COOPER NUCLEAR POWER STATION

10 CFR 50, APPENDIX R

SUPPLEMENTARY INFORMATION REPORT

TO VOLUMES I AND II

SUBMITTED TO NRC

JUNE 28, 1982

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1. INTRODUCTION

On June 28, 1982, Nebraska Public Power District (NPPD) requested exemptions from Section III.G of Appendix R for seven plant areas and for the generic category of three-hour rated fire boundaries.[1/] Based on the Draft Safety Evaluation transmitted December 14, 1982, to J. M. Pilant from D. B. Vassallo, the NRC Staff made a preliminary conclusion that the existing and proposed level of fire protection provided for six plant areas and the generic category of fire boundaries does not achieve the required level of safety and recommended denial. A review of this preliminary recommendation indicates, however, that the Staff's evaluation did not consider all of the pertinent information contained in the June 28, 1982, submittal. It is believed that a more detailed Staff review of specific information contained in the Cooper Nuclear Station Appendix R analysis, which may have been overlooked, would lead to the conclusion that granting exemptions from the requirements of Appendix R would achieve the required level of protection of the

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1/ Letter from Mr. J. M. Pilant (NPPD) to Mr. D. B. Vassallo (NRC), Subject: Fire Protection Rule 10 CFR 50, Appendix R, Cooper Nuclear Station NRC Docket No. 50-298, DPR-46, LQA8200158, dated June 28, 1982.

public health and safety. For this reason, Nebraska Public Power District is submitting this report with the objective of further clarifying the extent of fire protection modifications completed to date and proposed for implementation and outlining the bases for their adequacy.

This review also establishes the basis for the Staff's previous conclusions in the Fire Protection Safety Evaluation Report (FPSER) concerning the fire protection safety of Cooper Nuclear Station (Amendment 56 to the Facility Operating License), notes any changes in the plant's design or operation which may affect the validity of those conclusions, outlines the detailed analysis presented in the June 28, 1982, Appendix R submittal including additional proposed modifications, and presents the basis for the Staff's rejection of these proposals. The purpose of this review is to demonstrate that a basis exists for concluding that the required level of protection of the public health and safety may be provided at Cooper Nuclear Station through implementation of those features previously defined by the NRC in the FPSER, proposed by NPPD in the June 28, 1982, Appendix R analysis, and proposed in this Supplement.

This report also addresses analytical methodology issues raised by the Staff in its SER and areas of uncertainty highlighted by Brookhaven National Laboratory (BNL) in their review of the Cooper analysis. Each issue is discussed in the context of clarifying areas of possible oversight or confusion concerning the relationship of the methodology to the fire hazard considered in the development of the Appendix R separation criteria (i.e., 2-5 gallons of flammable liquid).[2/]

NPPD has also performed additional detailed hot shutdown system circuit analysis and has confirmed that the HPCI System is capable of maintaining the plant in the hot standby condition with depressurization provided through the HPCI test line as soon as the RHR system is available for eventual cold shutdown. NPPD proposes to modify the HPCI system which will ensure system operation considering the potential level of damage postulated to system control circuits in the Control Room, Cable Spreading Room, or Auxiliary Relay Room thus providing alternate shutdown capability.

The proposed modification to HPCI would change the block diagram, Figure 4-2, Volume I of our June 28, 1982, response to having only HPCI being required for hot shutdown at Cooper Nuclear Station.

2/ Memorandum from Mr. H. R. Denton, D/NRR, to Mr. R. B. Minogue, D/RES, dated April 24, 1981.

2. SUMMARY RESPONSE TO NRC COMMENTS REGARDING MODELING METHODOLOGY

In their review, BNL applauded Cooper Station for utilizing a structured process based upon well-documented and proper analytical methods to evaluate the effects of fires on safe shutdown systems. In that context, BNL also raised questions concerning areas of confusion regarding the uniform application of these models in individual instances. These questions were presented by BNL in a positive manner more in an apparent attempt to suggest methods of improving upon the presentation of analytical results rather than to criticize the methodology.

With this perspective, the Staff's highly critical tone in their treatment of the modeling methodology is surprising and without apparent basis. Areas of potential uncertainty, identified by BNL with the goal of enhancing the review process of an essentially sound methodology, were restated by the Staff in the SER as a justification for disregarding the Cooper analysis and not recognizing the results. In so doing, the Staff appears to have missed, entirely, BNL's summary evaluation of the Cooper Station fire hazards analysis:

> "The unit-problem approach employed, together with the correlations and electrical cable damage criterion, can be classified as most current and methodologically consistent with what is being suggested in the open literature as a viable approach for assessing the fire hazard potential associated with cable tray fires.

> "Thus, in most respects, we find the method employed to be technically sound and the overall approach, if applied properly (as described subsequently) could yield realistic and conservative results for assessing the thermal environment in the fire area."[1/]
>
> (emphasis added)

The Staff's reorientation of selected passages of BNL's effort did not lead to recognition of the research in the literature to confirm the methodology's basis and validate the analysis through audit calculations. No mention is given by the Staff to this extensive confirmatory effort on the part of BNL nor does the Staff appear to acknowledge the sophistication and high quality of analysis.

The comments made by BNL in the review are responded to in Section 3 of this report. It should be stated at this point that no issues are taken with BNL's comments. Rather the responses are fundamentally clarifications of areas of uncertainty, acknowledge BNL corrections of typographical errors, or present more detailed information where necessary.

This section responds to the Staff's utilization of the BNL general comments concerning the modeling methodology in support

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1/ Letter from Mr. John L. Boccio, BNL, to Mr. Randall Eberly, DE/CEB, Subject: "Evaluation of the Analytical Fire Modeling by Nebraska Public Power District in Cooper Nuclear Station, Response to 10 CFR 50, Appendix R, 'Fire Protection of Safe Shutdown Capability'", dated November 2, 1982.

of their apparent rejection of the process. The comments responded to herein appear to be the only known basis for that Staff position. It is believed that although the BNL comments as they appear in the SER were taken out of context, a satisfactory resolution of the Staff's concerns may nevertheless be achieved and the basis for rejecting the methodology removed.

SER Comment:

> "The method does not consider the heat released to the room by secondary fires involving in-situ combustibles. The method uses an electrical failure criteria with the thermal energy release to the room by a single exposure fire. When the cables of concern are at the conditions of electrical failure, other cables within the enclosure are burning and also releasing energy to the room."

Response:

Present test data for electrical cable fires indicates that the heat release rate per unit surface area is small in comparison with the exposure fires postulated in the Cooper Analysis.[2,3,4]

2/ I. I. Pinkel, "Estimating Fire Hazards Within Enclosed Structures As Related to Nuclear Power Stations", BNL-NUREG-23892, Brookhaven National Laboratory, Upton, NY, January, 1978.

3/ A. Tewarson, "Categorization of Cable Flammability", NP-1200, Electric Power Research Institute, Palo Alto, CA, October, 1979.

4/ J. Lee, "A Study of Damageability of Electrical Cables in Simulated Fire Environments", NP-1767, Electric Power Research Institute, Palo Alto, CA, March, 1981.

This fact has been previously explained in detail to the Staff and BNL in a meeting with a utility on another docket. As a result of these discussions at that meeting, both BNL and the NRC Staff agreed that secondary fires in the zone of influence of the exposure fire were not a generic concern. While this phenomenon is generally understood by knowledgeable researchers, the concept of secondary fires is moot in any case at Cooper Nuclear Station since there are few exposed cables in the plant in any area where the model process was used. As is stated in the Cooper analysis for the Control Building Basement, for example, all cables therein are routed in conduit. Hence, the potential for exposed cables igniting and attributing energy to the room simply does not exist. Consequently, the District believes the Staff's rejection of the methodology for lack of completeness in the area of secondary fires is without basis.

SER Comment:

> "The method does not consider the increased heat release rate of a given fire when it occurs against a wall or in a corner; the method only considers the heat release of a fire as it occurs in an open area."

Response:

This issue is based on an apparent misinterpretation of a statement made on page 6 of the BNL evaluation of the NPPD Appendix R Exemption Submittal and represents a need for clarification of the physics involved in the combustion process.

To be precise, the BNL report states that "the models employed and methodology used do not consider the increased heat flux [not "rate" as reported by the Staff], that exposure fires can generate when located near walls and corners." BNL is correct in noting that care must be taken in the application of the models. However, these models are not meant to be completely generalized but rather were intended to meet basic objectives for analyzing the effects of fires as required by the Commission to support exemption requests. Clearly, the mere presence of corners or walls has no effect on any fuel's heat of combustion or, equivalently, its heat release rate contrary to the statement made in the Cooper SER.

