GENERAL ELECTRIC

NUCLEAR ENERGY BUSINESS OPERATIONS
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MFN-016-86

February 20, 1986

U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Washington, D.C. 20555

Attention: Mr. Herbert N. Berkow, Chief
Standardization and Special Projects Branch

Gentlemen:

SUBJECT: GENERAL ELECTRIC LICENSING TOPICAL REPORTS "SAFETY EVALUATION OF THE GENERAL ELECTRIC HYBRID I CONTROL ROD ASSEMBLY FOR THE BWR 4/5 C LATTICE" (NEDE-22290-A, SUPPLEMENT 1 AND NEDO-22290-A, SUPPLEMENT 1) DATED JULY 1985 AND OCTOBER 1985, AND "SAFETY EVALUATION OF THE GENERAL ELECTRIC ADVANCED LONGER LIFE CONTROL ROD ASSEMBLY" (NEDE-22290-A, SUPPLEMENT 2 AND NEDO-22290-A, SUPPLEMENT 2), DATED AUGUST 1985 AND OCTOBER 1985

General Electric herein submits twenty-two (22) copies each of the proprietary versions (NEDE-22290-A, Supplements 1 and 2), and thirty (30) copies of the nonproprietary versions (NEDO-22290-A, Supplements 1 and 2) of the NRC approved General Electric Licensing Topical Reports "Safety Evaluation of the General Electric Hybrid I Control Rod Assembly for the BWR 4/5 Lattice" and "Safety Evaluation of the General Electric Advanced Longer Life Control Rod Assembly."

Information contained in NEDE-22290-A, Supplements 1 and 2 is of the type which General Electric maintains in confidence and withholds from public disclosure. It has been handled and classified as proprietary by General Electric as indicated in the affidavit of Ricardo Artigas (Attachment A) and we hereby request that it be withheld from public disclosure in accordance with the provisions of 10CFR2.790.

Very truly yours,

R. Artigas, Manager
Licensing Services
Safety & Licensing

Two Rids

T007 NEDE-22290-A Supll. 1&2 1/22

T008 NEDO-22290-A Suppl. 1&2 1/26

Attachments

cc: L. S. Gifford (GE), w/att.
M. W. Hodges (NRC, P-1022) w/att.
L. E. Phillips (NRC, P-1022) w/att.

8602250298 XA

G E N E R A L   E L E C T R I C   C O M P A N Y

AFFIDAVIT

I, Ricardo Artigas, being duly sworn, depose and state as follows:

1. I am Manager, Licensing Services, General Electric Company, and have been delegated the function of reviewing the information described in paragraph 2 which is sought to be withheld and have been authorized to apply for its withholding.

2. The information sought to be withheld is contained in the reports entitled, "Safety Evaluation of the General Electric Hybrid I Control Rod Assembly for the BWR 4/5 C Lattice," NEDE-22290-A, Supplement 1 and "Safety Evaluation of the General Electric Advanced Longer Life Control Rod Assembly," NEDE-22290-A, Supplement 2.

3. In designating material as proprietary, General Electric utilizes the definition of proprietary information and trade secrets set forth in the American Law Institute's Restatement of Torts, Section 757. This definition provides:

   "A trade secret may consist of any formula, pattern, device or compilation of information which is used in one's business and which gives him an opportunity to obtain an advantage over competitors who do not know or use it. . .. A substantial element of secrecy must exist, so that, except by the use of improper means, there would be difficulty in acquiring information. . .. Some factors to be considered in determining whether given information is one's trade secret are: (1) the extent to which the information is known outside of his business; (2) the extent to which it is known by employees and others involved in his business; (3) the extent of measures taken by him to guard the secrecy of the information; (4) the value of the information to him and to his competitors; (5) the amount of effort or money expended by him in developing the information; (6) the ease or difficulty with which the information could be properly acquired or duplicated by others."

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   a. Information that discloses a process, method or apparatus where prevention of its use by General Electric's competitors without license from General Electric constitutes a competitive economic advantage over other companies;

   b. Information consisting of supporting data and analyses, including test data, relative to a process, method or apparatus, the application of which provide a competitive economic advantage, e.g., by optimization or improved marketability;

   c. Information which if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality or licensing of a similar product;

   d. Information which reveals cost or price information, production capacities, budget levels or commercial strategies of General Electric, its customers or suppliers;

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f. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection;

g. Information which General Electric must treat as proprietary according to agreements with other parties.

