Northern States Power Company

414 Nicollet Mall
Minneapolis, Minnesota 55401-1927
Telephone (612) 330-5500

February 10, 1994

Generic Letter 92-08

US Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
Docket Nos. 50-282 License Nos. DPR-42
50-306 DPR-60

Response to a Request for Additional Information
Related to Generic Letter 92-08, "Thermo-Lag 330-1
Fire Barriers", (TAC Nos. M85592 and M85593)

References: (a) L. J. Callan, Nuclear Regulatory Commission, to R. O. Anderson, Northern States Power Company, letter dated December 20, 1993

(b) R. O. Anderson, Northern States Power Company, to the Nuclear Regulatory Commission, letter dated June 24, 1993

(c) Marsha Gamberoni, Nuclear Regulatory Commission, to R. O. Anderson, Northern States Power Company, letter dated May 18, 1993

(d) R. O. Anderson, Northern States Power Company, to US Nuclear Regulatory Commission 10 CFR 50.54 (f) Response, dated April 16, 1993

(e) Nuclear Regulatory Commission Generic Letter 92-08, dated December 17, 1992

150093

A029
1/1

In Reference (a), the Nuclear Regulatory Commission (NRC) requested that Northern States Power Company (NSP) provide additional information regarding the Thermo-Lag 330-1 fire barriers installed at Prairie Island. The request for additional information is a follow-up to the information requested in Generic Letter 92-08, Reference (e). NSP's response to GL 92-08 was provided in Reference (d). NSP's response to the NRC's earlier request for additional information, Reference (c), was supplied via Reference (b).

This letter provides NSP's response to Reference (a). The attached response provides a summary of the background to the NRC's letter (Section A) a description of NSP's Thermo-Lag Qualification Program Plan (Section B), and a quotation (in bold type) of the specific requests in the NRC's letter along with NSP's response to each request item (Section C).

In addition, please note that NSP had originally planned to provide a description of the planned actions and schedular commitments regarding Thermo-Lag to the NRC within 30 days after completion of the NUMARC program, as requested in Reference (c). However, Reference (a) required NSP to provide a differently structured response roughly two months ahead of NSP's original response schedule. Therefore, the information provided in this letter may need to be updated at a future time, following completion of the NUMARC program.

This correspondence contains the following new NRC commitment:

> We will resolve the Thermo-Lag issue at Prairie Island using Section B of Attachment 1, THERMO-LAG QUALIFICATION PROGRAM PLAN as a guide with completion occurring by December 31, 1996 as shown in Attachment 4, Prairie Island Station's Thermo-Lag Program schedule. This completion date is based on the potential need for cable rerouting which would take place during unit refueling outages.

Please contact Jack Leveille (612-388-1121, Ext. 4662) if you require further information.

Douglas D Antony
Vice President
Nuclear Generation

cc: Regional Administrator - III, NRC
NRR Project Manager, NRC
Sr Resident Inspector, NRC
State of Minnesota
Attn: Kris Sanda
J Silberg

Attachments: A) Affidavit to the US Nuclear Regulatory Commission
1) NSP Response to Request for Additional Information Regarding Generic Letter 92-08, Pursuant to 10 CFR 50.54(f)
Tables
1: Thermo-Lag Installation Summary
2: Effect of Configuration Parameters on Fire Endurance Performance of Wrapped Raceways
2) Program Plan Process Flow Chart
3) Technical approach to resolving cable percent fill in cases not covered by NUMARC testing
4) Prairie Island Station's Thermo-Lag Program schedule

ATTACHMENT A

UNITED STATES NUCLEAR REGULATORY COMMISSION

NORTHERN STATES POWER COMPANY

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

DOCKET NOS. 50-282
50-306

THERMO-LAG 330-1 FIRE BARRIERS

Northern States Power Company, a Minnesota corporation, with this letter is submitting information requested by Generic Letter 92-08, Thermo-Lag 330-1 Fire Barriers, pursuant to 10 CFR 50.54(f).

This letter contains no restricted or other defense information.

NORTHERN STATES POWER COMPANY

By Douglas D Antony

Douglas D Antony
Vice President
Nuclear Generation

On this 10th day of February 1994 before me a notary public in and for said County, personally appeared Douglas D Antony, Vice President, Nuclear Generation and being first duly sworn acknowledged that he is authorized to execute this document on behalf of Northern States Power Company, that he knows the contents thereof, and that to the best of his knowledge, information, and belief the statements made in it are true and that it is not interposed for delay.

Judy L. Klapperick

JUDY L KLAPPERICK
NOTARY PUBLIC-MINNESOTA
ANOKA COUNTY
My Commission Expires Sept 29, 1997

ATTACHMENT 1

Northern States Power Company

Response to NRC Request for
Additional Information Regarding
Generic Letter 92-08

A. BACKGROUND

The NRC issued Generic Letter 92-08 in December 1992 to request licensees and CP holders to provide information on Thermo-Lag 330-1 fire barrier materials installed at their plants. Specifically, the Generic Letter requested information on: fire endurance and ampacity derating qualification testing; consistency between installed and tested configurations; corrective actions needed including schedules; and, compensatory measures taken in accordance with technical specifications or administrative controls.

NSP's response to Generic Letter 92-08 was provided on April 16, 1993. In the response letter, NSP stated that "At the present time we are awaiting the results of the efforts in place by the Nuclear Management and Resource Council (NUMARC)." Phase 1 of NUMARC's test program was completed in November 1993. Phase 2 is scheduled for completion in March 1994. NUMARC expects to issue an industry application guide based on the tests in April 1994.

Recently, the NRC Staff has raised concerns relative to the adequacy and progress of the NUMARC test program. The NRC has now issued follow-up letter, pursuant to 10 CFR 50.54(F), dated December 20, 1993, to request information on the applicability of the NUMARC test program to Prairie Island.

The following sections provide NSP's response to the requests contained in the December 20, 1993, letter.

B. THERMO-LAG QUALIFICATION PROGRAM PLAN

1.0 Introduction

Northern States Power Company (NSP) has been actively reviewing potential options for qualifying Thermo-Lag fire barriers since the inception of the NUMARC test program. As a result, NSP has developed a Thermo-Lag qualification plan that we believe will provide a satisfactory resolution of this issue. The foundation of the proposed plan consists of an integrated engineering evaluation. The goal of this evaluation

is to determine the most appropriate qualification strategy for each Thermo-Lag configuration at Prairie Island.

An important feature of the qualification plan is that all Thermo-Lag configurations in the plant will be comprehensively evaluated regardless of whether or not they are bound by the NUMARC test program. Therefore, qualification of Thermo-Lag by reference to NUMARC test results is considered one option among several possible resolution options in the NSP's program plan.

In addition, although plant-specific testing is one possible qualification approach to Thermo-Lag configurations that fall outside the NUMARC test program scope, NSP does not believe that plant-specific testing should be the central focus of the qualification plan. The primary reason for this is that testing does not necessarily guarantee final resolution. Another issue is the cost-effectiveness of plant-specific testing. As discussed in Section C of this response, one of the plant-unique Thermo-Lag configuration may be different from the NUMARC test assemblies. NSP does not believe that fire endurance testing of this type of configuration is a cost-beneficial approach, particularly since satisfactory results are not guaranteed. It is possible, however, that our detailed engineering evaluations may determine that plant-specific testing is the only available option for qualifying a specific configuration, however NSP believes that, in general, the testing approach should be pursued only after all other potential solutions have been eliminated from consideration.

2.0 Summary of NSP Qualification Program Plan

The Thermo-Lag qualification program plan consists of 14 steps, however, the plan can be summarized under five main tasks as follows (see flow chart, Attachment 2):

2.1 Task 1 - Establish Field Configuration

Steps 1 through 3 of the process establish the field configuration and provides the means for multi-disciplined engineering evaluation. Step 1 is a data collection step which has been completed.

In Step 2, Key Plans, the team will prepare key plan drawings showing the raceways required to be wrapped in accordance with the station's design and licensing basis. The team will select the most appropriate project drawings as a background for the key plans. Walkdowns will be used to reconcile the field conditions with the design/licensing basis. This step is now in progress and is scheduled to be completed by February 28, 1994.