SER Comment:

> "The method does not consider the effects of excess pyrolyzate resulting from the degradation of plastics burning in the stratified layer."

Response:

As a phenomenon, excess pyrolyzates resulting from evolution of combustible vapors from cable insulation material (plastics) exposed to heat fluxes have not been reported to be a significant mechanism for failure of cables. Recent Sandia tests of cable tray installations, designed to examine the stratification effects of a heptane fire in a small enclosure, did not report the phenomenon of pyrolyzate accumulation contributing to damage (energy deposition) at the target cables.[5] Furthermore, full-scale cable fire tests conducted by Factory Mutual Research Factory Mutual Research Corporation (FMRC) for Electric Power Research Institute (EPRI) failed to show any evidence of the existence of the phenomenon in nuclear power plant configurations.[6,7]

For practical purposes, this issue is reduced to a triviality at Cooper Nuclear Station because in many plant areas, all cable therein is located in conduit. In the other areas of interest, a high percentage of cables are located in conduit with only isolated instances of exposed tray segments. Due to these facts along with the inherent conservatisms built into the models, excess pyrolyzate effects are insignificant at the Cooper Station. Since the Staff cites such purported effects as a phenomenon of concern and the focus of a perceived deficiency in the Cooper analysis, suitable reference to the literature or NRC research efforts should be noted in order that the issue be considered more directly in future analyses.

5/ L. J. Klamerus, "Evaluation of Twenty-Foot Separation Distance, 10 CFR 50, Appendix R", Interine Report, "Sandia National Laboratories, Albuquerque, NM, May, 1982.

6/ J. P. Hill, "Fire Tests in Ventilated Rooms", NP-2660, Electric Power Research Institute, Palo Alto, CA, December, 1982.

7/ J. S. Newman and J. P. Hill, "Assessment of Exposure Fire Hazards to Cable Trays", NP-1675, Electric Power Research Institute, Palo Alto, CA, January, 1981.

SER Comment:

> "The method does not consider all of the alternatives set forth in Section III.G., i.e., 3-hour fire barrier, 1-hour fire barrier with suppression system, twenty-feet separation free of combustibles with automatic suppression and alternate or dedicated shutdown capability independent of the area. The method only considers separation without automatic suppression and uses a stratification model which does not include the effects of separation."

Response:

The Staff is correct is noting that the methodology does not consider whether the alternative measures alone provide fire resistance equal to a one-hour fire barrier or any other particular alternative in Section III.G. Showing such an equality is not a requirement for an exemption nor was it ever the intention of the Cooper Analysis to demonstrate since, clearly, only another one-hour barrier is precisely equivalent to itself.

As is stated in the submittal, the purpose of the Cooper Analysis was to evaluate the existing fire protection in the form of administrative controls, system separation, detection and suppression and those features proposed for implementation in order to demonstrate that the resulting fire protection program protects the public health and safety to an extent equivalent to the separation criteria of Section III.G. For this reason, the Staff assertion that the methodology fails to model the procedure used to quality fire barriers to the ASTM E-119 standard does not support rejection of the entire analysis. On the contrary, the use of structured analytical techniques to define the nature of alternative fire protection measures, as in the Cooper Analysis, is entirely consistent with the Commission's objectives in establishing the exemption process.

In response to the second item, while it is true that the stratification model does not include the effects of separation, the Staff's comment also lacks candor. As BNL notes in their review,

> "This correlation [i.e., the stratification model] should be adequate for evaluating the heat flux due to pool exposure fires"

With regard to discounting the effects of separation, BNL states that:

> "...the neglect of the decrease in heat flux with radial distance by Newman and Hill [the stratification model] should yield a conservative result."

Rejection of the methodology simply because it is guilty of conservatism is not valid.

It has been noted that the Staff has taken the BNL review and isolated essentially valid questions raised on the application of a "technically sound" methodology in order to justify rejecting the Cooper Nuclear Station analysis in its entirety. As the BNL effort illustrates, reviewing a comprehensive technical analysis is extremely time consuming and demands an attention to detail. The District recognizes the constraints imposed on the Staff by the review schedule and respectfully requests that the above clarification be taken into consideration.

This section has addressed the Staff's basis for rejecting the Cooper analytical methodology. The following section discusses the BNL review itself and responds directly to the technical issues raised therein.

3. SUMMARY RESPONSE TO BNL REVIEW

In their evaluation of the Cooper Analysis, BNL outlined the features of a "state-of-the-art" approach to fire modeling as embodying a unit-problem concept addressing of seven basic features:

(1) burning object;
(2) combusting plume;
(3) hot layer;
(4) cold layer;
(5) targets;
(6) enclosure geometry; and
(7) ventilation.

BNL then assessed the features of the Cooper Analysis in the context of these seven elements to determine the overall validity of the modeling approach and its implementation. In this summary, BNL concluded:

> "The unit-problem approach employed [by NPPD], together with the correlations and electrical cable damage criterion, can be classified as most current and methodologically consistent with what is being suggested in the open literature as a viable approach for assessing the fire hazard potential associated with cable tray fires".

BNL continues:

> "Thus, in most respects, we find the method employed to be technically sound and the overall approach, if applied properly (as described subsequently) could yield realistic and conservative results for assessing the thermal environment in the fire area."

BNL concludes:

> However, we do give credit to NPPD for utilizing current modeling techniques (as we have defined); we give credit for their use of reasonable physical data, and, in some respects, the degree of conservatism employed. To editorialize for the moment, we feel hard-pressed to judge the overall conservatism. In some fire phenomena factors, the models and assumptions lead to overconservatism; in others, non-conservatism prevails.

BNL's review also identified a number of issues related to the application of the model to particular circumstances. These issues are essentially related to "overall traceability" and related concerns over BNL's difficulties in quickly reproducing all of the results. No judgement is made by BNL as to the accuracy of the analysis due to these traceability issues. In fairness to BNL, these difficulties ought not be either surprising or unsettling since the Cooper models required approximately one year to develop. That BNL could accomplish as much in their review in the few weeks available to them is itself an achievement.

The comments presented by BNL in their review may be addressed without a great deal of difficulty. It should be emphasized that, as comments, they represent valid questions raised on the particular application and are indicative of uncertainties which may have been developed in the review process. The responses presented below are directed at the detailed evaluation portion of the BNL letter.

3.1 Appendix A.1 - Heat Release Rate

BNL notes that conservative limits are used to define the combustion process and ventilation effects. No questions or issues appear to be taken with the propriety of the Cooper assumptions.

Response

None deemed necessary.

3.2 Appendix A.2 - Stratification

The review letter of BNL reveals conservatism involved in not taking credit for the variation of heat flux relative to horizontal separation:

> "...the neglect of the decrease in heat flux with radial distance by Newman and Hill should yield a conservative result."

Furthermore, the conservative nature of the modified correlation is granted by BNL:

> "The modified correlation is more conservative than the original".

However, a comment on the effect of walls and corners on the behavior of fire is also made:

> "On the other hand, References 3 and 5 show that if the exposure fire is near a wall or in a corner, the ceiling temperatures increase as if the fire heat release rate is increased by a factor of 2 and 4 respectively. Therefore, care must be taken in applying the Newman and Hill correlation for exposure fires in the vicinity of walls or corners so that non-conservative results are not obtained".

Response

BNL's comments concerning the conservatisms in the stratification model are noted and no response is deemed necessary. Regarding the "corner and wall" effect, BNL is correct in highlighting the importance of taking special care in the application of the models. These models are not meant to be completely generalized but rather are designed to meet the basic objectives of the Commission of performing fire hazard analysis. BNL's concern in this instance may not be appropriate since the phenomenon in question is, in reality, a manifestation of flame stretch associated with a disrupted plume geometry rather than an enhanced combustion process. Intuitively, this follows since the presence of physical walls would not be expected to increase the heat of combustion inherent in any fuel. On the other hand, it should be emphasized that the Newman and Hill correlation which forms the basis for the stratification model is a function of the fuel's heat release rate independent of the coherency of the plume geometry. Consequently, the presence of walls or corners is not considered to be a concern in the behavior of a stratified ceiling layer.

3.3 Appendix A.3 - Diffusion Plumes

BNL notes the following comment concerning the Cooper diffusion model:

> "These models represent the more recent correlations for hydrocarbon pool-fire plumes.

> However, there are several errors, most likely typographical, which should be corrected."

BNL then presents several examples and presumed corrections based apparently on an example of the original papers in the literature.