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7. The procedure for approval of external release of such a document is reviewed by the Section Manager, Project Manager, Principal Scientist or other equivalent authority, by the Section Manager of the cognizant Marketing function (or his delegate) and by the Legal Operation for technical content, competitive effect and determination of the accuracy of the proprietary designation in accordance with the standards enumerated above. Disclosures outside General Electric are generally limited to regulatory bodies, customers and potential customers and their agents, suppliers and licensees only in accordance with appropriate regulatory provisions or proprietary agreements.

8. The document mentioned in paragraph 2 above has been evaluated in accordance with the above criteria and procedures and has been found to contain information which is proprietary and which is customarily held in confidence by General Electric.

9. The detailed design data, nuclear evaluations and models are considered proprietary.

10. The information to the best of my knowledge and belief, has consistently been held in confidence by the General Electric Company, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties have been made pursuant to regulatory provisions or to proprietary information agreements which provide for maintenance of the information in confidence.

11. Public disclosure of the information sought to be withheld is likely to cause substantial harm to the competitive position of the General Electric Company and deprive or reduce the availability of profit-making opportunities because approximately $500,000 was spent to obtain the information.

STATE OF CALIFORNIA)
ss:
COUNTY OF SANTA CLARA)

Ricardo Artigas, being duly sworn, deposes and says:

That he has read the foregoing affidavit and the matters stated therein are true and correct to the best of his knowledge, information, and belief.

Executed at San Jose, California, this 20th day of February, 1986.

R. Artigas

Ricardo Artigas
General Electric Company

Subscribed and sworn before me this 20 day of FEBRUARY, 1986.

OFFICIAL SEAL
KAREN S VOGELHUBER
NOTARY PUBLIC - CALIFORNIA
SANTA CLARA COUNTY
My comm. expires DEC 30, 1988

Karen S. Vogelhuber
NOTARY PUBLIC,
STATE OF CALIFORNIA

bcc: K. W. Brayman
J. E. Cearley
J. S. Charnley
J. F. Klapproth
J. L. Rash
G. G. Sherwood
P. Van Dieman

NEDO-22290-A
SUPPLEMENT 1
CLASS I
OCTOBER 1985

SAFETY EVALUATION OF THE GENERAL ELECTRIC HYBRID I CONTROL ROD ASSEMBLY FOR THE BWR4/5 C LATTICE

GENERAL ELECTRIC

8602250306 31pp.

NEDO-22290-A
Supplement 1
DRF L12-00581
Class I
October 1985

SAFETY EVALUATION OF THE
GENERAL ELECTRIC HYBRID I
CONTROL ROD ASSEMBLY FOR THE
BWR4/5 C LATTICE

Approved: R. J. Brandon, Manager
Application Engineering

Approved: R. Artigas, Manager
Licensing Services

NUCLEAR ENERGY BUSINESS OPERATIONS • GENERAL ELECTRIC COMPANY
SAN JOSE, CALIFORNIA 95125

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

June 12, 1985

Mr. J. F. Klapproth
Principal Licensing Engineer
Nuclear Technologies and Fuel Division
General Electric Company
175 Curtner Avenue
San Jose, California 95125

Dear Mr. Klapproth:

SUBJECT: ACCEPTANCE FOR REFERENCING OF LICENSING TOPICAL REPORT NEDE-22290, SUPPLEMENT 1, "SAFETY EVALUATION OF THE GENERAL ELECTRIC HYBRID I CONTROL ROD ASSEMBLY FOR THE BWR4/5 C LATTICE"

We have completed our review of the subject topical report submitted by General Electric Company (GE) by letter dated February 20, 1985. We find the report to be acceptable for referencing in license applications to the extent specified and under the limitations delineated in the report and the associated NRC evaluation, which is enclosed. The evaluation defines the basis for acceptance of the report.

We do not intend to repeat our review of the matters described in the report and found acceptable when the report appears as a reference in license applications, except to assure that the material presented is applicable to the specific plant involved. Our acceptance applies only to the matters described in the report.

In accordance with procedures established in NUREG-0390, it is requested that GE publish accepted versions of this report, proprietary and non-proprietary, within three months of receipt of this letter. The accepted versions shall incorporate this letter and the enclosed evaluation between the title page and the abstract. The accepted versions shall include an -A (designating accepted) following the report identification symbol.