Step 3, Establish the Field Condition, is a detailed walkdown effort that is designed to breakdown the wrapped raceways shown on the key plan drawings into elements that can be compared against test configurations. Configuration parameters that can be extracted from field inspections will be collected at this step. Configurations that can not be matched with a test basis will also be documented and pertinent information collected. This step is scheduled to be completed within 8 weeks from the release of NUMARC's application guidelines.

2.2 Task 2 - Engineering Evaluation/Analysis

Steps 4 through 7 provide for the engineering evaluation of the entire scope and will close the items/fire areas that can be accepted as is or resolved by analysis with no field work. To accomplish this, classification of the field configurations are needed. To perform this review, the values of the configuration parameters not collected in Step 3 (parameters internal to the barrier system), will be established through the following methods:

* Assume limiting conditions, e.g., post-buttered versus pre-buttered joints, no internal bands versus internal bands.

* Reviews of contractor work practices and procedures through documentation or testimony.

* Destructive examination of barriers on a sample basis to obtain information on construction techniques.

2.2.1 Configuration Classification Review.

A fire protection engineer will perform a detailed review of the field configuration data and compare it against the approved NUMARC test reports. Each configuration will be categorized as follows:

Category 1: Bounded and acceptable as is.

Category 2: Bounded, but requires minor modification, such as adding tie wires.

Category 3: Bounded, but requires moderate modification, such as seam repairs, using stress skins and trowel grade material plus tie wires.

Category 4: Bounded, but requires extensive modification, such as full wrap with extra layer of wrap.

Category 5: Not bounded by NUMARC test report.

Configurations in Categories 1 and 2 will be further evaluated for cable functionality, if required,and acceptable ampacity, under Tasks 3 and 4. Configurations in Categories 3, 4 and 5 will be reviewed to identify available alternate options to resolve the problem areas without relying on modifications (Categories 3 and 4), or relying on station unique testing (Category 5).

2.2.2 Combustibility Review

This task will be performed in accordance with the NUMARC program. All the Thermo-Lag installations in a given fire area will be addressed including potential upgrades using additional Thermo-Lag materials.

2.3 Task 3 - Fire Wrap Qualification/Upgrade

Steps 8 and 9 of this process address fire wrap field installation modifications and station unique testing required to bring the installations into compliance with the regulatory requirements.

2.4 Task 4 - Design Basis Update

Steps 10 through 13 of this process complete the design and licensing basis update to reflect the qualified condition. These will be completed on a fire area basis after field work is completed to reflect as-built conditions. The completion of this group of steps for a particular fire area allows the ending of compensatory fire watch measures by declaring the fire barrier in this fire area as operable.

2.5 Task 5 - Closure Report

Step 14 of this process is the final closure report that shall be prepared for the entire scope to document the compliance of Prairie Island to the regulatory requirements.

3.0 Types of Resolutions

The following is a list of the various technical solutions that will be considered to resolve station specific Thermo-Lag fire barrier configurations (most favorable listed first):

Accept As Is - Match the configuration with an acceptable qualifying baseline test (with no upgrade).

Resolution By Analysis - Perform analysis to eliminate, or abandon the fire barrier based on any combination of the following aspects:

- Safe Shutdown Analysis Review
- Reevaluation of licensing commitments
- Taking credit for the 20-foot separation criteria
- Probabilistic Risk Assessment (PRA)
- Appendix R Exemption

Please note that an ongoing review of the NSP Appendix R program is now nearing completion. This review affects the safe shutdown list for Prairie Island and resulted in reducing the requirement for Thermo-Lag fire wrap.

Repair/Upgrade - Repair existing Thermo-lag fire barrier, or upgrade the assembly based on NUMARC Industry Test Data. This may require overlay with a second application of Thermo-Lag or the use of another fire barrier.

Modifications - Reroute cable - This is partially completed as a result of the Station Blackout modification. This modification included cable reroutes for separation of redundant cables.
- Install fire rated cable
- Install structural barrier
- Redesign Existing Configuration

Replace - Remove Thermo-Lag and install another qualified fire barrier.

Station Unique Testing - Perform testing for site specific applications.

C. NRC REQUESTS AND NSP RESPONSES

I. **Thermo-Lag Fire Barrier Configurations and Amounts**

I.B.1 Describe the Thermo-Lag 330-1 barriers installed in the plant to:

a. meet 10 CFR 50.48 or Appendix R to 10 CFR Part 50,
b. support an exemption from Appendix R,
c. achieve physical independence of electrical systems,
d. meet a condition of the plant operating license,
e. satisfy licensing commitments.

The descriptions should include the following information: the intended purpose and fire rating of the barrier (for example, 3-hour fire barrier, 1-hour fire barrier, radiant energy heat shield), and the type and dimension of the barrier (for example, 8-ft by 10-ft wall, 4-ft by 3-ft by 2-ft equipment enclosure, 36-inch-wide cable tray, or 3-inch-diameter conduit).

Response:

NSP has performed various levels of investigative walkdowns to establish preliminary estimates of the quantity of Thermo-Lag and configuration characteristics. A detailed walkdown is planned as part of the full scale evaluation program (see Section B of this Attachment), in accordance with the program plan's schedule. Therefore, the enclosed Table 1, Thermo-Lag Installations Scope, provides the best estimates of Thermo-Lag installation data available at this time.

I.B.2 For the total population of Thermo-Lag fire barriers described under Item I.B.1, submit the following information:

1. For cable tray barriers: state the total linear feet and square feet of 1-hour barriers and the total linear feet and square feet of 3-hour barriers.

2. For conduit barriers: state the total linear feet of 1-hour barriers and the total linear feet of 3-hour barriers.

3. For all other fire barriers: state the total square feet of 1-hour barriers and the total square feet of 3-hour barriers.

4. For all other barriers and radiant heat shields: state the total linear or square feet of 1-hour barriers and the total linear or square feet of 3-hour barriers as appropriate for the barrier configuration or type.

Response:

See Table 1 and the response to Item I.B.1 above.

II. Important Barrier Parameters

II.B.1 State whether or not you have obtained and verified each of the aforementioned parameters for each Thermo-Lag barrier installed in the plant. If not, discuss the parameters you have not obtained or verified. Retain detailed

information on site for NRC audit where the aforementioned parameters are known.

Response:

The NRC 10 CFR 50.54(f) letter discusses and lists a number of parameters of importance concerning cable protection by fire barriers. It is not presently clear that consideration of all of these parameters would be necessary for most barriers. Therefore, efforts to obtain the listed parameters, or describe how barriers will be evaluated in the absence of these parameters, are unjustified at this time.

The NUMARC industry application guideline will discuss bounding parameters and their application to installed configurations using combinations of tested configurations. Based on testing performed to date, the draft application guideline would address the parameters listed in the 10 CFR 50.54(f) letter. The listing provided in Table 2 represents a clarification and expansion of the 24 point listing provided in the 10 CFR 50.54(f) letter, and addresses installed configuration types that would be bound by given test configurations.

As indicated in Section B, Item 2.1 of this attachment, Task 1 - Establishing Field Conditions, is now in progress. Table 1 shows some of these parameters that are listed in the 10 CFR 50.54 (f) letter. The key plan preparation, now in progress, will establish additional items on that list of parameters. In addition, preliminary review of the documentation used as the basis for the installation yielded some more items. Items 22, 23, and 24 may not be of any significance as the NUMARC tests will not include these provisions which improve the fire endurance performance of the envelop. The remaining parameters which are presently unknown are Items 4, 6, 8, and 12 through 21 of the NRC list.

II.B.2 **For any parameter that is not known or has not been verified, describe how you will evaluate the in-plant barrier for acceptability.**

Response:

Following the issue of the NUMARC application guide the remaining important parameters will be determined as part of Task 1 and Task 2 activities (refer to Section B of this attachment, Items 2.1 and 2.2).

Task 2, Item 2.2 of Section B of this letter provides description on how these parameters will be used in the Engineering Evaluation process.