With regard to heat flux correlations derived from the literature for the stagnation point, BNL comments:

> "The heat flux correlations of You and Faeth for the stagnation region (r/H <0.2) and the ceiling jet are also presented. The correlations are for Rayleigh numbers of 10^9 to 10^{14}, whereas the fires discussed in Section 6 of the submittal have Rayleigh numbers of about 10^{18}. There should be some defense of this extension".

Response

BNL's comments concerning the typographical errors and recommended corrections are appropriate. Regarding the question concerning the You and Faeth correlation, the question is moot since the stagnation heat fluxes were not used in the Cooper analysis. The purpose of providing this information in the exemption submittal was merely to demonstrate that the stratification model is conservative in discounting the effect of horizontal separation for cables at that elevation.

From a phenomenological perspective, it is noted that the perceived limitations in the Rayleigh number are applicable only to the stagnation region at the ceiling and are not valid where cylindrical cross-flow heat transfer is used as is actually employed in the exemption analysis. In response to the BNL comment, no defense of the inferred extension is deemed necessary.

3.4 Appendix A.4 - Radiation

In this section BNL summarizes the radiation model and concludes:

> "These classical expressions and assumptions are acceptable as present state of knowledge in radiant heat transfer."

BNL then notes a minor documentation error and recommends a correction based on their review of the literature.

Response

BNL's comments are noted and no response is deemed necessary. Their identification of the minor typographical error and its correction is appropriate.

3.5 Appendix A.5 - Thermal Shields

> "In Appendix A.5 of the submittal, an analysis is presented which is used to provide a basis for determining the required size of baffles used to protect a vertical stack of trays from convective heating due to direct impingement of an exposure fire plume. A data correlation [10] based on the turbulent wake behind a blunt body is used to obtain an expression for the required baffle width in terms of the downstream extent of the zone to be protected. The condition that the velocity be reduced to 20 percent of the free steam value was used as a protected zone boundary definition. However, it is then implied that the temperature reduction (defect) in the wake is linearly proportional to the velocity defect. A closer review of reference 10 indicates that experimental data

> and theoretical results based on Taylor's assumption of turbulence, rather than Prandtl's theory of free turbulence, results in the wake temperature defect being equal to the square root of the velocity defect. Therefore, a shield which limits the velocity to 20% of the free stream velocity, will only reduce the temperature to 45% of its free stream value. This is less conservative than implied in Appendix A.5".

Response

BNL is correct in noting that the effects of turbulent diffusion on gas temperature are non-linear. However, their conclusion suggesting the potential for non-conservatism in the Cooper analysis is not supported either by analysis or full scale tests.

Two calculations are presented herein for the effects of baffles in disrupting an 1800F (1255K) gas flowing at the rate of 31.2 ft/s (9.1 m/s), characteristic of immersion in a fire. The first case is for a bare cable in space while the second assumes the presence of a baffle. BNL's assumption of 20% freestream gas velocity and 45% freestream excess gas temperature is used to represent the baffled conditions. The calculations and all intermediate steps are presented below:

UNBAFFLED	BAFFLED
$T = 1255.6^{o}K$	$T = 0.45\ (1255.6 - 294.4) + 294.4 = 726.9^{o}K$
$V = 9.5$ m/sec	$V = (0.2)(9.5$ m/sec$) = 1.9$ m/sec
$T_{amb} = 294.4^{o}K$	$T_{amb} = 294.4^{o}K$
$nu = 1.7 \times 10^{-4}\ m^2/sec$	$nu = 7.0 \times 10^{-5}\ m^2/sec$
$Re = 848$	$Re = 416$
$h = 6.06 \times 10^{-2}\ kW/m^2K$	$h = 2.82 \times 10^{-2}\ kW/m^2K$
$q_c = \underline{58.3}\ kW/m^2$	$q_c = h(T-294.4)$ $= \underline{12.2}\ kW/m^2$

As may be evident, under the most severe fire conditions within the flames, a baffle which reduces the gas temperatures and velocities as defined by BNL does indeed lead to an 80% reduction in incident heat flux to an exposed electrical cable as suggested in the Cooper analysis.

These results are further supported by tests performed at Factory Mutual Research Corporation (FMRC) under the sponsorship of the Electric Power Research Institute (EPRI).1 / In two tests where cable tray impingement baffles were employed, electrical cables were shown to be completely protected and unaffected following immersion in the flames of a fire involving 17-gallons

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1 / J.S. Newman and J.P. Hill, "Assessment of Exposure Fire Hazards to Cable Trays", NP-1675, Electric Power Research Institute, Palo Alto, Ca., January 1981.

of #2 fuel oil contained in a 3.9 ft (1.2-m) diameter pan located 5.9 ft (1.8m) below the trays. When the same configuration of electrical cables was exposed to the same fire conditions without the benefit of the impingement baffle, severe cable damage was rapidly accumulated.

On the basis of these tests and analysis, the efficacy of baffles in protecting against impinging fires has been conclusively demonstrated.

3.6 Appendix A.6 - Internal Component Model

BNL's comments on this model are directed at their difficulty in understanding how the modeling process was structured and its boundary conditions.

As BNL notes:

> "However, the issue is not how to solve the equation, but rather, how NPPD should demonstrate that the complex heat conduction processes taking place during a fire can be adequately modeled by the equation."

Response

BNL's difficulty in tracing the finite-element analysis deserves a more detailed explanation. This discussion intends to respond to that issue.

The accuracy of the MERLIN code used in the Cooper analysis to obtain a numerical solution to a series of partial differential equations was validated prior to its use by comparison with a series of problems for which analytical solutions can be obtained. These test problems were chosen to investigate all combinations of boundary conditions and geometry which can be handled by MERLIN's heat conduction elements. These test problems were also used to study the effects of fine step choice and element aspect ratio on accuracy. It was found that maximum error is in the order of 2 percent or less.

The boundary conditions used in the simulation cited in Section 6.7.4 of the Cooper analysis were very simple and conservative. The outer face of the switch and panel facing the fire were subjected to a fixed heat flux of 50 kW/m^2 for a period of 100 seconds. This heat flux is assumed to turn on instantly at the start of the fire with no credit taken for the transient buildup period of the fire. No credit is taken for heat loss from the outer face due to convection or reradiation though, in reality, the inclusion of such reradiation would substantially reduce the temperatures reported by the simulation. The rear surfaces of the panel and switch were given a linear convective heat loss boundary condition using a heat transfer coefficient of 1 $BTU/hr\text{-}ft^2\text{-}F$. This coefficient is typical for natural convection driven by small temperature differences. The heat sink temperature was assumed to be fixed at 100F. All other model surfaces were assumed to be adiabatic.

A three-dimensional model was not developed since the two-dimensional model indicated that the significant features of the switch response to a short-lived intense fire are one-dimensional in nature. The model indicated that the only portion of the switch potentially at risk due to exposure to such a fire are the switch knob and mounting plate. These components are made of a heat resistant phenol plastic which has a low thermal diffusivity. Because of this low diffusivity, the component's outer surface heats up rapidly while the inside of the component remains cool. Since the penetration depth of this effect is so thin, it could be modeled using a simple one-dimensional model.

The question of applicability of finite element modeling to study the effects a fire on panel components is not nearly so complex as implied by the reviewer. The use of Laplace's equation to model heat conduction has been well established over two centuries. Its use in determining the internal response of the switch due to the imposed boundary conditions can be accepted with confidence. The applicability question focuses on the choice of boundary conditions. For the purposes of the present application, it is sufficient that the boundary conditions be chosen conservatively.

To meet this goal, very little credit was taken for heat loss from the boundaries. Only convection from the rear panel surface was applied. In particular, the neglecting of reradiation from the panel outer surface is very conservative since surfaces reach roughly 1000F at the end of 100 sec. The black body radiation loss at this temperature is 24.5 kW/m^2, nearly one half of the assumed incident heat flux.

In summary, a proven modeling technique was used with a conservative choice of boundary conditions to show that only the outermost surface of the panel components would be damaged by an unlikely large fire. Moreover, it is shown that this damage is confined to the outer surface and would not impede the component's proper function after the end of the fire thereby demonstrating that it be free of fire damage as required by Appendix R.

3.7 Appendix A.7 - Macroscopic Equipment Analysis

BNL's only comments in this area are in the area of request for a more involved discussion of the model's limitations and a notation of some typographical errors.

Response

BNL's corrections of the typographical errors are noted without comment. With regard to possible model limitations, the simplicity and conservatism of the one-dimensional approach leads to a bounding analysis consistent with the conservatisms presented elsewhere in the models. As in the microscopic model, a constant heat flux of $50 kW/m^2$ is imposed for the duration of exposure.