Should our criteria or regulations change such that our conclusions as to the acceptability of the report are invalidated, GE and/or the applicants referencing the topical report will be expected to revise and resubmit their respective documentation, or submit justification for the continued effective applicability of the topical report without revision of their respective documentation.

Sincerely,

Cecil O. Thomas

Cecil O. Thomas, Chief
Standardization and Special
Projects Branch
Division of Licensing

Enclosure:
As stated

Enclosure

Evaluation of NEDE-22290, Supplement 1

(TACS 56929)

By letter dated February 20, 1985 (MFN 023-85) General Electric Company submitted Reference 1 for staff review. The Core Performance Branch has reviewed the report and prepared the following evaluation.

1. Description of Report

Reference 1 describes proposed replacement control rod assemblies to be used in BWR/4 and 5 reactors as substitutes for current standard assemblies. The new assembly design, designated HICR-C, is a variation on the previously approved HICR assemblies (Reference 2). Section 2 of Reference 1 consists of a description of the design, Section 3 presents design bases, and Section 4 describes the physical, chemical, irradiation and mechanical properties of the HICR-C materials. Sections 5 and 6 present the design evaluations and transient and accident effects.

The emphasis in the report is on comparison of the proposed assembly with the currently used control rods. The most significant differences between the two are:

1. Improved B_4C absorbers rod tube material to eliminate cracking during the residence time of the assembly, and

2. Replacement of some B_4C rods with solid hafnium absorber rods to increase blade life.

Since the hafnium has a higher density than B_4C the HICR-C assembly is heavier than the current all B_4C assembly. In other respects the proposed design is identical in outline to the current B_4C C-lattice design. Materials changes in the B_4C absorber rods and the pins and rollers do not impact the safety performance of the new assemblies.

The design bases and materials evaluations are the same as those for the HICR production assemblies described in Reference 2, as is the thermal expansion and irradiation growth of the hafnium rods. It is concluded that the increase in weight of the assembly will have an insignificant effect on the mechanical adequacy of the control rod. Likewise the results of the nuclear evaluation show that the reactivity worth of the HICR-C control rod is the same as that of the all B_4C rod to within the uncertainty in the calculations.

The effect of the increased weight of the HICR-C on the scram speed was calculated by a computer code that models the scram performance of the control rod drives. The model has been verified against actual full stroke scram data. The results of the calculation show an insignificant increase in scram times for the HICR-C assembly as compared to the all B_4C assembly. An extension to the surveillance program presented in Reference 2 is given which provides additional monitoring of the performance of the HICR rods. The results of this extended program will be applicable to the HICR-C rods.

2. Summary of Evaluation

The design bases for the HICR-C assembly are the same as those of the HICR assembly described in Reference 2. Those bases were approved for the HICR assembly and continue to be acceptable for the HICR-C assembly. For the same reason the materials evaluation, including the thermal expansion and irradiation growth of the hafnium, is acceptable. Since the increase in weight is a small fraction of the total weight and large margins to stress limits are present in the design we concur with the conclusion that the effect of the weight increase on the mechanical adequacy of the HICR-C assembly is negligible.

The comparison of reactivity worth for the two rod designs was performed with a Monte Carlo calculation which has been verified against experiment (see Reference 2). We conclude that suitable comparisons of reactivity worth have been made. The analysis of the scram time for the heavier HICR-C rods has been performed by a method which has been verified by comparison with experiment. The results show that the scram times for the HICR-C rods are significantly less than those assumed in safety analyses and are therefore acceptable.

3. Conclusions

Based on our review, which is described above, we conclude that HICR-C assemblies may be substituted for the current all B_4C control rods in BWR/4-5 reactors having C lattice fuel designs. No additional analysis beyond those presented in supplemental reload licensing submittals will be required. The staff encourages the continued monitoring of the performance of the Hybrid I control rods and wishes to be informed of any significant findings.

References

1. NEDE-22290, Supplement 1, "Safety Evaluation of the General Electric Hybrid I Control Rod Assembly for the BWR4/5 C Lattice", October 1984.

2. NEDE-22290-A, "Safety Evaluation of the General Electric Hybrid I Control Rod Assembly", September 1983, (Approval letter follows immediately after the Proprietary Information Notice in this report).