To the extent that fire test results are satisfactory on the basis of temperature, as provided in the NRC draft test and acceptance criteria, NUMARC believes the NRC listing of cable performance parameters need to be limited to the percent cable fill in cable trays (subset of item 4 of the NRC listing), which relates to enclosed thermal mass and barrier performance. Please note that Table No. 1 includes raceways with percent cable fill values of less than 15%.

If fire tests demonstrate cases where the temperature criteria have been exceeded, one optional approach to resolution, as provided in the NRC draft test and acceptance criteria, would be to evaluate cable functionality at the elevated temperatures. In this case, determination of cable performance at elevated temperature (item 8 of the NRC listing) would be necessary, using cable performance test data or information for specific installed cable types (items 1, 2, 3, and 7 of the NRC listing).

However, NRC has yet to finalize requirements for cable functionality evaluation, nor are test results yet available that would clearly indicate the need for or the scope of such evaluations. The degree and conservatism of cable functionality evaluation requirements implied here, and discussed in proposed Supplement 1 to Generic Letter 86-10, significantly exceeds the original requirements of GL 86-10.

Nevertheless, if the proposed Supplement 1 to Generic Letter 86-10 is finalized and is

basically unchanged, several options are available to NSP to evaluate the effects of percent cable fill and test results exceeding the temperature criteria on several of the wrapped raceways in Prairie Island. These options have been discussed in Section B of this attachment, Item 3.0. In cases where a site specific testing is determined to be unavoidable, NSP intends to investigate applying the technical approach discussed in Attachment 3. We understand that NUMARC has received several recommendations on the percent cable fill concerns, and is currently deciding on which course of action to adopt. If NUMARC does not change their current plans on this concern, NSP will investigate teaming with other utilities on implementing the approach of Attachment 3, or any other alternate solution that may evolve in the coming months. As such, NSP will select the approach deemed most appropriate for the conditions encountered during the engineering evaluation phase of implementing our program plan. NSP would welcome NRC's review of the proposed approach of Attachment 3 to help in the decision process on which option to adopt.

Items 4, 5 and 6 of the above NRC listing address issues relative to potential cable/barrier contact for cable trays. This is an unresolved issue at this time, and barrier inspection in this regard would be difficult or impossible. Barrier contact would be most likely to occur in situations of large cable fills. However, the large cable fills also provide significant thermal mass that would improve barrier system performance and mitigate the effect of cables in contact with the barrier. NUMARC has agreed to provide additional thermocouples in the Phase 2 cable tray tests to provide information on temperatures on raceway surfaces in contact with the cold side of the fire barriers. Further, note that a small piece of Sealtemp cloth (NRC item 6) was used only in NUMARC test Number 1-4 (24" steel cable tray with air drop, three hour test), and did not impact performance or useability of the test.

The NRC 10 CFR 50.54(f) letter discusses chemical testing of Thermo-Lag. Chemical

testing performed by NUMARC on a wide variety of aged samples, has not revealed significant variations in chemical composition. These test results will be shared and discussed with NRC, and distributed to industry along with the Phase 1 test reports. Further, Phase 2 testing will include barrier materials of various ages, as well as additional chemical testing. Unless unexpected results are encountered, NUMARC does not believe plant unique chemical evaluation should be necessary.

II.B.3 To evaluate NUMARC's application guidance, an understanding of the types and extent of the unknown parameters is needed. Describe the type and extent of the unknown parameters at your plant in this context.

Response:

The NRC 10 CFR 50.54(f) letter lists a number of parameters of importance concerning fire barriers. It should be noted that parameters not listed in Table No. 2, including barrier panel ribs facing out, raceway gage (mass), type of cable tray side rails ("C" shape facing in, "C" shape facing out, "I" shape), cable tray ladder rung spacing, and thermal shorts penetrating the barrier but not contacting the raceway, have been identified as potentially important. It is not presently clear that consideration of all these parameters would be necessary for most barriers. Upon completion of the NUMARC Phase 2 testing (schedule for March 1994), a better understanding of the important parameters will be known.

Presently, NSP has not attempted to identify these unknown parameters. The primary reason is that the NUMARC parameter list is considered preliminary. Based on the results of the NUMARC test program, some of the parameters may prove to be unimportant or additional parameters may need to be added to the list.

III. Thermo-Lag Fire Barriers Outside the Scope of The NUMARC Program.

III.B.1 Describe the barriers discussed under Item I.B.1 that you have determined will not be bounded by the NUMARC test program.

Response:

Preliminary scope estimates completed to date identified only two areas where it appears that NUMARC testing program would not bound the installations at Prairie Island. These two areas are 1. Tray cable fill less than 15% and 2. non standard cable tray configuration. Please refer to response II.B.2 and Attachment 3 for discussions on the percent cable fill.

Although not in the original Phase 2 test program, upgraded 3-hour 30" X 4" cable trays with Tee section may be tested in the expanded NUMARC testing program. As such, this NUMARC test No. 2-17 may provide the basis for resolving a 1-hour 30" X 6" cable tray section that includes a Tee section, in Prairie Island's Fire Area No. 74. One of the options available to NSP in this case is to conservatively apply a 3-hour upgrade to a 1-hour installation, to avoid a potential site specific test. One other option available to NSP is to structurally reinforce (by adding steel angle reinforcement at the corners) non-standard cable tray junctions in addition to applying the same upgrades required to qualify the adjacent standard cable tray sections meeting at that junction. This has been proposed to NUMARC. There is a possibility that NUMARC might use features of this proposal in their expanded test Nos. 2-13 and 2-15.

It is important to note here that the scope of Thermo-Lag installations, as shown on Table 1, is roughly 850 feet long of wrapped raceways. Out of these, only one configuration appears with potential to be requiring site specific testing. This configuration is approximately 6 feet long, representing less than 1% of the total population. Therefore, as stated earlier in Section B of this response, NSP does not believe that site specific testing would be a central focus of the qualification plan for Prairie Island.

This assessment is subject to change pending completion of the NUMARC expanded test program, issuance of the industry application guide, and

completion of Tasks 1 and 2 of the NSP program plan (refer to Section B of this Attachment).

III.B.2 **Describe the plant-specific corrective action program or plan you expect to use to evaluate the fire barrier configurations particular to the plant. This description should include a discussion of the evaluations and tests being considered to resolve the fire barrier issues identified in GL 92-08 and to demonstrate the adequacy of existing in-plant barriers.**

Response:

Please refer to Section B of this attachment. The scope of this issue and the specific item-by-item approach to resolution depends on three main variables:

1. The performance of the NUMARC Phase 2 testing including the expanded scope;

2. The finalization of the NRC acceptance criteria; and

3. The completion of the engineering evaluation (Task 2) in NSP's qualification program.

NUMARC's letter of December 17, 1993 requested licensees to provide information on determination of installed configurations outside the scope of the current NUMARC program. NUMARC will evaluate this information, and, through the Fire Protection Working Group, provide recommendations to the NUMARC Executive Committee for potential test program expansion. The generic testing program, including potential expansions, will be limited to cable raceway protection applications. Preliminary feedback from the industry meeting indicated potential additional generic benefit might be realized from testing of the following types of configurations:

1. Air drops;
2. Cable trays with small (less than 15%) cable fills;
3. Cable trays with large (greater than 15%) cable fills;
4. Cable trays with T-sections;

5. Box installations with panel ribs facing outward;
6. Further testing of alternate upgrade materials/techniques for cable raceways; and
7. Further testing of box enclosures mounted to concrete.

NUMARC expects to provide information on test program scope expansion in April 1994.

With regard to test and acceptance criteria, generic test and acceptance criteria for cable raceway fire barriers are under development by NRC (draft proposed supplement to Generic Letter 86-10), and have been subject to considerable public review, technical scrutiny, CRGR and ACRS review, and NRC management involvement. This criteria, when final, would be required for establishing ratings for cable raceway fire barriers used for protection of safe shutdown functions in accordance with Appendix R. NSP intends to apply the NRC's generic criteria, when finalized. We have no current plans to develop plant-specific test and acceptance criteria.

As discussed earlier in this response, NSP intends to investigate possibilities of teaming with other utilities for cases where site specific testing is determined to be unavoidable. The NSP program plan is discussed further in Section B of this Attachment.

