation exposure of 200 megarads and during a postulated Loss-of-Coolant-Accident (LOCA) occurring at any time during the 40 years.

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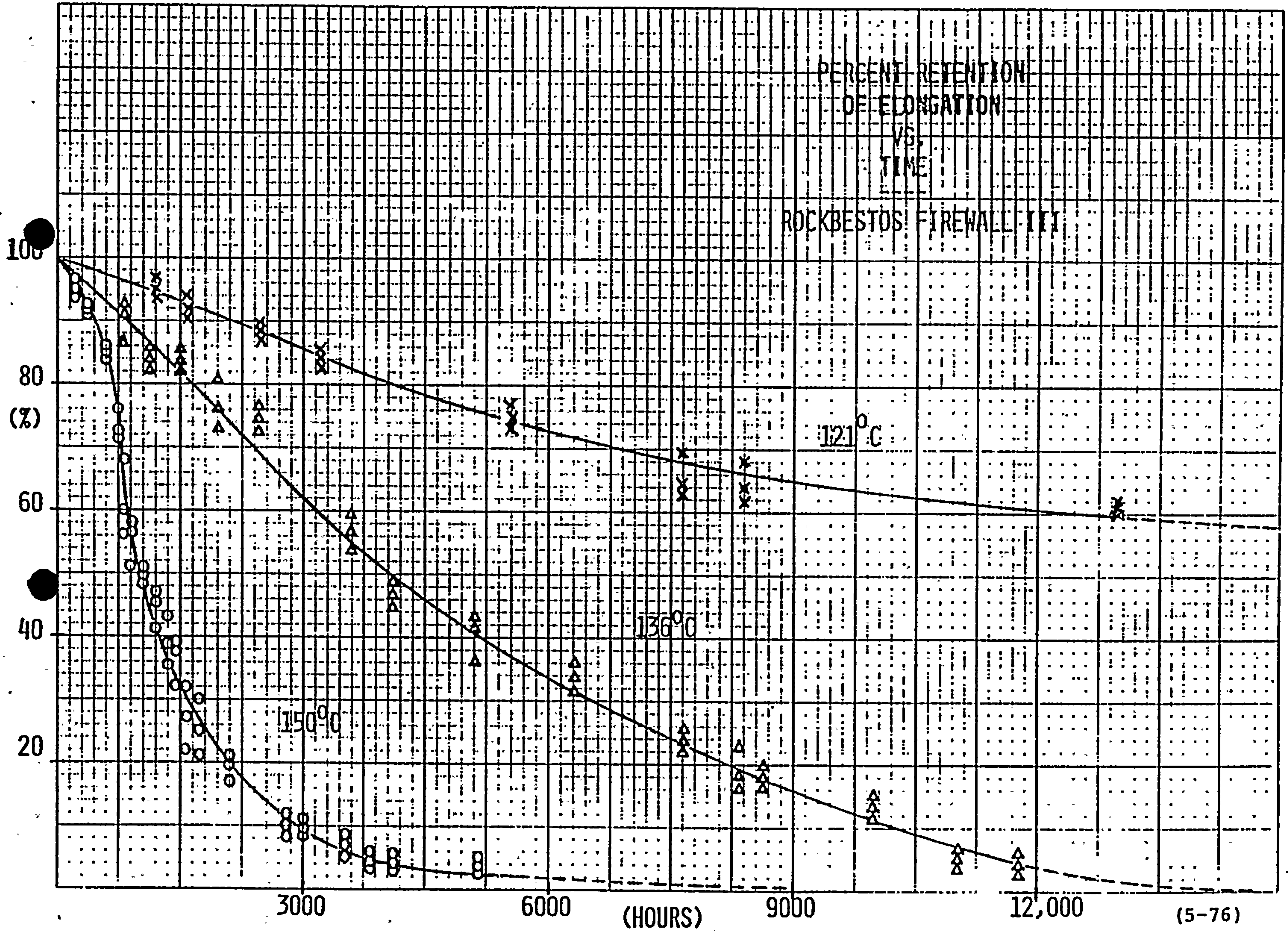
PERCENT RETENTION
OF ELONGATION
VS.
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ROCKBESTOS FIREWALL III
100
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(HOURS)