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1. INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

This supplemental report describes additional design and safety evaluations performed to extend the application of the General Electric Hybrid I Control Rod Assembly (HICR) to General Electric BWR4/5 C lattice plants. The HICR for the BWR4/5 C lattice plants will be designated HICR-C. HICR-C's are intended to be standard replacement control rod assemblies for all General Electric BWR4/5 C lattice operating reactors. The HICR-C's form, fit and function are identical to that of the control rod it replaces. The HICR-C is designed to increase control rod assembly life and to eliminate cracking of the absorber tubes containing boron carbide (B_4C).

Like the HICR, the essential differences between the HICR-C and the BWR4/5 C lattice control rod currently in use are:

a. Improved B_4C absorber rod tube material to eliminate cracking during the lifetime of the control rod assembly, and

b. Some B_4C absorber rods are replaced with solid hafnium absorber rods to increase blade life.

1.2 SUMMARY

The design description and analyses in this supplemental report and Reference 1 demonstrate that the HICR-C satisfies the performance and safety requirements for use as a direct replacement for the BWR4/5 C lattice control rod assembly. The design bases for the HICR-C are given in Section 3.

Section 4 describes the physical, chemical, irradiation and mechanical properties of the HICR-C materials. Section 5 sets forth the HICR-C design evaluations including mechanical, nuclear, thermal hydraulic performance, and prototypical tests.

Section 6 contains evaluations showing that the measured scram speed and scram reactivity are not affected significantly when the HICR-C is used in BWR cores. Furthermore, it is shown that application of the HICR-C has no impact on the linear heat generation rate (LHGR), minimum critical power ratio (MCPR) and maximum average planar linear heat generation rate (MAPLHGR) design limits.

2. DESIGN DESCRIPTION

2.1 CONFIGURATION

The HICR-C design configuration is identical to that of the present BWR4/5 C lattice as shown in Figure 2-1. As shown in Figure 2-2, three solid hafnium absorber rods replace the B_4C absorber rods at the outer edge of each wing, in the same manner as the HICR production version in Reference 1. Both absorber rod designs, Hf and B_4C are identical for the HICR-C and the HICR.

The total weight of the HICR-C is ____ pounds heavier than the assembly it replaces. The weight increase is due to the substitution of the 12 hafnium absorber rods for the boron carbide absorber rods. Further discussions on the weight increase are contained in Sections 5.1.2 and 6.4. The increased weight does not affect the design configuration or envelope. Table 2-1 shows a comparison of key parameters between the HICR-C, the HICR and the current standard all B_4C C lattice control rod assemblies. Because there are no design configuration or envelope differences the HICR-C is directly interchangeable with the present BWR4/5 C lattice design control rod assemblies and is therefore compatible with existing NSSS hardware. *

2.2 MATERIALS

2.2.1 Pins and Rollers

The materials to be used for pins and rollers will be the same as those described for the HICR in Section 2.2.1 of the Reference 1 report.

Two control rods using these materials for pins and rollers were placed in the core of a domestic operating BWR in February, 1980. ____________ ____________________________ ____________.

*General Electric Company Proprietary Information has been deleted.

2.2.2 Control Rod Tubing Material

The material to be used for control rod tubing material will be the same as the high purity Type 304 stainless steel described for the HICR (production version) in Section 2.2.2 of the Reference 1 report.

2.2.3 Absorber Material

As in the production version of the HICR, three of the B_4C absorber rods per blade (12 in each control rod assembly) will be replaced with solid, unclad hafnium rods. These replacement rods are located at the three outside positions of each blade (Figure 2-2).

Table 2-1

TYPICAL PARAMETERS FOR GE CONTROL ROD ASSEMBLIES

	STD All B_4C C-Lattice	HICR D-Lattice	HICR-C C-Lattice
Control Rod Weight, Pounds	186	218	___
Absorber Rod - B_4C			
Number per Control	76	72	64
Length (in.)	143	143	143
Density (gr/cm^3)	1.76 (NOM) (70% THEO)	1.76 (NOM) (70% THEO)	1.76 (NOM) (70% THEO)
B_4C Cladding Material	Commercial 304 S.S.	HP 304 S.S.	HP 304 S.S.
Outside Dia. (in.)	0.188	0.188	0.188
Wall Thickness (in.)	0.025	0.025	0.025
Absorber Rod - Hafnium			
Number Per Control Rod	0	12	12
Length (in.)	-	143	143
Diameter (in.)	-	0.188	0.188
Density (gr/cm^3)	-	13.3	13.3
Type	-	___	___
Stiffner (Replaces 2 absorber rods)	Yes	No	Yes
Sheath Thickness (in.)	0.030	___	___
Pin Material	Haynes Alloy 25	___	___
Roller Material	Stellite-3	___	___