III.B.3 If a plant-specific fire endurance test program is anticipated, describe the following:

1. Anticipated test specimens,

2. Test methodology and acceptance criteria including cable functionality.

Response:

Plant-specific fire endurance testing is not anticipated at this time. NSP's position regarding plant specific testing is discussed in the qualification plan description in Section B of this Attachment. Refer to the response to Items II.B.2, II.B.3, III.B.1, and III.B.2 for further discussion.

IV. Ampacity Derating

IV.B.1 For the barriers described under Item I.B.1, describe those that you have determined will fall within the scope of the NUMARC program for ampacity derating, those that will not be bounded by the NUMARC program, and those for which ampacity derating does not apply.

Response:

Ampacity derating is an issue that applies only to cable raceways containing power cables. Ampacity derating factors determined for upgraded configurations can be conservatively applied to baseline configurations. The NUMARC program for ampacity derating evaluation contain the following elements:

For upgraded one hour cable trays and conduits, NUMARC will be discussing with NRC the generic applicability of ampacity derating factors derived by TUEC using the methodology of IEEE P848 Draft 11, with some modifications. The IEEE P848 test methodology has been extensively discussed with NRC by NUMARC and TUEC. However, NRC acceptance of the methodology is still pending. NRC has informed NUMARC that they will issue a request for further information to TUEC in January 1994 regarding the submitted ampacity test report. The TUEC testing provided *preliminary* ampacity derating factors of 32% for cable trays and 11% for conduits, which are within the range of previously reported values.

NUMARC will conduct ampacity testing of upgraded three hour barriers to the requirements of IEEE P848, following determination of appropriate barrier upgrades for three hour installations, and agreement with NRC on ampacity test methodology. It is expected that this testing would be conducted in the second quarter of 1994, at the earliest. To the extent that successful upgrades using alternative materials are identified, ampacity testing of these upgrades would be considered as well.

The IEEE P848 approach provides for testing of a single cable tray, and small and large conduits. The limiting conduit derating factor (of the two sizes tested) is applied to the range of conduit sizes, cable fills, etc. For cable trays, single cable tray derating factor is applied to all sizes of cable trays, cable fills, etc. Thus, ampacity testing can be performed generically with broad applicability, unlike fire testing where many performance parameters must be considered. The NUMARC program is expected to provide ampacity derating factors for one and three hour barriers, for cable trays and conduits. Assuming NRC agreement with the IEEE P848 approach, few if any installations are expected to fall outside the generic scope.

Based on preliminary reviews completed to date, it appears that the Texas Utilities (TU) and the Tennessee Valley Authority (TVA) ampacity test results may not be applicable to the Prairies Island Station. Therefore, no comparison to these configurations have been made at this time. This comparison will be made, however, during the full scale implementation of the qualification program.

As indicated by the NSP response dated June 24, 1993 (Reference b), the Prairie Island design addressed power cable ampacity derating using an analytical approach rather than using the originally published TSI ampacity derating factors. This analytical approach was used because it provided conservative, yet practical results. These values were conservative as compared with the values originally published by TSI and are in line with the preliminary results of the TU testing for a similar configuration.

The following screening approach will be used in documenting acceptable ampacity values for wrapped raceways after the need for upgrades have been determined (Task 3, Item 2.3 of Section B of this attachment):

1. Values from the NUMARC Industry Program, as well as applicable TU and/or TVA test results, will be used to confirm that acceptable cable ampacity design is documented. The effect of

any reduction to cable ampacity would be assessed to ensure that the cable's actual load current does not exceed the calculated ampacity.

2. The analytical approach used for the Prairie Island design can be applied to any upgrades that may be made to the existing in-plant barriers to determine the ampacity derating for these upgraded configurations. Because the heat transfer models for the upgraded configurations may be more complex than the design configurations, the analytical approach may need to depend on some conservative assumptions. Where these assumptions result in impractical ampacity derating, the NUMARC testing (and perhaps the TU and TVA testing, if applicable) will be used as a basis for the removal of some conservatism.

3. Where the load current appears to exceed the calculated ampacity, detailed calculations will be performed to address each apparent overload. These detailed calculations would consider the actual heat (I^2R) generated by each cable (Stolpe's method assumes that each cable carries its allowable current, while the cables may actually be carrying less than this value and some may carry no current at all).

4. Where these methods do not resolve the apparent overload, a variety of alternatives are available, including the following:

   a. consideration of the actual ambient temperature in the area of the cable tray (actual temperature may be lower than maximum design temperature),

   b. rerouting of the specific "problem" cable,

   c. perform site specific testing of the configuration or

   d. derate the barrier to a one hour barrier and eliminate the need for the upgrade

IV.B.2 For the barriers you have determined fall within the scope of the NUMARC program, describe what additional testing or evaluation

you will need to perform to derive valid ampacity derating factors.

Response:

Refer to the response to Item IV.B.1.

IV.B.3 **For the barrier configurations that you have determined will not be bounded by the NUMARC test program, describe your plan for evaluating whether or not the ampacity derating tests relied upon for the ampacity derating factors used for those electrical components protected by Thermo-Lag 330-I (for protecting the safe-shutdown capability from fire or to achieve physical independence of electrical systems) are correct and applicable to the plant design. Describe all corrective actions needed and submit the schedule for completing such actions.**

Response:

Refer to the response to Item IV.B.1. With regard to schedules, refer to the response to Item VI.B

IV.B.4 **In the event that the NUMARC fire barrier tests indicate the need to upgrade existing in-plant barriers or to replace existing Thermo-Lag barriers with another fire barrier system, describe the alternative actions you will take (and the schedule for performing those actions) to confirm that the ampacity derating factors were derived by valid tests and are applicable to the modified plant design.**

Response:

Refer to the response to Item IV.B.1. With regard to schedules, refer to the response to Item VI.B

V. **Alternatives**

V.B **Describe the specific alternatives available to you for achieving compliance with NRC fire protection requirements in plant areas that contain Thermo-Lag fire barriers. Examples of possible alternatives to Thermo-Lag-based upgrades include the following:**

1. **Upgrade existing in-plant barriers using other materials,**

2. **Replace Thermo-Lag barriers with other fire barrier materials or systems,**

3. **Reroute cables or relocate other protected components.**

4. **Qualify 3-hour barriers as 1-hour barriers and install detection and suppression systems to satisfy NRC fire protection requirements.**

Response:

Currently, there are five undefined factors that must be considered in determining whether upgrades using additional Thermo-Lag materials are practical, and what alternatives would be most appropriate in case Thermo-Lag upgrades cannot be developed:

1. Test and acceptance criteria have not been finalized and issued by NRC. Proposed draft criteria contain new conservatism in fire test methods and acceptance criteria that could affect the scope and complexity of upgrades to installed barriers. The content of the final criteria, and the resulting impact on Prairie Island specific action plans, is uncertain.

2. Complete Phase 2 test results will not be known until the mid-March time frame. Results of baseline (as installed) and upgraded test configurations from Phase 2 must be considered to determine appropriate Prairie Island action plans to address specific configurations.

3. The Application Guideline, to be final by mid-April, will include a matrix of important performance parameters and bounding conditions. Discussion with NRC will be necessary to reach agreement on the comparison parameters and bounding conditions. The results of these NRC interactions will define the final document and would directly impact the generic

applicability of a given test to an installed configuration.

4. The expanded NUMARC test program would expand the coverage of the NUMARC program and would potentially include alternate material, refer to Response to III.B.2, Item 6.

5. Finalization of the ongoing NRC reviews of test reports of fire barrier materials other than Thermo-Lag, such as 3M, Kaowool, etc. This review is indicated by the statement included in Information Notice IN 93-41 that "the staff previously requested additional information on Kaowool from Thermal Ceramics, Inc. in a letter of April 27, 1993, and on 3M fire barrier systems from 3M Company in a letter of May 4, 1993." Therefore, without clear indication of NRC's position on those materials, NSP can not replace certain Thermo-Lag installations in Prairies Island Power Station with another material, say 3M, only to find out that the NRC has identified concerns with the related test report.

The four possible alternatives listed in the 10 CFR 50.54(f) letter will be considered in the NSP evaluation program. In addition, the following alternatives will be considered:

- Reevaluation of engineering analyses used for determination of Appendix R safe shutdown pathways, equipment, and actions. This could provide a basis for reduction in scope of protected circuits, and their associated fire barriers.