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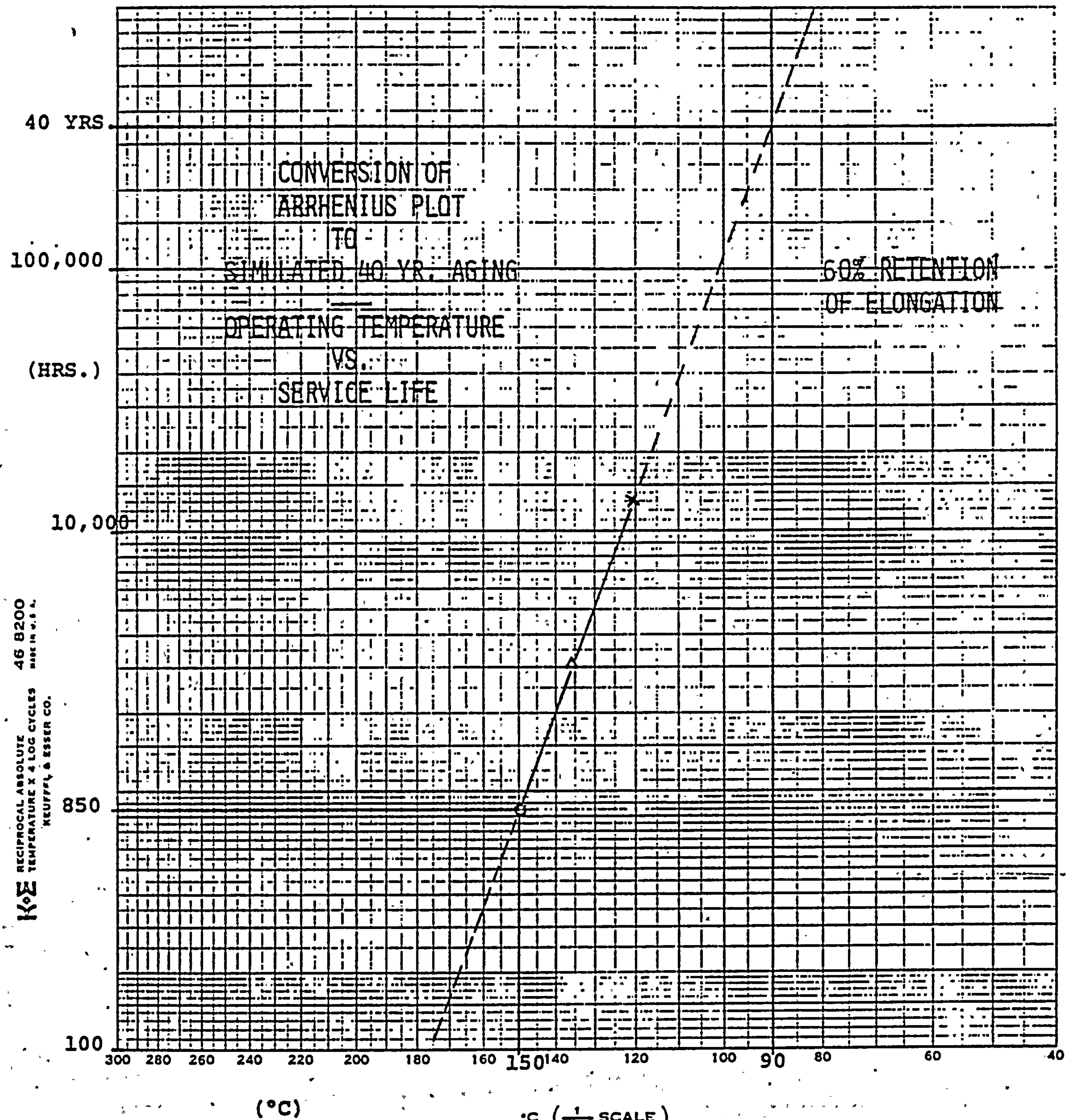
ROCKBESTOS FIREWALL III