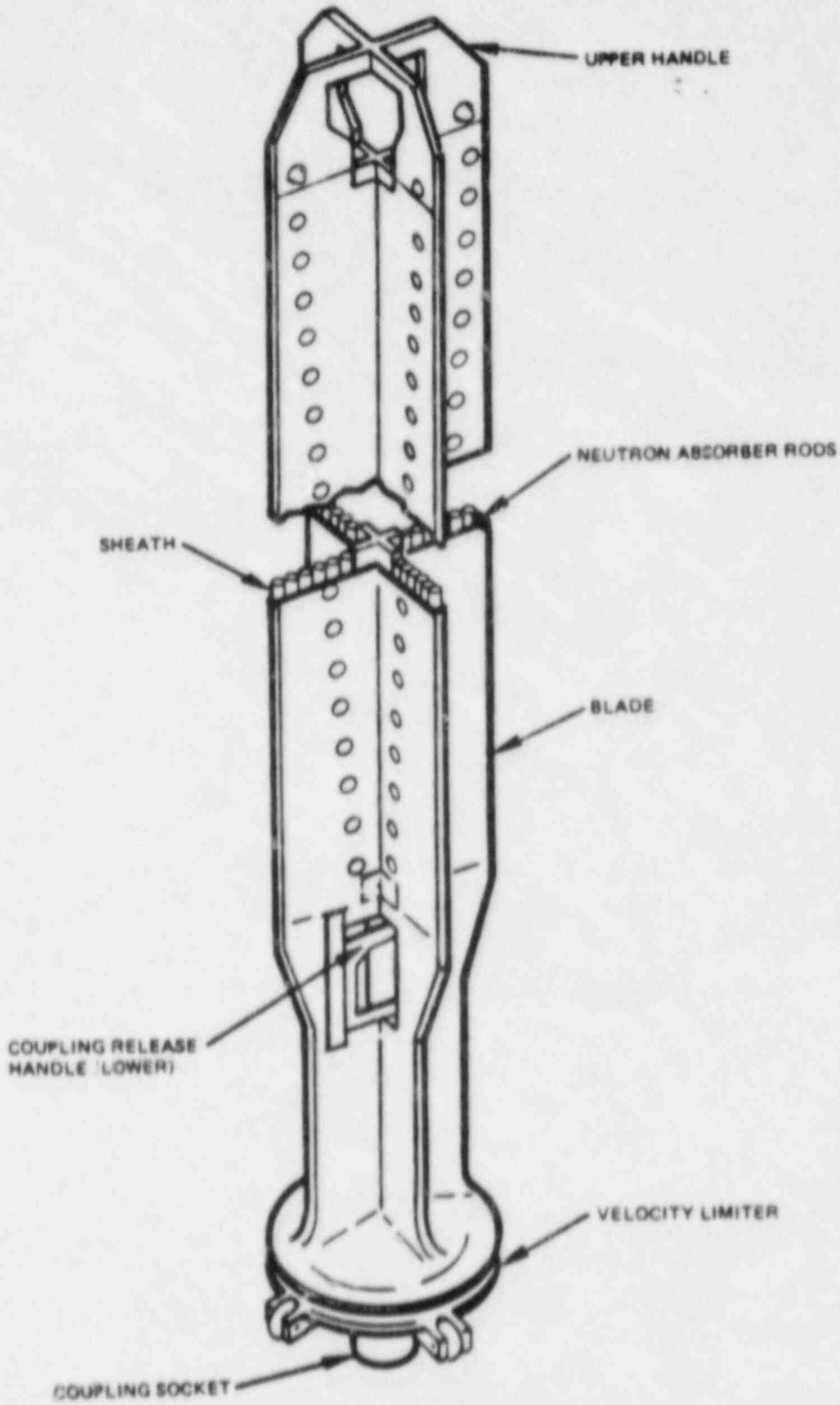

Figure 2-1. Typical HICR-C Control Rod Configuration

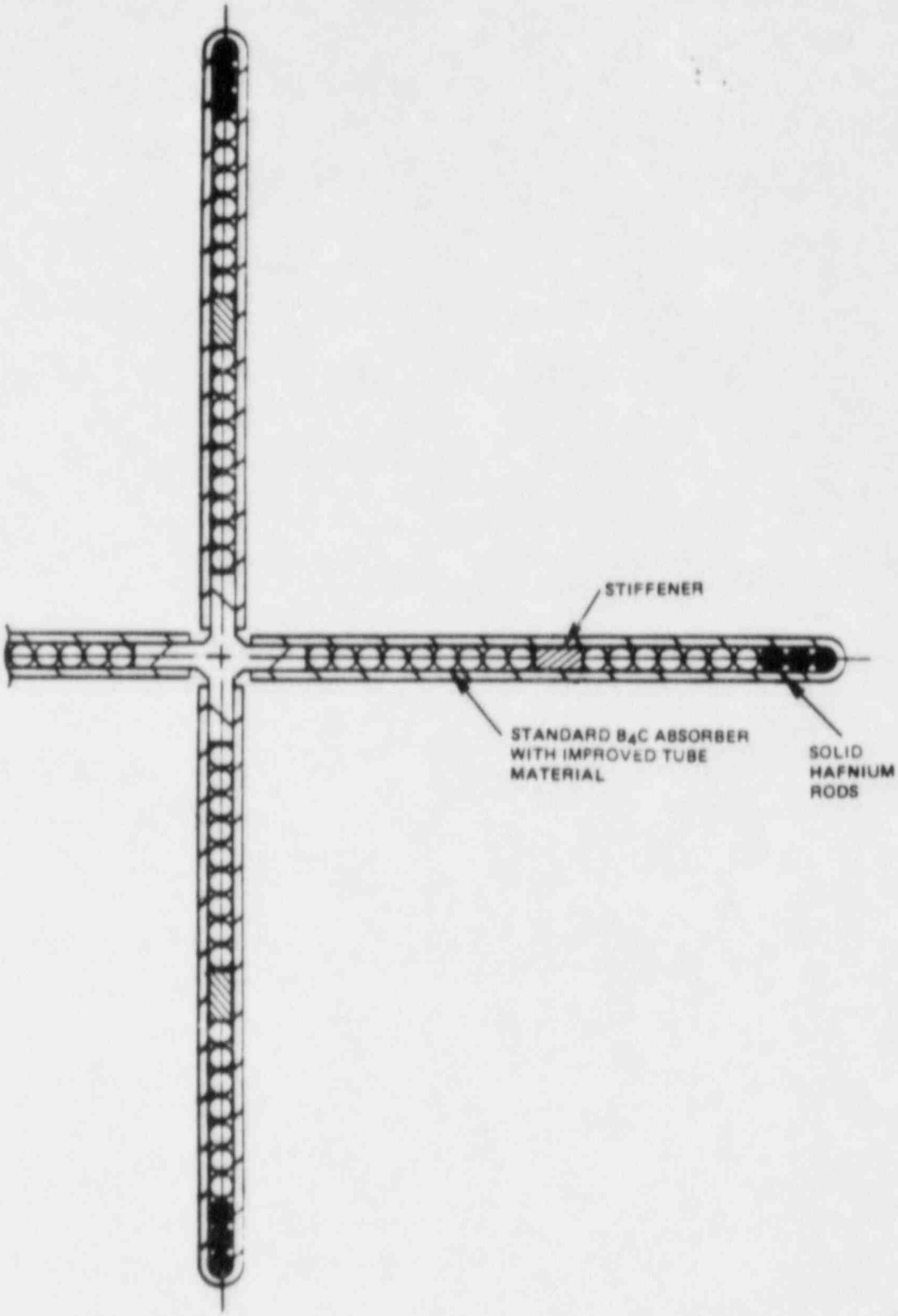

Figure 2-2. Location of Hafnium Rods in HICR-C Control Rod

3. DESIGN BASES

The HICR-C is designed to the same design bases as the HICR. The bases for the HICR design are described in Section 3 of Reference 1.