- Exemption requests could be submitted based upon the use of fire modeling in conjunction with NUMARC's baseline (non-upgraded) test results to demonstrate adequate protection for the postulated hazard. Alternatively or in conjunction, probabilistic safety assessment (PSA) could be used as an exemption basis, by demonstrating insignificant core damage frequency impacts assuming barrier inoperability.

- Reevaluation of licensing commitments that may exceed the requirements of the pertinent regulations may be undertaken.

- Use the 20-foot separation criteria with installation of suppression and detection where necessary to meet NRC requirements.

- Installation of fire-rated cable or structural fire barriers.

VI. Schedules

VI.B Submit an integrated schedule that addresses the overall corrective action schedule for the plant. At a minimum, the schedule should address the following aspects for the plant:

1. Implementation and completion of corrective actions and fire barrier upgrades for fire barrier configurations within the scope of the NUMARC program,

2. Implementation and completion of plant-specific analysis, testing, or alternative actions for fire barriers outside the scope of the NUMARC program.

Response:

The scheduling of the resolutions of the various items in the station's scope will be established based on the combined worth of the following factors:

1. Importance to safety (PRA/PSA)
2. Contribution to the completion of the scope in a given area/zone or raceway
3. Cost of the fix
4. Economy of grouping of fixes, as opposed to implementing the work for one item as soon as its fix is finalized
5. Outage schedules, where applicable
6. Potential for teaming arrangement with other stations/utilities on site specific testing

The implementation of modifications in the field, or site specific testing, need careful planning and integration with other station activities (e.g., outages). This requires adequate time to design the most effective, and

at the same time the most economic, resolutions. Site specific testing and upgrades will not be started until the impact on ampacity (for the safe shutdown cables in the entire raceway), the ability of the seismic supports to accommodate the additional weight, and the fire loading of the area (combustibility review) are evaluated and determined to be acceptable. Also, engineering evaluation of the design/licensing basis and resolution by analysis reviews will be completed first before field work and/or site specific testing are committed. This is to avoid doing expensive and operation disruptive field work that would not be required after these reviews are completed. For example, the review of the safe shutdown analysis may identify equipment and their associated cables, such as cubicle coolers, that can be deleted from the requirements of fire wrap.

Although timely resolution of the Thermo-Lag problem is desirable, adequate time to ensure prudent resolutions are reached is important for the economic performance of the plant, as long as provisions are in place to ensure the plant's safe operation are maintained in the interim period. Accordingly, the attached preliminary schedule for the station (Attachment 4) was developed based on the station's program plan for the resolution and takes into account the above considerations.

The schedule in Attachment 4 reflects the time frame required to complete the engineering evaluation and the field work for the entire scope, whether bound or not bound by the NUMARC program. Any modifications requiring plant shutdowns shall be completed within the following scheduled outages:

Unit 2 Outage Starts 5/27/95
Unit 1 Outage Starts 1/6/96

Note that the coming Unit 1 outage starts in May 1994 which is too early to take it into consideration.

As explained previously in Section B, item 2.1, the project team at NSP has already begun in preparing the key plan drawings of the Thermo-

Lag wrap design basis. But the completion of Task 1 and the subsequent full scale implementation of that program is scheduled to start within one month from the release of the NUMARC application guidance. This ensures a stabilized basis for committing resources to such an extensive program. At the same time, this start date allows for timely receipt of input from the ampacity portion of the NUMARC and the expanded scope of the NUMARC testing. It is hoped also that the finalized NRC acceptance criteria (Supplement 1 to GL 86-10) will be released within the same time frame.

Below is the current schedule for the NUMARC program activities. As noted previously, information on the expanded NUMARC test program will be available in April 1994.

Activity	Schedule (1994)
Issue Phase 1 test reports	January 31
Perform Phase 2 testing	January 26 March 24
Generic test program scope information	April 1
Shared testing information	April 1
Issue Phase 2 test reports	April 15
Issue Application Guide	April 15
Ampacity program information	April 29
Perform ampacity testing	July (estimated)
Issue Ampacity test report	August (estimated)

*NUMARC did not release this report as of this date.

VII. Sources and Correctness of Information

VII.B Describe the sources of the information provided in response to this request for information (for example, from plant drawings, quality assurance documentation, walk downs or inspections) and how the accuracy and validity of the information was verified.

Response:

The following sources were used as the basis for preparing this response:

1. Report No. SL-4894, Revision Draft, dated 2/10/94 - Program Plan for Cable Raceway Fire Barrier Qualification at Prairies Island Station.

2. Stone and Webster Ampacity Study Report Number 1291.23-E(D)-1.

3. Thermo-Lag Test Reports, I.T.L 85-1-106, 85-4-377, and 84-12-181

4. Thermo-Lag Installation Procedure, 20684

5. Prairie Island Modification Package 83Y480

Please note that the preparation of this response required 160 person-hours to complete.

TABLE 1
PRAIRIE ISLAND POWER STATION
THERMO-LAG INSTALLATION SUMMARY

BARRIER				RACEWAY								
NO.	RATING	FIRE AREA	BARRIER MATERIAL REMOVED	CABLE IDENTIFICATION	TYPE	DRAWING NO	WIDTH OR DIA	HT	LGTH (FT.)	MAT	% FILL	FHA DRAWING NO
2SG-LA11-001	1 HOUR	31	YES	2SG-LA11	T	NF-40107-2	9"	6"	7.5	TL	26.5	FHA-003
TB-2304-001	1 HOUR	31	YES	TB-2304	B	NF-40107-2	APP. 2'	APP. 3'	2'	TL	N/A	FHA-002
1AG-LB1-001	1 HOUR	58	NO	1AG-LB1	T	NF-40112-1	30"	6"	9	TL	11.3	FHA-007
1AG-LB1-001	1 HOUR	58	NO	1AG-LB2	T	NF-40112-1	30"	6"	6.5	TL	10.2	FHA-007
1AG-LB1-001	1 HOUR	58	NO	1AG-LB3	T	NF-40112-1	30"	6"	7.5	TL	10.4	FHA-007
1AG-LB1-001	1 HOUR	58	NO	1AG-LB4	T	NF-40112-1	30"	6"	6	TL	12.6	FHA-007
1AG-LB1-001	1 HOUR	58	NO	1AG-LB11	T	NF-40112-1	30"	6"	15	TL	4.2	FHA-007
1AG-LB28-001	1 HOUR	58	YES	1AG-LB12	T	NF-40112-1	30"	6"	17.5	TL	1.9	FHA-007
1AG-LB8-001	1 HOUR	58	NO	1AG-LB28	T	NF-40112-1	18"	6"	10	TL	21.5	FHA-007
1AG-LB9-001	1 HOUR	58	NO	1AG-LB8	T	NF-40112-1	9"	6"	7	TL	3.7	FHA-007
1AR-LB6-001	1 HOUR	58	YES	1AG-LB8	T	NF-40112-1	9"	6"	5	TL	3.7	FHA-007
1AM-LB1-001	1 HOUR	59	YES	1AR-LB6	T	NF-40112-1	18"	6"	5	TL	21.5	FHA-007
1AM-LB10-001	1 HOUR	59	NO	1AM-LB1	T	NF-40113-1	24"	6"	21.5	TL	18.62	FHA-008
1AM-LB10-001	1 HOUR	59	NO	1AM-LB9	T	NF-40113-1	30"	6"	13.5	TL		FHA-008
1AM-LB2-001	1 HOUR	59	YES	1AM-LB10	T	NF-40113-1	30"	6"	6.5	TL		FHA-008
1AM-LB2-001	1 HOUR	59	YES	1AM-LB2	T	NF-40113-1	30"	6"	3.5	TL	12.7	FHA-008
1AM-LB24-001	1 HOUR	59	NO	1AM-LB3	T	NF-40113-1	30"	6"	19	TL	17.1	FHA-008
1AM-LB25-001	1 HOUR	59	YES	1AM-LB24	T	NF-40113-1	9"	6"	28.5	TL	28.2	FHA-008
1AM-LB25-001	1 HOUR	59	YES	1AM-LB25	T	NF-40113-1	18"	6"	7	TL	14.1	FHA-008
1AM-LB25-001	1 HOUR	59	YES	1AM-LB27	T	NF-40113-1	18"	6"	61.5	TL	21.5	FHA-008
1AM-LB3-001	1 HOUR	59	YES	1AM-LB28	T	NF-40113-1	18"	6"	52.5	TL	21.5	FHA-008
1AM-LB3-001	1 HOUR	59	YES	1AM-LB3	T	NF-40113-1	30"	6"	5	TL	17.1	FHA-008
1AM-LB3-001	1 HOUR	59	YES	1AM-LB4	T	NF-40113-1	30"	6"	5	TL	17.1	FHA-008
1AM-LB4-001	1 HOUR	59	YES	1AM-LB5	T	NF-40113-1	30"	6"	5	TL	16	FHA-008
1AM-LB5-001	1 HOUR	59	YES	1AM-LB4	T	NF-40113-1	30"	6"	22.5	TL	17.1	FHA-008
1AM-LB5-001	1 HOUR	59	YES	1AM-LB5	T	NF-40113-1	30"	6"	4	TL	16	FHA-008
1AM-LB6-001	1 HOUR	59	NO	1AM-LB6	T	NF-40113-1	30"	6"	17.5	TL	11.5	FHA-008
1AM-LB6-001	1 HOUR	59	NO	1AM-LB6	T	NF-40113-1	30"	6"	5	TL	11.5	FHA-008
1AM-LB7-001	1 HOUR	59	NO	1AM-LB7	T	NF-40113-1	30"	6"	5	TL	12.5	FHA-008
1AM-LB8-001	1 HOUR	59	NO	1AM-LB8	T	NF-40113-1	30"	6"	12.5	TL	12.5	FHA-008
1AM-LB9-001	1 HOUR	59	NO	1AM-LB8	T	NF-40113-1	30"	6"	17.5	TL	3.06	FHA-008
1AM-LB9-001	1 HOUR	59	NO	1AM-LB9	T	NF-40113-1	30"	6"	3	TL	3.06	FHA-008
1AR-LB6-002	1 HOUR	59	YES	1AR-LB6	T	NF-40113-1	18"	6"	3	TL		FHA-008
16405-1-001	1 HOUR	59	NO	16405-1	C	NF-92179-3	4"	N/A	15	TL	21.5	FHA-008
25405-1D-001	1 HOUR	73	NO	25405-1D	C	NF-92178-4	4"	N/A	75	TL	21.2	FHA-008
25405-1D-002	1 HOUR	73	NO	25404-1	C	NF-92178-4	4"	N/A	75	TL	21.2	FHA-029
25405-1D-002	1 HOUR	73	NO	25405-1D	C	NF-92178-4	2.5"	N/A	65	TL	40.5	FHA-029
							4"	N/A	65	TL	21.2	FHA-029