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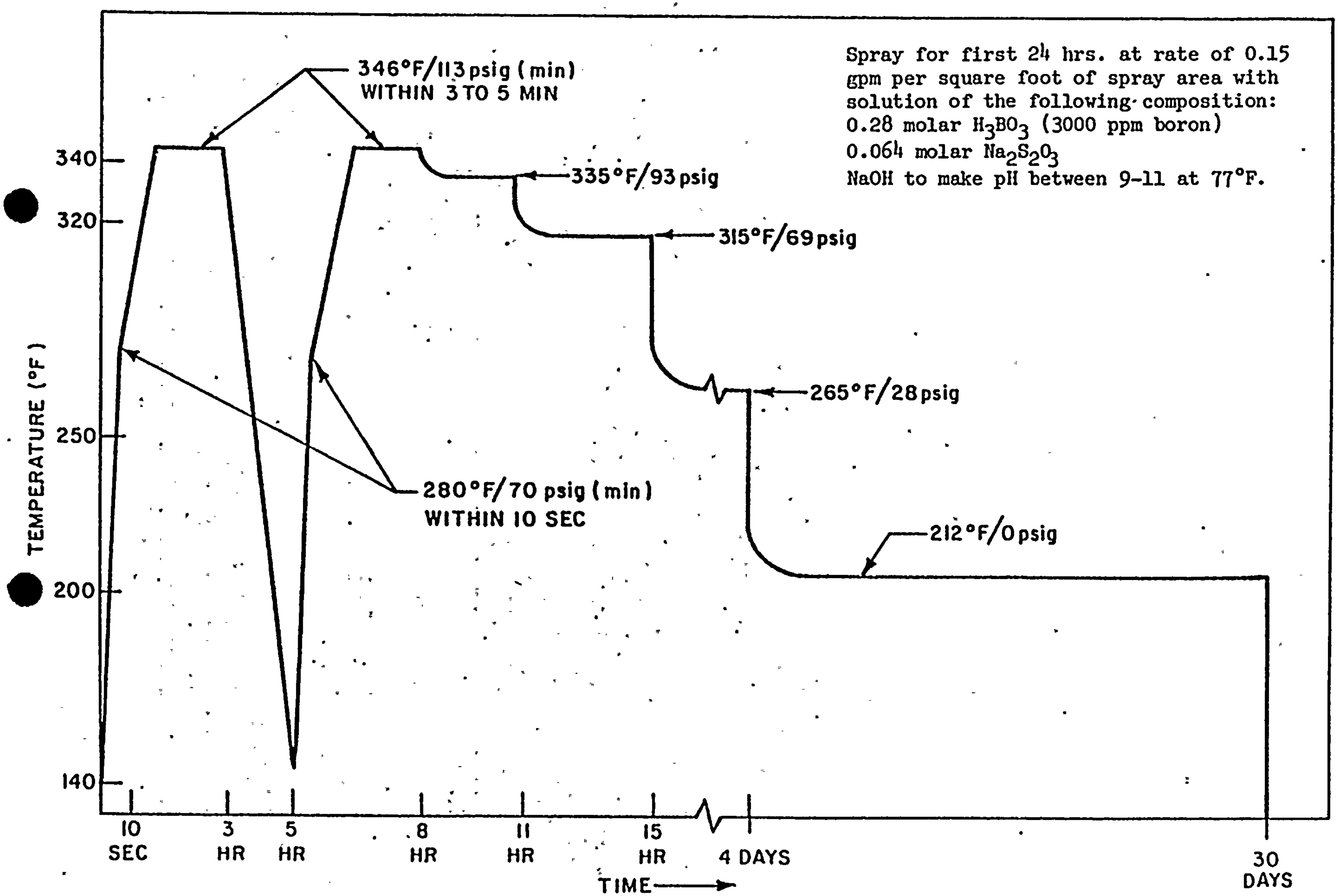
LOCA Profile



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CHICAGO DIVISION • 7828 Nagle Ave., Morton Grove, Illinois 60053 (312) 966-1160

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Irradiation was completed on August 1, 1975, and the mandrel was picked up by your personnel.

Very truly yours,

George R. Dietz
Manager, Radiation Services

GRD:km