4. MATERIALS EVALUATION

Since the materials for the HICR-C assembly are the same as the materials for the production version of the HICR assembly, the materials evaluation (physical, chemical, irradiation and mechanical properties) presented in Section 4 of Reference 1 is applicable to the HICR-C.

5. DESIGN EVALUATION

5.1 MECHANICAL EVALUATION

5.1.1 Thermal Expansion and Irradiation Growth of Hafnium Rods

Section 5.1.1 of the Reference 1 report describes the thermal expansion and irradiation growth of the solid hafnium rods for the HICR. This evaluation is also applicable to the HICR-C.

5.1.2 Weight Increase Due to Hafnium Absorber Rods

Substitution of hafnium as an absorber material for boron carbide results in a __ lb increase in control rod weight. This weight increase has been evaluated to determine its effect on the sheath design margins. Since the additional loading per wing (____ lb distributed over a 12 ft length) is insignificant compared to the sheath strength and design margins, the small increase in weight will have no effect on the mechanical adequacy of the control rod.

5.2 NUCLEAR EVALUATION

5.2.1 Reactivity Worth

The reactivity worth of the HICR-C was calculated using the _____ computer program. All Monte Carlo results are based on 100,000 neutron histories. In addition, the reactivity worth of the production HICR was recalculated to 100,000 neutron histories to obtain improved statistics over the results previously reported in Table 5-1 of Reference 1. The _____ geometry input model represents an infinite array of controlled fuel in a reactor core geometry analogous to that described in Section 5.2.1 of Reference 1. The results of the reactivity worth comparison between the HICR (update of information in Reference 1), HICR-C and standard all B_4C control rod, are summarized in Table 5-1. ______________________________________

____

____ The numerical results in Table 5-1 are very similar for both control rod design applications. As a result, there will be no significant impact on cold shutdown margin or normal core and fuel operation of a core containing some or all HICR-C's. A list of plants is provided in Table 5-2 showing the potential application of both control rod design types.

5.2.2 Experimental Results

The experimental results described in Section 5.2.2 of Reference 1 are applicable for benchmarking the ______ computer code.

5.2.3 Methods Qualificati

The methods qualification described in Section 5.2.3 of Reference 1 describe the benchmark calculations performed to qualify the ______ computer code to perform the calculations presented in Section 5.2.1.

5.2.4 Fluence Limitations

The fluence limitations described in Section 5.2.4 of Reference 1 apply to the HICR-C.

5.2.5 Summary

The current practice by General Electric in Standard Lattice Physics methods is to model the standard all-B_4C control rod assemblies as non-depleted. The effects of control rod depletion on core performance during any one fuel cycle are small and are corrected for by the critical eigenvalue normalization process performed for each fuel cycle. Section 5.2 demonstrates, through the use of a benchmarked Monte Carlo computer code, that a non-depleted HICR-C has direct nuclear interchangeability with a non-depleted all-B_4C control rod assembly. The HICR-C also has the same end-of-life reactivity worth reduction limit as the all-B_4C control rod assembly. As a result, the HICR-C can be used without change in the current lattice physics treatment of control rod assemblies and current design procedures.

5.3 THERMAL HYDRAULIC EVALUATION

The thermal hydraulic evaluation contained in Section 5.3 of Reference 1 is directly applicable to the HICR-C.

5.4 SURVEILLANCE PROGRAM

The surveillance programs described in Section 5.4 of Reference 1 are directly applicable to the HICR-C.

Table 5-3 contains an updated listing of the surveillance programs that directly support the advanced control rod designs which includes the HICR-C.

Table 5-1

REACTIVITY WORTH COMPARISON - HYBRID
(GE COMPANY PROPRIETARY)

I. BWR2-4 D-Lattice, (Information Only) - HICR

	$\Delta k/k$ ($\pm 1\sigma$)		
Condition	Hybrid	STD All B_4C	Δ [$\Delta k/k$]

II. BWR4/5 C-Lattice - HICR-C

	$\Delta k/k$ ($\pm 1\sigma$)		
Condition	Hybrid	STD All B_4C	Δ[$\Delta k/k$]

Table 5-2

POTENTIAL CONTROL ROD TYPE APPLICATION

HICR D Lattice Plants	HICR-C C Lattice Plants

FOREIGN PLANTS (FOR INFORMATION ONLY)