RACEWAY: C=CONDUIT, T=TRAY, MC=MULT CONDUIT, B=JUNCT BOXES

TABLE 1
PRAIRIE ISLAND POWER STATION
THERMO-LAG INSTALLATION SUMMARY

BARRIER				RACEWAY								
NO	RATING	FIRE AREA	BARRIER MATERIAL REMOVED	CABLE IDENTIFICATION	TYPE	DRAWING NO	WIDTH OR DIA	HT	LGTH (FT)	MAT	% FILL	FHA DRAWING NO
2AM-LB1-001	1 HOUR	74	YES	2AM-LB1	T	NF-40476	24"	6"	17	TL	14 7	FHA-030
2AM-LB1-001	1 HOUR	74	YES	2AM-LB30	T	NF-40476	24"	6"	7 5	TL	8 7	FHA-030
2AM-LB2-001	1 HOUR	74	NO	2AM-LB2	T	NF-40476	30"	6"	3	TL	8 5	FHA-030
2AM-LB2-001	1 HOUR	74	NO	2AM-LB3	T	NF-40476	30"	6"	20	TL	8 5	FHA-030
2AM-LB3-001	1 HOUR	74	YES	2AM-LB3	T	NF-40476	30"	6"	5	TL	8 5	FHA-030
2AM-LB3-001	1 HOUR	74	YES	2AM-LB4	T	NF-40476	30"	6"	5	TL	12 7	FHA-030
2AM-LB3-001	1 HOUR	74	YES	2AM-LB5	T	NF-40476	30"	6"	5	TL	8 2	FHA-030
2AM-LB4-001	1 HOUR	74	YES	2AM-LB4	T	NF-40476	30"	6"	15	TL	12 7	FHA-030
2AM-LB5-001	1 HOUR	74	YES	2AM-LB5	T	NF-40476	30"	6"	7 5	TL	8 2	FHA-030
25405-1D-003	1 HOUR	74	NO	25403-1D	C	NF-92178-4	3 5"	N/A	15	TL	20 7	FHA-030
25405-1D-003	1 HOUR	74	NO	25404-1	C	NF-92178-4	2 5"	N/A	15	TL	40 5	FHA-030
25405-1D-003	1 HOUR	74	NO	25405-1D	C	NF-92178-4	4"	N/A	15	TL	21 2	FHA-030
								TOTAL	839.5			

RACEWAY: C=CONDUIT, T=TRAY, MC=MULT CONDUIT, B=JUNCT BOXES

TABLE 2
(Page 1 of 2)

TESTED AND BOUNDED CONFIGURATIONS
RACEWAY PARAMETERS

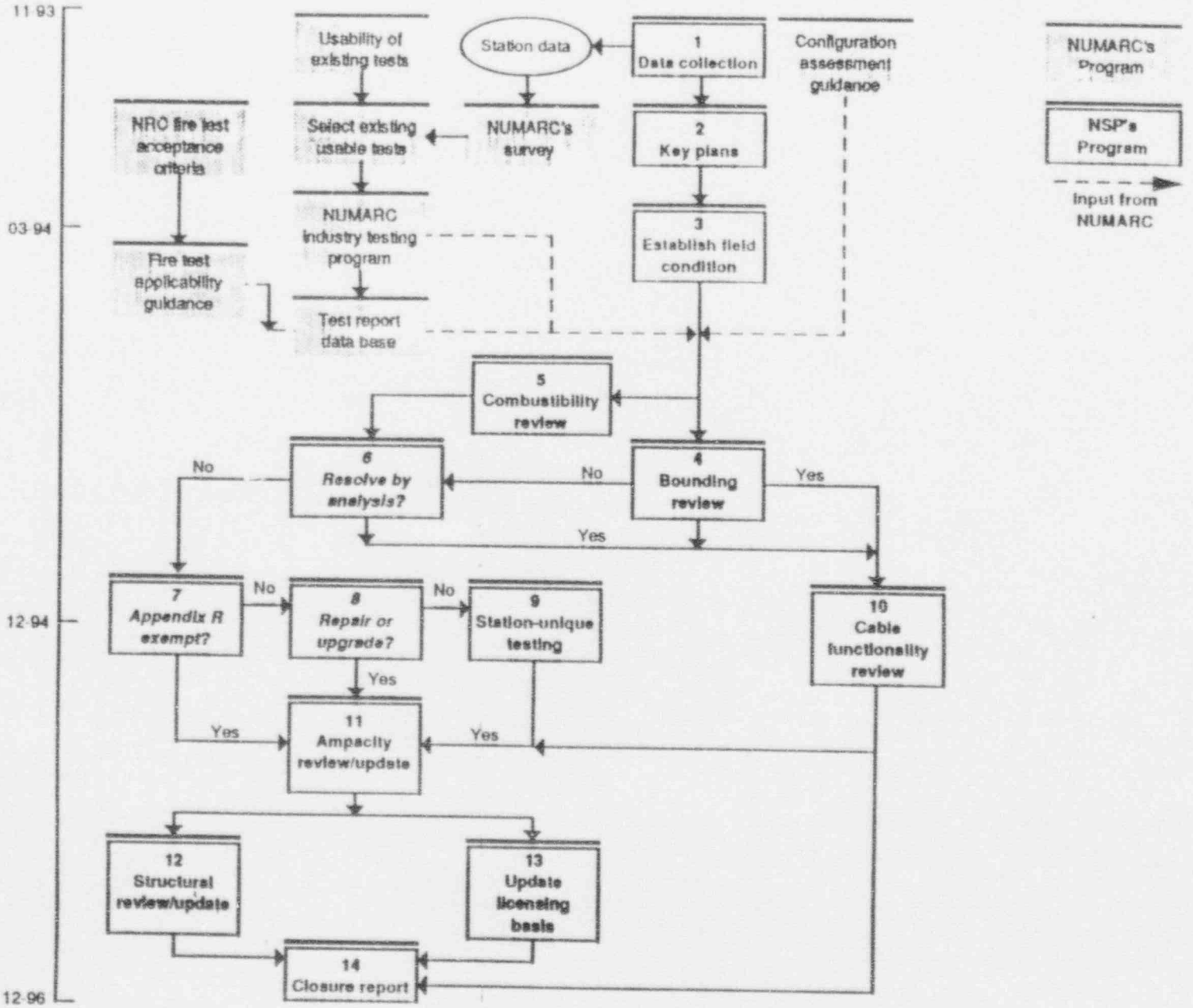
Tested Configuration	Bounded Installed Configuration
Orientation (horizontal, vertical, radial bends	All orientations
Dimensions (small and large limits)	Range bounded by test specimen dimensions
Conduit (No cable)	Conduits, bounded by test specimen dimensions, with any cable fill
Junction Boxes and Lateral Bends	Junction Boxes and Lateral Bends bounded by test specimen dimensions
Ladder Back Cable Tray with or single layer cable fill	Solid back and ladder back cable trays or equal less dimensions and equal or greater cable fill (in terms of thermal mass) Boxed Conduits, Boxed Enclosures (of equal or greater thermal mass and equal or less dimensions)
Cable Tray with T-Section	Cable Tray of equal or less dimension with T-section, and equal or greater cable fill
Aluminum	Steel (side by side testing of conduits and trays will be conducted to validate bounding condition)
Support protection, thermal shorts (9" protection for one hour, 18" protection for three hour)	Thermal Shorts with equivalent or greater protection
Air Drops	Air drops of equivalent construction and dimensions
Box barrier systems attached to concrete walls, ceilings, etc.	Barrier systems of similar construction