3.8 Chapter 5 - Analytical Methods

BNL's comments in this area are along three dimensions:

(1) ventilation;
(2) excess pyrolyzate; and,
(3) liquid spill ignitibility;

BNL notes the following concerning the ventilation assumptions:

> "The assumption is made that there is always sufficient ventilation to support an optimum stoichiometric fuel/air ratio and to maintain the compartment desmoked. This results in conservative estimates of the heat release rates. Also conservatism is imparted in the analysis as a result of the neglect of attenuation of radiant energy due to smoke."

BNL also comments on the potential for excess pyrolyzate igniting in an enclosure. Finally, BNL identifies errors in the spill ignitibility analysis.

Response

BNL's comments regarding the ventilation assumptions in the Cooper analysis are noted and no response is deemed necessary. The concept of excess pyrolyzate is addressed in Section 3.9 of this report.

Concerning the spill ignitibility analysis, BNL identification of this error in the hand calculation is correct. A re-calculation of the heat flux necessary to achieve ignition for substrate at 70F has been re-performed and results are presented below.

MAGNITUDE OF EXTERNAL HEAT FLUX NECESSARY TO ACHIEVE DESIRED TEMPERATURE FOR SPILL ON CONCRETE

	Thin Spill	Thick Spill(>20mm)
Lubricating Oil - Flash Point (489K)	13.29kW/m^2	3.33kW/m^2
-Ignition (650K)	24.62kW/m^2	6.17kW/m^2

These results indicate that a thin spill of lubricating oil would have to receive radiant heat from a source having a steady state surface temperature of at least 836K (1045F) for a period of at least ten minutes for ignition to occur. It is unlikely that any piece of equipment in the affected areas at Cooper Nuclear Station would have a surface temperature of this magnitude. Any other heat source capable of achieving this temperature for this duration would have to be a pre-existing, substantial fire. A thick spill would require a heat source with a steady state surface temperature of 591K (604F) to be located directly above the surface of the spill for a minimum of ten minutes to result in ignition of the spill. It must be remembered that radiation is diffuse and non-directional and that the amount of heat transferred to a nearby object is dependent upon the configuration factor, which is a geometric function of the spatial relationship between the heat source and the receiving element. Displacing the heat source horizontally or vertically from direct thermal contact with a spill increases the energy requirements for the potential ignition source dramatically.

These fire tests and analyses support the Staff's own conclusion that high fire point liquid hydrocarbons are not significant fire hazards when spilled on concrete removed from hot surfaces.

3.9 Chapter 6 - Analysis and Exemption Requests

BNL provides a series of general comments regarding the detailed analysis. Each significant comment is responded to below:

BNL Comment:

> "All electrical cables are assumed flame retardant and are therefore not considered as intervening combustible material. This is based on the low heat release rate and low propagation potential of these cables However, one should still consider the potential of the combustibility of the products of pyrolysis of the cables. For instance, the XPE/Neoprene cable has carbon monoxide and gaseous hydrocarbon yields of 8-12% and 1-3% of the mass loss rate, respectively. These products can collect in the ceiling layer and result in a secondary fire. However, the stratification model is not valid for such secondary fires".

Response:

BNL's analysis appears to overlook the fact that Cooper Nuclear Station has little if any exposed electrical cable. The overwhelming majority of cables in the plant are routed in conduit. Areas such as the Control Building Basement have no cable trays at all. For these situations, the concept of excess pyrolyzate is simply not relevant.

From a modeling standpoint, excess pyrolyzate is also considered to be not relevant. Due to energy conservation considerations, if the excess pyrolyzate accumulation rate increases due to incomplete exposure fire combustion, then the heat release rate associated with the exposure fire must accordingly decrease due to reduced combustion efficiency. This implies that the heat flux exposure of the target cables must also be less. Exposure fire combustion in the Cooper analyses was assumed to be unaffected by oxygen starvation and reduced combustion efficiency in order to maximize the heat flux and energy deposition at the target cable. Therefore, to be consistent with the assumptions of the analysis, maximization of the imposed heat fluxes obviated the need to consider excess or unburned fuel pyrolyzates.

Practically, excess pyrolyzate as a potential hazard has never been evident under stratification conditions for nuclear power plant configurations. Recent Sandia tests of cable tray installations specifically designed to enhance the stratification effects of a heptane fire in a small enclosure did not report the phenomenon of pyrolyzate accumulation contributing to damage (energy deposition) at the target cables nor has the phenomenon been observed in any of EPRI's full scale tests. 2, 3, 4/

2/ Klamerus op.cit.

3/ Newman and Hill, op.cit.

4/ Hill, op.cit.

Consequently, the issue is not considered to impact the validity of the Cooper analysis.

BNL Comment:

> "The next consideration is the important one of selection of a cable damage criterion. The analysis focuses on the minimum conditions necessary to cause a loss of cable function through piloted electrical failure as defined by Lee [13]. The choice of the electrical failure appears to be somewhat less conservative for two reasons.
>
> First, as stated by Tewarson [14], cable damage first appears as insulation/jacket degradation, then piloted ignition and then electrical failure. Since Appendix R states that cables should be free from fire damage, it would be more conservative to use the insulation/jacket degradation failure mode as a cable damageability criterion.
>
> Secondly, the electrical failure tests of Lee were based on short circuiting a 70V signal. However, voltages in plant cables are usually much higher than this and could conceivably cause earlier damage than the tests indicated.

Response:

Jacket degradation is not a well defined failure mode. Attention is directed to EPRI research on this subject 5/ where the critical heat flux is obtained by linear extrapolation of data on the inverse time to failure-exposed heat flux diagram. According to this data the initiation of jacket degradation occurs at any imposed heat flux values including those well below

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5/ Lee, op.cit.

the critical heat flux for insulation degradation. In fact, for such reasons Sandia rejects insulation degradation as a failure criteria lacking meaning on the basis of extensive testing and notably urges the NRC to base cable damage on functionability. 6/ Accordingly, the concept of insulation degradation as a failure threshold is inappropriate in an intense fire environment of relatively short duration. The choice of piloted ignition is also not realistic due to the presence of protective conduits and lack of direct contact between flame and the cable.

BNL Comment:

BNL notes that some discretion exists in selecting a particular cable for use in the analysis. For example, data for two cross-linked polyethylene cables with neoprene jackets (XPE/N) is available. BNL also notes some confusion in the report concerning the definition of cable damage between electrical failure and autoignition.

Response

The problem of target cable selection is difficult to resolve in a vacuum since any particular one selected would always be subject to disagreement by a third party. It may be reasonably stated that in the context for which this analysis was performed, i.e., to demonstrate the effectiveness of passive

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6/ L.L. Lukens, "Nuclear Power Plant Electrical Cable Damageability Experiments", NUREG/CR-2927, US Nuclear Regulatory Commission, Washington, DC, October 1982.

measures alone in inhibiting the onset of cable damage when exposed to a fire, the particular cable used is not especially important. This view is further reinforced by the fact that the XPE/N-cables referred to by BNL have relatively comparable resistance to fire damage which, in the vast majority of situations, is enhanced by the additional protection afforded by heavy steel conduit which is not credited in the analysis. Consequently, potential uncertainties in the cable selection process are not considered to be especially relevant.

BNL Comment:

> "Another factor in applying the methodology is the assumption of instantly achieving a stead-state, overventilated combustion condition. Assuming steady-state conditions are reached immediately conservatively maximizes the heat release from the exposure fire.

Response:

No response is deemed necessary.

BNL Comment:

> "In the analysis the cables are routed in conduit and some cable trays are routed above large insulated pipes which supposedly protect the cables from failure due to direct plume impingement. However, since little detail of these surrogate shields is given, the credit taken for their attendant fire protection should be further scrutinized by NPPD and elaborated upon by analysis."

Response:

As is discussed in Appendix A.5 of the Cooper analysis and further amplified upon in Section 3.4 of this report, turbulent wake effects lead to a significant reduction in the heat flux, even in locations removed from the interviewing object by several of its diameters. It was felt that the treatment presented in the original report based on correlations to experimental data reported in Schlichting 7/ presented a good explanation of the process. If BNL still has specific questions concerning particular details of application appropriate responses may be provided.

BNL Comment:

BNL summarizes the individual fire area analyses and presents a number of issues concerning traceability and typographical errors. In Fire Area B, BNL did perform an audit calculation and noted that their results were in agreement with the Cooper analysis.