HICR	HICR-C

Table 5-3

SUMMARY OF HYBRID IRRADIATION PROGRAMS

Plant	Type	Insertion	Qty
Monticello	Pins and Rollers	2/80	2
Peach Bottom 2	Unclad HF Test Rods	3/80	2
Millstone	Pins and Rollers	9/80	2
Quad Cities 1	High Purity Type 304SS Production Rods	8/82	30
Peach Bottom 3	Hybrid Surveillance Rods (HP 304SS, Bare HF)	4/83	5
Additional Plant	Similar to PB 3	1984-5	2
Monticello	Hybrid Production Rod (HP 304SS, Bare Hafnium) Long Term Surveillance	9/84	1
Additional Plant	Similar to Monticello	1984-5	1

6. SAFETY EVALUATION

6.1 ACCIDENT EVALUATION

The mechanical and nuclear properties of the HICR-C do not differ from those of current assemblies in any manner that might be significant in a safety evaluation for normal or accident conditions. Accordingly, the HICR's can be used to replace the currently used control rods without additional considerations beyond those used in the safety analyses for the current assemblies. Additional discussion follows:

6.2 MECHANICAL EVALUATION

Except for minor differences described in Section 2 the HICR-C assembly is mechanically identical to control rod assemblies for which many reactor years of safe operating experience are available.

The HICR-C weighs ___ pounds more than the current BWR4/5 C lattice control rod. This weight is less than the BWR2 D lattice (Table 2-1) and BWR6 control rods. Accordingly the mechanical safety analysis for the HICR-C is enveloped by the mechanical safety analyses for the BWR2-4 D lattice control rod assembly and the BWR6 control rod assembly which is subjected to much higher loads.

6.3 THERMAL EVALUATION

The thermal limits for the HICR-C are bounded by the limits given for the HICR in Section 6 of Reference 1.

6.4 REACTOR CORE RESPONSE EVALUATION

The HICR-C has been evaluated against the current control rod to compare LHGR, MCPR and MAPLHGR limits and scram times. The LHGR, MCPR and MAPLHGR limits remain unchanged for the following reasons:

- o The reactivity worth of the HICR-C is equivalent to the all B_4C control rod currently in use at BWR4/5 C lattice plants (Section 5.2.1).

- o The weight of the HICR-C control rod is ______________ pounds less than the BWR2-4 D lattice control rod (Table 2-1).

- o The same locking piston control rod drive design is used in all BWR2-5 plants.

- o ____ ____ ________________________________

- o ____ ____ ____

- o The LHGR, MCPR and MAPLHGR limits are not affected by the application of the HICR-C to BWR4/5 C lattice plants.

6.4.1 BWR4/5 Performance Evaluation

For information, a scram speed evaluation was performed to quantify the effect of increasing the weight of the BWR4/5 C lattice control rod by __ pounds, the weight increase of the HICR-C as compared to the standard all B_4C control rod currently in use at BWR4/5 C-lattice plants.

Scram times were evaluated for the HICR-C by use of an analytical computer model that models the scram performance of the locking piston control rod drive. Included in the model are the friction and hydraulic drag forces acting on the drive piston during scram and the pressure drops occurring in various flow paths within the drive. Where required, instrumented scram tests were performed to obtain data to more accurately model drive forces and pressure drops. The analysis is capable of evaluating three possible scram modes, which are accumulator scram, vessel scram and mixed scram. Mixed scram occurs when the ballcheck valve oscillates in the cage between the vessel inlet port and the accumulator port. The results of this model have been verified against actual full stroke scram data, encompassing all three scram modes. The analytical model can simulate any core and drive arrangement (i.e., BWR4, BWR5, or BWR6) or vessel condition.

Using the scram analytical model to evaluate the HICR in a BWR4/5 C-lattice plant in place of the __ lb lighter all B_4C control rod results in the differential scram times shown in Table 6-1. The results are shown for various reactor pressures.

As stated in Section 6.4, the differential scram times provided in Table 6-1 have no impact on plant safety margins.

Table 6-1

CALCULATED SCRAM PERFORMANCE OF HICR-C
(GE COMPANY PROPRIETARY)

% Insertion	Scram Time Increase (sec)
5	
20	
50	
90	

7. REFERENCE

1. "Safety Evaluation of the General Electric Hybrid I Control Rod Assembly," General Electric Company, September 1983 (NEDO-22290-A).

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