TABLE 2
(Page 2 of 2)

FIRE BARRIER PARAMETERS

Tested Configuration	Bounded Installed Configurations
Baseline Panel thickness (On Hour 0.50", +0.125", -0") (Three Hour 1.00", +0.250", -0")	Equal of greater panel thickness
Preformed conduit panels	Sprayed on or troweled on installations of equivalent or greater thickness and stress skin configuration
Panel Ribs (parallel to raceway)	Parallel or perpendicular to raceway
Unsupported span (typically 48")	Equal or less dimensions
Stress Skin (One hour, inside) (Three hour, inside and outside)	As tested, plus panels using additional stress skin
No stress skin over joints	Stress skin over points
No stress skin ties	Stress skin ties
Dry fit, post buttered joints	Pre-buttered joints
Joint gap width	Equivalent or small gap width
Butt joints	Grooved and scored radial bends
Cable tray radial bends with separate mitered pieces	Grooved and scored radial bends
Steel bands	Tie wires (will be validated through testing)
Band/wire spacing	Equivalent or closer spacing
Band/wire distance to joints	Equivalent or closer distance
No internal bands in trays	Internal bands in trays
No additional trowel material over sections, joints	Additional trowel material applied
No edge guards	Edge guards

Prairie Island Power Station Program for Thermo-Lag Resolution



Attachment 2

Analytical Approach to the Determination of Actual Envelope/Cable Temperature for Station Cases with Other than 15% Cable Fill Inside Thermo-Lag Wrapped Raceways (Trays)

General Discussion:

At the current time, the NUMARC testing program for Thermo-Lag covers a set of standard configurations which are commonly found at the member utilities stations based upon the survey results submitted to NUMARC. These configurations will be tested using a cable mass equivalent to 15% fill for the trays tested. This will result in all cases with greater than 15% fill being bound by the tests and those with less than 15% not bound. Also, the test results may be conservative for those cases with significantly greater than 15% cable fill.

An analytical method needs to be developed for evaluating the cases which are not bound by the NUMARC test program in order to avoid station specific testing or unnecessary modifications. Unlike other configuration parameters affecting the Thermo-Lag performance in fire endurance testing, cables' thermal mass is a mathematically quantifiable parameter. Therefore, a slightly modified NUMARC testing detail can provide adequate data to establish the effects of the cable fill on the temperature performance of the wrap assembly. This evaluation method could also be used to establish the conservatism in the cases where more than 15% fill occurs in order to reduce the scope of the cable functionality reviews which will be required as a result of some of the testing exceeding the temperature acceptance criteria.

Sargent & Lundy (S&L) has the capability to adapt one of our existing computer programs for the task as described above. This program has been used successfully to evaluate the temperature of structural steel members with damaged or degraded fire proofing materials at several nuclear power stations. If the results of the current NUMARC testing program are made available, S&L can use these results to perform benchmark evaluations. The purpose of these evaluations would be to establish the effect of the cable fill on the Thermo-Lag enclosure's temperature performance. This effort would provide a methodology which could be used to predict the actual temperatures within the enclosure for site specific cable fill conditions.

Technical Basis:

S&L employs an advanced computer program that uses the finite element method to perform three-dimensional linear and nonlinear transient heat transfer analyses. The program can solve the field equations representing the radiation, conduction and convection modes of heat transfer between the heat source/sink and the material in question. A wide variety of material models and heat transfer coefficients can be modeled with precision. Using this computer program, the heat input to the cable tray will be modeled as a radiation heat exchange (emission and absorption) between the fire and the Thermo-lag enclosure surface. The Thermo-Lag enclosure will be prescribed

with a nonlinear conductivity model in order to simulate the heat transmission from the exterior to the interior. The transfer of heat from the enclosure to the cable tray and the cable will be modeled using a combination of conduction and radiation. The test configuration and thermal properties of the cable tray and the cables will be simulated as close as possible in order to duplicate the temperature history using a nonlinear transient analysis.

Proposal:

S&L requests that we be authorized to develop the methodology discussed above. The steps involved in this process are listed below. A listing of the input to the evaluation process is also provided.

Process:

1. Review a representative sample test results from the various configurations tested to date (e.g., NUMARC Test 1-5).

2. Develop a computer model of the enclosure and the cable fill. This model would provide nodes at the thermocouple locations which would be compared to the test time history.

3. Perform a time history analysis of the initial model subjecting it to the test temperatures outside the enclosure and iterating the insulating behavior of the Thermo-Lag materials to achieve a match with the thermocouple readings taken during the test.

4. Using this initial model, we would then compare the results of subsequent tests to the calibration run discussed in Step 3. This would be used to develop a model which would envelope the results of the test of the 15% cases.

   Note that in order to develop the process, test results from identical enclosures with at least two different fill levels are needed. We suggest that an arrangement similar to test assembly 2-11 be tested at 5% fill and at 15% fill, preferably within the same test.

5. Use the results of the identical configurations with different fill level (5%) to determine the effect of the cable fill on the temperatures within the enclosure.

6. Based upon the results of the comparison done in Step 5, develop an evaluation methodology to predict the effect of cable fill on the envelop temperatures.

Input Required:

1. Test assembly details and time history results of some recent testing of Thermo-Lag which are currently available (for example, NUMARC Test 1-5).

2. Test assembly cross-section details of the configuration being tested in accordance with this proposal. As suggested above, assembly 2-11 with 5% and 15% fill would serve as a good basis.

3. NUMARC testing results of one identical assembly using two different fills in the test.

Deliverables:

The deliverable for this task is a summary report documenting analytical findings, comparison to test results and a guideline which can be used to perform analytical investigation to assess cable trays with non-standard cable fills. The basis for this guideline would be justified in calculations which would be available to NUMARC.

Applications:

The attached figures illustrate how time temperature curves from NUMARC test (15% cable fill) modified using the proposed methodology can be used to address site specific actual cases of less than 15% (Case 1) and more than 15% (Case 2).