Response:

It is hoped that the discussions presented earlier in this report would clarify areas of possible uncertainty in the individual analyses. Since none of BNL's comments appeared to be of major significance or question the basis of Cooper methodology and, in fact, a BNL audit calculation actually verified the

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7/ H. Schlichting, Boundary Layer Theory, Seventh Edition, McGraw-Hill Book Company, New York, New York, 1979.

accuracy of the stratification model, no response is provided to the general traceability comments. BNL's correction of the typographical errors in referring to the tables is noted without comment.

4. SUMMARY RESPONSE TO INDIVIDUAL AREA EXEMPTION DENIALS

The following section will provide a response to the Appendix R Exemption Request denials made by the Staff in the Cooper Station SER. The following will be provided for each area:

(1) The basis for the previous NRC acceptance of each specific area;

(2) The basis for the NPPD Appendix R Exemption Request;

(3) The basis for the NRC denial stated in the Cooper Station SER; and,

(4) The NPPD response to the NRC Staff denial.

4.1 Control Building Basement

4.1.1 Basis for Previous NRC Acceptance:

In a detailed analysis of this area, the NRC concluded in the FPSER that the Control Building Basement met the objectives of protecting the safe shutdown capability on the following basis:

(1) Low combustible loading in the area;

(2) Presence of automatic detection;

(3) Existence of manual hose reels and portable CO_2 extinguishers; and,

(4) Additional modifications to be made by NPPD, specifically:

(a) Add curbs around the conduit risers adjacent to the south wall and in front of the man ways adjacent to the east wall, and

(b) Install manual foam suppression.

4.1.2 Basis for NPPD Exemption Request

The basis for the request for exemption from Appendix R as documented in the June, 1982, Cooper Appendix R fire hazards analysis is as follows:

(1) No systems required for hot standby in the fire zone;

(2) Limited combustible loading in the area;

(3) No exposed hot surfaces;

(4) Low fire hazard due to lack of ignition source and high flash point in the oil present as an in-situ combustible;

(5) Unrealistically large quantities of transient combustibles are required to damage a single division;

(6) No exposed cable in the area (all cable in metal conduit);

(7) Extensive use of fire propagation retardants:

(a) IEEE-383 cable

(b) Conduit

(8) Highly sensitive smoke detection systems in the area; and,

(9) No change in plant design or operation since the NRC's previous conclusions of adequacy in the FPSER which would alter either the nature of the hazard in the area or the level of protection in the area.

Since, on the basis of the above, at least one division of hot standby equipment would be available in the event of any credible fire, NPPD concluded that the additional fire protection modifications would not enhance protection of the public health and safety. On this basis, an exemption from the requirements for additional separation and automatic suppression was requested for the area.

4.1.3 Basis for Present NRC Denial

The Staff's present evaluation of the Control Building Basement fire hazards analysis only considered the following issues:

(1) An exposure fire of unspecified magnitude or location could conceivably damage redundant divisions prior to the arrival of the fire brigade; and,

(2) IEEE-383 cable routed in conduit is known to fail when exposed to a heat source of "sufficient magnitude".

The Staff concluded:

> "Based on our evaluation, the level of existing protection for the control building basement does not provide a level of fire protection equivalent to the technical requirements of Section III.G of Appendix R. Therefore, the exemptions should be denied."1/

4.1.4 Response

NPPD believes that the Staff's evaluation of the Control Building Basement fire hazards analysis is incorrectly focused. Emphasis on the preceding issues misrepresents the importance of the Control Building Basement and misrepresents the results of the associated fire hazards analysis.

1/ Draft Safety Evaluation by the Office of Nuclear Reactor Regulation of Appendix R Exemption Request for Cooper Nuclear Station, Transmitted December 14, 1982, from D. B. Vassallo to J. M. Pilant.

The Staff's evaluation notes in the second sentence, "There is no alternative shutdown capability independent of this area." Contrary to that, NPPD in the opening line of Section 6.4.2 entitled "Safe Shutdown Equipment," noted as follows, "Fire Area B contains no equipment considered as necessary for hot shutdown." A re-review of the cabling within the area indicates that the NPPD statements previously made are still correct.

The Staff's focus is on the postulated existence of a fire of "sufficient magnitude" in an unspecified location that could cause damage to redundant divisions. NPPD believes that no fire of the magnitude postulated by the Staff could occur in the Control Building Basement. The area in question is generally accessed by passing through the guarded Control Room entrance and by subsequently walking down three flights of stairs. This area is not subject to random personnel access. Because of these facts, transient combustibles do not pose a significant hazard to the redundant divisions of cold shutdown equipment in this area. The analysis showed that a fixed combustible fire composed of 10 to 15 gallons of lubrication oil would pose no hazard. This fact, along with the numerous items showed in Section 4.1.2 above, form a substantial basis for the requested Appendix R exemption request.

The Staff may have inadvertently believed that hot shutdown equipment was contained within the area because of the detailed description of the conduits and cables listed within the area which are required for cold shutdown capability.

The intent of the Exemption Request was to achieve Staff concurrence that the existing level of fire protection was such that any concern with regard to the ability to affect repairs to the diesel generator power feeds and the service water power feeds need not be addressed.

In the previous 1977 analysis a commitment was made to provide curbing out six feet off the south wall to prevent the intrusion of flammable liquids into the vicinity of the vertical conduits shown in Figure 6.5, Section AA, Volume I of Appendix R Submittal. The effects of a fire at a minimum distance of 55 inches from the leading edge of the conduit was presumed at that time and could be shown today by calculations not to affect the functionality of the cables within the conduit. Therefore, since no fire damage would be expected, no cold shutdown repair procedures for those 4160Vac conduits would need to be provided by the station.

The cables for cold shutdown equipment in conduits in the overhead are also felt to be adequately protected, given the low in-situ combustible loading, the low transient combustible loading, the high flash point of the small quantity of the oil present, and the lack of exposed hot surfaces.

In their denial the Staff suggested that either a one-hour barrier or suppression system be installed to protect the conduit located high above the floor. The few conduits of interest are behind a four-inch dike previously installed per the NRC Staff's request to preclude the intrusion of any combustible or flammable liquids to the immediate proximity of those conduits.

As stated above, the fixed combustible loading within the area is very low, under ten gallons of lubricating oil. Given the lack of hot surfaces and the difficulty with the ignition of that type of material, it would be very unlikely that any fire would occur during power operation which would be sufficient to cause damage to cables within the conduits in their existing locations.

Likewise, the installation of a fixed suppression system throughout the area is felt to be unnecessary. The room is very spacious with excellent access for manual suppression. Fire brigade response is from the Control Room above.

On the basis of the above, NPPD submits that its request for an exemption from III.G for the Control Building Basement is properly justified and that the request should be granted.

4.2 Cable Spreading Room and Cable Expansion Room

4.2.1 Basis for Previous NRC Acceptance:

In a detailed analysis of this area, the NRC concluded in the FPSER that the Cable Spreading Room met the objectives of protecting the safe shutdown capability on the following basis:

(1) Electrical cables meet or exceed IEEE-383;

(2) A large part of the cables are in conduit;

(3) Presence of an automatic pre-action sprinkler system;

(4) Metal tray covers provided wherever cable trays which provide for core cooling do not meet IEEE-279-1971;

(5) Early warning detection system;

(6) Good firefighting access and capability;

(7) Remote shutdown capability (within the context of the Appendix A review); and,

(8) Upgrade cable penetration seals.

4.2.2 Basis for NPPD Exemption Request

The basis for the request for exemption from Appendix R as documented in the Cooper Appendix R fire hazards analysis was as follows:

(1) IEEE-383 cable with power cable routed in conduit;

(2) Moderate cable tray loadings;

(3) Presence of redundant and diverse fire detection;

(4) Existence of automatic suppression;

(5) Good access for manual firefighting capability;

(6) No change in plant design or operation since the NRC's previous conclusions of adequacy in the FPSER which would alter either the nature of the hazard or the level of protection in the area; and,

(7) Additional modifications be made by NPPD contingent upon exempting the Cable Spreading Room and Cable Expansion Room from Appendix R, specifically, the implementation of cable tray bottom baffles.

Since, on the basis of the above, at least one division of safe shutdown equipment would be protected in the event of a credible fire, it was concluded that additional modifications beyond the implementation of cable tray bottom baffles would not enhance fire protection safety. On this basis, an exemption from the requirements for additional separation was requested for the area.

4.2.3 Basis for Present NRC Denial

The Staff's recent evaluation of the Cable Spreading Room and Cable Expansion Room fire hazards analyses only considered the following issue:

> "Because most if not all safety and shutdown systems could be affected by a single fire in this area, the compensatory features [proposed modifications] do not provide equivalent protection to an alternate shutdown system independent of these areas."2/

The Staff concluded:

> "Based on our evaluation the level of existing protection for the cable spreading room and cable expansion room does not provide a

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2/ Op. cit., Page 10.

level of fire protection equivalent to the technical requirements of Section III.G of Appendix R, and therefore, the exemption should be denied."3/

4.2.4 Response

NPPD believes that the Staff has come to an incorrect conclusion in denying the Cable Spreading Room and Cable Expansion Room Appendix R exemption request. NPPD believes that there is a substantial technical basis for granting the requested exemption.

The fire protection for the area consists of both passive and active safety features. Fire propagation retardants in the form of cable tray baffles and metal tray covers limit the threat of fires. Reinforcing this protection is a complete automatic suppression system and remote shutdown capability. The suppression system in the cable spreading room consists of a full coverage water system. The suppression system in the cable expansion room consists of a full coverage water system for the cable trays. The floor space for both rooms is wide open with no obstructions or hindrances to manual fire fighting efforts.

Because there are limited in situ combustibles which would be made even more limited by virtue of the proposed tray bottom covers in this area, any postulated fire would involve transient combustible materials. Because of the restricted access to this area via a narrow stairwell and access control, there is a very low probability of accumulation of a significant quantity of transient combustible materials in this area. A fire in this

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3/ Op. cit., Page 10.

area would, therefore, be of limited severity and duration. The installed redundant methods of early warning detection would be able to promptly detect incipient fire conditions and the extremely close access to the security guard's desk and the operators in the Control Room immediately above would ensure rapid fire brigade response prior to the onset of cable damage, especially to the power cable in conduit. Combined with existing passive and active features, this protection provides reasonable assurance that the shutdown-related cables will be free of damage from a fire in the area.

These facts, along with the items stated in Section 4.2.2, formed a basis for granting the requested exemption.

The Staff's "premise" that a single fire in the Cable Spreading Room could affect "most if not all safety and shutdown systems" is neither valid nor is it credible given the layout, the spaciousness, the installed fire detection and fixed suppression system, and the access for effective manual fire suppression. Fires in the Cable Spreading Room will be of limited magnitude, of limited duration, readily detected, and the damage will be limited to the specific cables of a limited number of systems of a particular division within the cable trays affected by a single exposure fire. Given the packing density with the trays, the IEEE-383 cable, the existence of metal tray covers (where appropriate) and the presence of non-flammable mineral board (as appropriate) beneath cables in the other division, the reasonable conclusions reached are:

(1) The magnitude, extent and heat released from a secondary fire within the CSR should be a small function of that of the postulated transient combustible fire; and

(2) That propagation between divisions is not only extremely unlikely, but effectively precluded by the existing design.

The NPPD-proposed installation of thermally resistant tray bottom covers, e.g. 3M "Fire Barrier" sheets, is probably unnecessary given the existing level of protection. Surely that additional modification would invalidate the Staff's general conclusion and generalized basis for rejection.

A supplemental, detailed review of the specific points of vulnerability of the Cable Spreading Room has been performed in order to specifically define additional fire protection enhancements which might be discussed with the Staff.

Within the Cable Spreading Room only selected areas require detailed consideration. One of these is the locations where the Division II HPCI 125V and 250Vdc power feeds penetrate through the Cable Spreading Room floor and rise vertically to a distance of about eleven feet above the floor before again dropping down to an approximate elevation of seven feet and turning and running into the south wall of the Cable Spreading Room where they pass into the north wall of the Cable Expansion Room along the most easterly side. These HPCI power conduits contain the principal circuits required for hot standby within the Cable Spreading Room. The limited distance which they travel as they pass through this discrete section of the Cable Spreading Room and the fact that they are located typically six feet below the ceiling indicates that the physical location provides adequate separation and protection from the effects of cable tray fires elsewhere in the Cable Spreading Room. Only a floor-based hydrocarbon fire, which would be extremely unlikely to occur at exactly that location within the Cable Spreading Room, could have an impact on these particular conduits.

Since HPCI power conduits are physically within a bank of dc power conduits, it would be difficult to individually provide a one-hour fire barrier or a wrap. The conduits' transition up into the congested overhead and then back down, as the conduits pass to the south wall of the Cable Spreading Room, also makes individual discrete wraps difficult. Flame impingement barriers of a material such as the 3M "Fire Barrier" material at the floor around the conduit bank to the extent feasible and appropriately placed beneath the conduit bank to prevent the effects of impingement of hot combustion gases on the conduit grouping could be provided if the Staff wished to acknowledge the effectiveness of this form of protection for these specific conduits. Installation of a one-hour fire barrier or a wrap around the individual conduits appears infeasible.

Additionally, there are a selected number of 4160Vac power Division II cold shutdown conduits which penetrate through the

Cable Spreading Room floor at the south wall of the Cable Spreading Room and immediately head through the wall into the Cable Expansion Room, where they pass along the eastern edge of the Cable Expansion Room into the 903-ft-6-in. elevation. Those conduits in turn have a very limited exposure to the effects of either a transient or fixed combustible fire within the Cable Spreading Room. It is believed that the existing protection for those particular 4160Vac power conduits is adequate. However, a reasonable form of additional protection could be afforded.

4.3 Auxiliary Relay Room (Control Building Corridor - EL 903 ft)

4.3.1 Basis for Previous NRC Acceptance

In a detailed analysis of this area, the NRC concluded that the Auxiliary Relay Room (Control Building Corridor) met the objectives of protecting the safe shutdown capability on the following basis:

(1) Electrical cables meet or exceed IEEE-383, and

(2) Reliance on administrative controls.

4.3.2 Basis for NPPD Exemption Request

The basis for the request for exemption from Appendix R as documented in the Cooper Appendix R fire hazards analysis was as follows:

(1) IEEE-383 cable with power cable routed in conduit;

(2) Light tray loading;

(3) Presence of automatic detection;

(4) Good fire fighting capability;

(5) Low likelihood of transient fire;

(6) Inadvertent water suppression system actuation could damage ECCS relays which would be detrimental to overall facility safety;

(7) Good system isolation and fire retardancy provided by cabinets; and,

(8) Additional modifications be made by NPPD contingent upon exempting the Auxiliary Relay Room from Appendix R, specifically, the caulking of cabinet bottoms to preclude the spill of combustible liquids beneath the cabinet wall.

Since, on the basis of the above, at least one division of safe shutdown equipment would be protected in the event of a credible fire, it was concluded that additional modifications beyond those proposed would not enhance the protection of the public health and safety. On this basis, an exemption from the requirements for additional separation and suppression was requested for the area.

4.3.3 Basis for Present NRC Denial

The Staff's recent evaluation of the Auxiliary Relay Room fire hazards analysis only considered the following issues:

(1) "The licensee's model shows that a fire within one cabinet does not have the potential to cause significant damage to redundant equipment prior to response of the area detection system and the response of the fire brigade."4/

4/ op. cit., Page 12

(2) "Because an exposure fire from the accumulation of transient combustibles could be significantly longer than 100 seconds, the metal electrical cabinets do not provide protection equivalent to twenty feet of separation free of combustibles or a one-hour fire barrier in conjunction with automatic suppression or an alternate shutdown capability independent of the area."5/

The Staff concluded as stated in the Cooper SER:

> "Based on our evaluation the level of existing protection for the auxiliary relay room does not provide a level of fire protection equivalent to the technical requirements of Section III.G of Appendix R. Therefore, the exemptions should be denied."6/

4.3.4 Response

NPPD does not agree with the Staff conclusion denying the requested Appendix R exemption. Because in situ combustibles in this area are only IEEE-383 cable, postulated fire would involve transient combustible materials. Restricted access to this area via key controlled access and card readers make the probability of a significant quantity of combustible transient materials accumulating low. A fire in this area would, therefore, be of limited severity and duration. The installed methods of early warning detection would be able to promptly detect incipient fire conditions and provide for rapid response by the fire brigade prior to the onset of significant cable damage. Combined with passive features afforded, this protection provides reasonable assurance that the required hot shutdown cables would be free of

5/, 6/ Op. cit., Page 12

damage from a fire in the area. NPPD does not agree with the Staff concern that an exposure fire outside the metal electrical cabinets could be significantly longer than 100 seconds, the duration of the analyzed exposure fire. Fires involving unconfined hydrocarbons on concrete will typically burn no longer than 30 seconds. To be conservative, 100 seconds was chosen for the duration of the analyzed external exposure fire. The internal cabinet fire duration was postulated to be 10 minutes, also in order to be conservative. Differences in geometry, type of fuels and oxygen depletion dictate that the internal cabinet fire will be longer in duration than the external exposure fire. NPPD does not believe that the conservative assumption regarding a 10-minute internal cabinet fire should be blindly carried over into the external cabinet analysis assumptions.