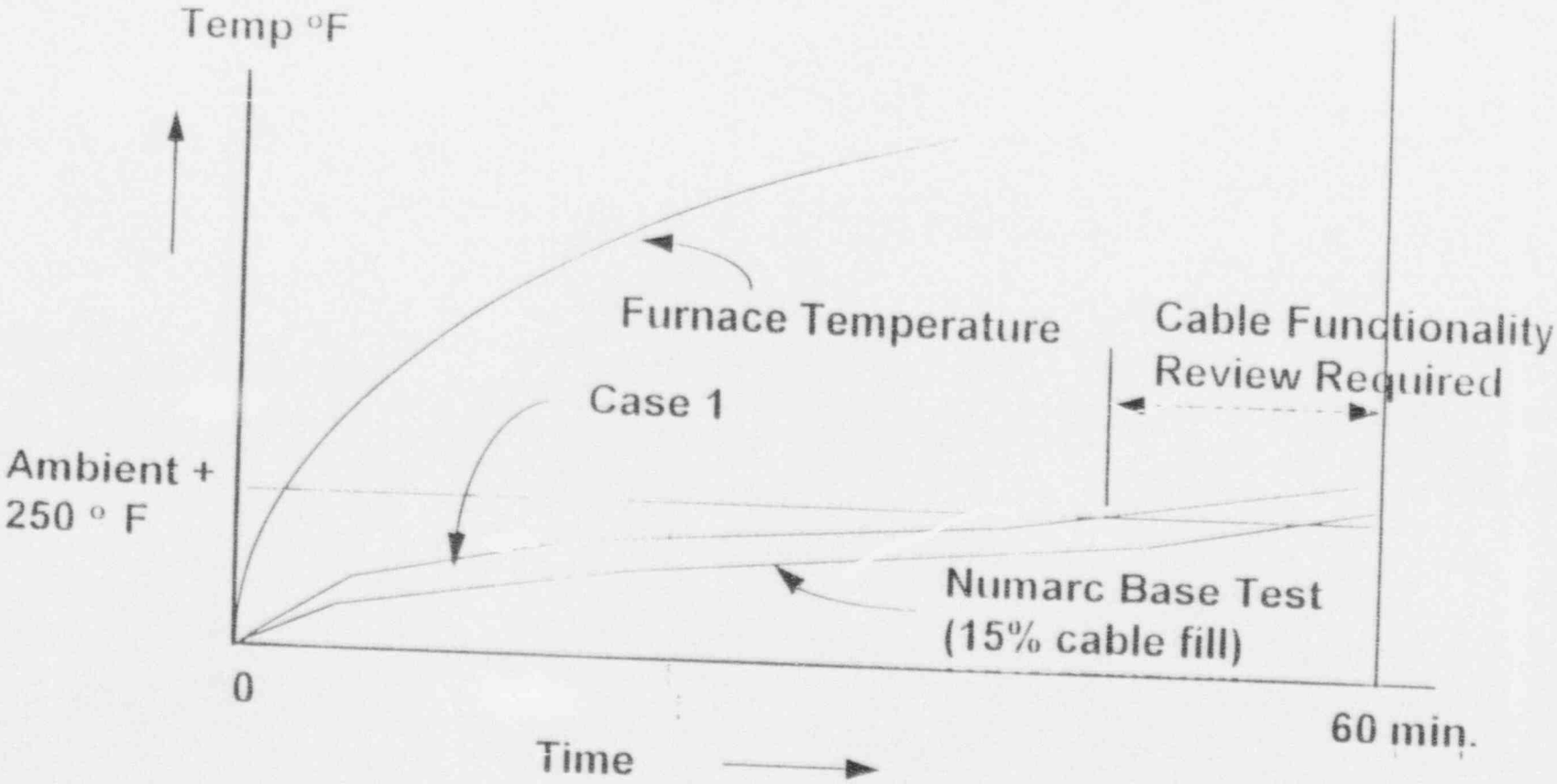
R. Knoebel
(312) 269-6297

M. A. Milad
(312) 269-8606

MAM:cab
c:\mam\case1.3

Sample Time Temperature Curve

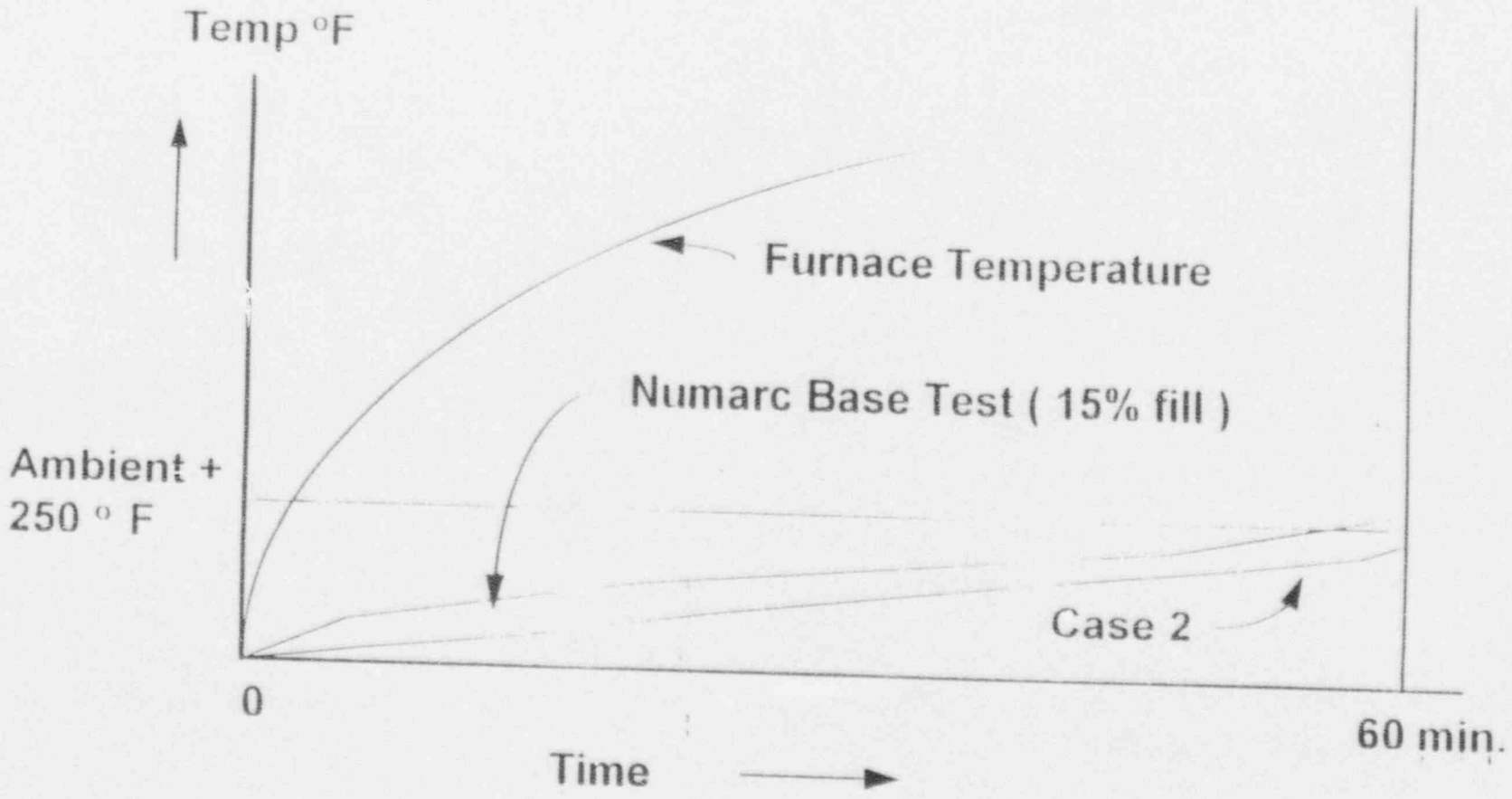
Case 1 : Actual Cable Fill Less Than 15%



Attachment 3

Sample Time Temperature Curve

Case 2 : Actual Cable Fill Greater Than 15%



Attachment 4