The fire protection for the area consists of both passive and active safety features. Fire propagation retardants in the form of solid metal cabinets and conduit limit the threat of fire propagation between redundant divisions. Reinforcing this protection is physical separation and the remote shutdown capability.

Supplemental to the previous analysis, a detailed review of the hot shutdown circuitry in the Auxiliary Relay Room was performed which indicates that a fire in either or both of the two auxiliary relay cabinets will not affect the ability of the plant to achieve hot standby conditions given certain modifications to its HPCI system, described in Section 4.4.4 below. These modifications would allow the station operators to take control and operate HPCI locally. This remote shutdown local HPCI operational capability would make the HPCI system completely independent of any fire induced control circuit damage in the Auxiliary Relay Room.

Additional operational procedures would be established consistent with NRC ASB criteria immediately to de-energize dc power to the ADS/SRV system upon indication of spurious (high tail pipe temperatures) operation of ADS/SRV valve operation.

Based on this evaluation, the level of protection for the Auxiliary Relay Room, coupled with the proposed modifications for independence of the hot standby systems from this area provides a level of fire protection equivalent to the technical requirements of Section III.C of Appendix R. The exemption should therefore be granted.

4.4 Reactor Building NE-NW Corners

4.4.1 Basis for Previous NRC Acceptance

In a detailed analysis of this area, the NRC concluded in the FPSER that the Reactor Building EL-903 ft 6 in. met the objectives of protecting the safe shutdown capability on the following basis:

(1) Electrical cables meet or exceed IEEE-383;

(2) A large part of the cables are in conduit;

(3) No significant quantities of transient combustible exist in the area during normal operations;

(4) An unmitigated fire in the area would not prevent the reactor from achieving hot shutdown condition. Damage to service water pump power cables could be repaired within 72 hours through the use of temporary power cable, thereby ensuring the availability of at least one service water pump;

(5) Early warning detection is present; and,

(6) Additional modifications will be made by NPPD, specifically:

  (a) Upgrade cable penetration seals, and

  (b) Installation of an automatic suppression system in areas of high cable density.

4.4.2 Basis for NPPD Exemption Request

The basis for the request for exemptior from Appendix R as documented in the Cooper Appendix R fire hazards analysis was as follows:

(1) IEEE-383 cable with power cable in conduit;

(2) Moderate tray loadings;

(3) Presence of automatic detection;

(4) Automatic suppression at the ceiling in the area of dense tray clusters and throughout the northeast corner at the floor;

(5) Excellent manual fire fighting capabilities;

(6) No transient loading;

(7) Additional modifications be made by NPPD contingent upon exempting the Reactor Building EL-903 ft 6 in., specifically, the addition of cable tray bottom baffles for the C-57 tray when that tray is routed beyond the limits of automatic suppression; and,

(8) No change in plant design or operation since the NRC's previous conclusions of adequacy in the FPSER which would alter either the nature of the hazard or the level of protection in the area.

Since, on the basis of the above, at least one division of safe shutdown equipment would be protected in the event of a credible fire, it was concluded that additional modifications beyond the implementation of cable tray baffles would not enhance fire protection safety. On this basis, an exemption from the requirements for additional separation and suppression was requested for the area.

4.4.3 Basis for Present NRC Denial

The Staff's recent evaluation of the Reactor Building EL-903 ft 6 in. fire hazards analysis only considered the following issue:

> "Neither of these [features, i.e. sheet metal covers and asbestos liners in cable trays and bottom baffles] can be considered equivalent to a one-hour fire rated barrier, as they may only inhibit fire damage for several minutes."7/

7/ op. cit., Page 14

The Staff concluded:

> "Based on our evaluation, the existing protection for the Reactor Building, Northeast and Northwest Corner Rooms, does not provide a level of protection equivalent to the technical requirements of Section III.G of Appendix R. Therefore, the exemption should be denied."8/

4.4.4 Response

NPPD does not agree with the Staff conclusion denying the requested Appendix R exemption for the Reactor Building for the Northeast Corner at elevation 903 ft 6 in. NPPD believes that the NRC Staff has not properly focused its evaluation on the inherent high level of protection afforded the public health and safety by the existing fire protection system design and the conduit and cable tray configuration in that area.

In the northeast corner of elevation 903 ft 6 in., the cable tray and conduit exit from the Cable Expansion Room through the North Wall. (See Figure 6-11 in the Appendix R report.) From east to west the banks of conduit/cable tray are as follows:

- Division II conduit containing dc power for the HPCI System and 4160Vac power feeds to and from the 4160V switchgear location on the 932 ft 6 in. elevation above.
- Division I conduit containing dc power for the RCIC and 4160Vac power feeds to and from the Division I 4160V switchgear contained on the 932 ft 6 in. elevation above.
- Division II conduit and cable tray containing control circuits.
- Division I conduit and cable tray containing control circuits.

8/ op. cit., Page 14.

When the banks enter through the north wall of 903 ft 6 in., the minimum elevation is 924 ft 6 in., approximately 20 feet above the floor elevation. It is important to note that the Division II power conduit in the easternmost bank continue along that wall without a decrease in elevation. Similarly, the majority of the Division II control conduit and cable trays also pass through the zone heading in the southerly direction.

The Division II power conduit bank is approximately 5-1/2 feet tall. It is protected from the effects of floor-based exposure fires by:

(1) The physical configuration of the floor below;

(2) By the installed fixed suppression system which is located approximately 11 ft 6 in. above the floor;

(3) By the sprinkler heads located at the ceiling approximately 15 feet to the west.

The Division II conduit are protected from the effects of direct plume impingement in the far northeast corner by the platform above stair 51 and by the installed equipment and piping along the easternmost wall. Platforms extending out from the wall and from the RCIC starter rack effectively preclude the accumulation during operation of significant quantities of transient combustibles in the area immediately below the Division II conduits. The physical configuration of and congestion along the east wall limits, if not eliminates concerns regarding "flame stretch" phenomenon, due to the general inability to place a significant fire along the east wall.

The potential damage to cable and conduits in the northeast corner of 903 ft due to a stratification heat flux is very limited due to the 28 ft ceiling height. Further, in order for damage to occur, one must assume that the ceiling sprinkler heads located approximately 15 feet horizontally to the south of Division II conduit bank would not function. Any functioning of the ceiling-mounted sprinkler heads would quickly quench and reduce the ceiling heat flux such that damage would not occur due to stratification.

Given the complete coverage of the fire suppression system within the area of concern and the redundancy within the water suppression system in terms of the piping configuration and sprinkler heads (floor and ceiling), it is difficult to postulate a damaging fire scenario. NPPD believes that the existing configuration for the northeast corner provides adequate protection of the public health and safety.

However, in order to provide additional assurance that hot shutdown conditions are achieved at Cooper Station, NPPD proposes to provide additional hardening of the control circuits of the HPCI system control circuits which are routed in cable tray through the 903 ft 6 in. elevation. This additional modification will allow the station operator to isolate the HPCI from any damaged control circuit which occurs upstream of the starter racks local to the HPCI and allow the operator to operate all required valves locally. This additional "hardening" provides additional capability to achieve hot shutdown conditions. Only the HPCI dc power cables, which are routed in the easternmost conduit bank within the conduit bank would remain of potential concern. NPPD believes that the physical configuration of this area in the northeast corner of 903 ft 6 in. elevation makes the existing HPCI power conduit routing essentially immune from the effects of any credible floor-based exposure fire; NPPD further believes that the additional redundant levels of water fire suppression capability existent within the area sufficiently reduce the potential for fire damage to the HPCI dc power conduit that an exemption request can reasonably be granted for this routing. NPPD believes that the equivalent protection of the public health and safety has been achieved through the combined effects of the physical configuration and the extensive active fire detection and suppression systems installed in the area. On the basis of this combination of fire protection existent at Cooper Station and the proposed control circuit modifications to the HPCI system, all reasonable efforts to provide protection to the HPCI have been taken.

A review has been performed of the practicality of providing a one-hour wrap. It does not appear possible to provide the required 1-hour wrap of the HPCI power conduits because of the location of the specific conduits within the conduit bank. Installation of the classical 1-hour fire protection wrap around the conduits of interest is not feasible because of the extreme height of the conduit bank, of the position of the subject conduits within the conduit bank, and because of the congestion of intervening and pipe and floor-based obstacles beneath conduit bank, etc. The same arguments which act to preclude the impingement of any floor-based exposure fire directly on the Division II conduit bank also work to preclude access to the conduit bank for the installation of conduit wraps. The close packing of the four-inch conduits within the bank preclude the installation of the classical one-hour fire barriers around the conduits of interest

For all of the above reasons, NPPD believes that all reasonable efforts have been taken to provide protection of the public health and safety and that an exemption for the northeast corner of elevation 903 ft 6 in. should be granted.

With regard to the issues associated with the west side of 903 ft 6 in., an area in which automatic suppression does not occur, NPPD believes that the previous exemption request is no longer required. The conduits of interest provided dc control power to LPCI injection valves which can be manually operated during the transition to cold shutdown. On that basis the specific dc conduits associated with those valves do not require protection nor is there any requirement for suppression within that area.

Also, previously NPPD had proposed to provide flame impingement shield beneath the length of the ADS/SRV cable tray in those areas where the cable tray C57 was beyond the area of the existing fixed suppression system. Additional detailed circuit review and review of potential operator actions available to mitigate any spurious initiation of ADS/SRV valves shows that operating procedures can be developed to terminate spurious operation of the SRVs upon indication of same. NPPD therefore proposes to implement such operating procedures and does not feel that there is requirement for protection of the ADS circuits within tray C57.

Additionally, controlled depressurization of the reactor pressure vessel which would have been affected through the use of an SRV can also be accomplished utilizing the HPCI test return line. Given the hardening and protection inherent with the HPCI system, there is no requirement for the preservation of the functionality of the ADS. Further, the ADS system as a depressurization system is not required for the hot standby function of a boiling water reactor but rather for the transition to cold shutdown.

4.5 Control Room

4.5.1 Basis for Previous NRC Acceptance

In a detailed analysis of this area, the NRC concluded in the FPSER that the Control Room met the objectives of protecting the safe shutdown capability on the following basis:

(1) Early warning detection exists;

(2) Manual CO_2 hose reels are provided; and,

(3) Additional modifications be made by NPPD, specifically:

(a) Install early warning detectors inside safety-related panels;

(b) Provide additional water fire extinguishers; and,

(c) A fire and smoke barrier will be provided around the HVAC ducting.

4.5.2 Basis for NPPD Exemption Request

The basis for the request for exemption from Appendix R as documented in the Cooper Appendix R fire hazards analysis was as follows:

(1) Remote shutdown capability;

(2) Presence of automatic detection inside panels and on the ceiling;

(3) Lack of exposed cable and extensive divisional isolation inside panels;

(4) Excellent fire fighting capability due to the continuous manning allowing for extermely rapid detection and prompt suppression;

(5) Limited in-situ combustibles;

(6) Excellent control over the introduction and storage of transient combustibles; and,

(7) No change in the plant design or operation since the NRC's previous conclusions of adequacy in the FPSER

which would alter either the nature of the hazard or the level of protection in the area.

Since at least one division of safe shutdown equipment would be protected in the event of a credible fire, it was concluded that additional modifications would not enhance fire protection safety. On this basis, an exemption from the requirements for additional separation and suppression was requested for the area.

4.5.3 Basis for NRC Denial

The Staff's recent evaluation of the Control Room fire hazards analysis only considered the following issues:

(1) Redundant circuits located in the same electrical panel can be damaged by fires either within the panel or in transient combustibles outside the panel. Redundant circuits located in physically separate panels can also be damaged by exposure fires outside the panels; and

(2) Although the licensee has the capability to take local control of essential systems, the control room is not electrically isolated from the control stations; therefore, a fire in the control room or in the area of any emergency control station could affect both areas, thus resulting in the inability to safely shutdown the plant. 9/

(3) "The licensee's analysis shows that a fire within one cabinet does not have the potential to cause significant damage to redundant equipment prior to response of the area detection system and the response of the fire brigade. The analysis also shows that an exposure fire of 100 seconds' duration will cause discoloration and disfiguration of electrical components mounted in cabinets. The analysis does not provide assurance that a fire of longer duration would not damage both divisions."10/

9/, 10/ op. cit., Page 15

(4) "Because the nature of electrical panels in this area make protection in accordance with Section III.G.2 of Appendix R impractical, the licensee should provide an alternate shutdown system for the area in accordance with Section III.G.3 of Appendix R."11/

4.5.4 Response

NPPD does not agree with the Staff conclusion denying the requested Appendix R exemption request for the following reasons:

(1) A fire internal to a segregated sub-panel within the main control panels will not damage redundant circuits;

(2) An external panel fire will not cause damage such that the loss of redundant system functions will occur;

(3) An internal sub-panel fire or an external panel fire will not cause damage such that electrical isolation between the control room and the local control station either because of the redundancies within the adjacent subpanels or because the effects of the external fire will not induce disabling failure modes requiring isolation.

(4) "A fire in the control room or in the area of any emergency control station" will not result in the inability to achieve hot standby.

The above statements are based upon the review of the existing "as is" circuits and configuration of the plant and upon a rational review of the potential impacts of internal sub-panel and external panel fires in the Control Room.

The conclusions of the rational review may be based either upon a detailed circuits review and the application of fire protection engineering judgements or upon the circuits review and

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11/ Op. cit., Page 15.

engineering calculations as previously performed and submitted by NPPD or a combination of same. (The Staff's concerns raised regarding the previously submitted calculations of fire effects on panels do not change the fundamental conclusions of those evaluations nor do they effectively challenge the appropriateness of the methodology.)

The District analyzed the safety system components that are susceptible to spurious operation with a postulated fire in the Control Room. The analysis indicates that the spurious operation of the safety system valves in the hot shutdown systems (however unlikely), will not cause any major damage. The plant can achieve a safe hot standby condition through certain local actuations such as securing HPCI System Valves locally (proposed modification), prevent sudden depressurization of the reactor by spurious opening of ADS/SRV Valves by tripping the power feed breakers to these valves, and other similar local actions. The spurious actuation of valves in the cold shutdown system can also be secured by local actuation from motor control centers. We consider the spurious actuation of high pressure and low pressure interface RHR suction valves as highly unlikely as it involves opening of two normally closed valves in separate divisions, per our previous NRC Appendix R response.

On this basis and on the basis of the previously presented rationale, an exemption from the requirements of Appendix R, Section III.G is respectfully requested.

4.6 Fire Area Boundaries

4.6.1 Basis for Previous NRC Acceptance

In a detailed analysis of this area, the NRC reviewed the Fire Area Boundaries in the FPSER and reached the following conclusions:

(1) Cable and conduit penetrations:

- Grout and cellular concrete
- Styrofoam spacing blocks in several barriers

No final decision pending results of testing.

(2) Fire doors and dampers - rating consistent with the barrier and found acceptable.

(3) Pipe penetrations - not evaluated.

4.6.2 Basis for NPPD Exemption Request

The basis for the request for exemption from Appendix R as documented in the Cooper Appendix R fire hazard analysis is as follows:

(1) fire doors - equivalent to barrier;

(2) Cable penetrations - substantial layers of protection;

(3) Pipe chases - enclosure may be detrimental to facility safety due to inhibition of normal thermal expansion and contraction; and,

(4) HVAC ducts - 2 instances of 1-1/2 hour dampers.

Since at least one division of safe shutdown equipment would be available in the event of credible fire, it is concluded that the additional modifications would not enhance fire protection safety. On this basis, an exemption from the requirements for additional separation and automatic suppression is requested.

4.6.3 Basis for NRC Denial

The Staff's recent evaluation of this topic only considered the following issue:

> The licensee's 1977 FHA does not consider the effects of exposure fires involving transient combustible materials. Therefore, it does not provide sufficient justification for the exemption.12/

4.6.4 Response

It is clear that the Staff did not consider all of the pertinent information because, while it is true that the 1977 FHA did not consider transient materials, adding their effects has little impact on the analysis. For example, assuming the involvement of 55 gallons of lubricating oil in a compartment fire, this contributes an equivalent fire severity of only several minutes to most fire areas at Cooper Nuclear Station. The result is that the overwhelming majority of fire areas at Cooper Nuclear Station remain at a fuel loading of well under two hours.

Nebraska Public Power District believes that the clarifying information contained in this report combined with the results of its Appendix R analysis should lead the Staff to revise its evaluation the fire protection afforded by existing fire boundaries.

12/ Op. cit., Page 17