CENPD-290-NP

# ABB BWR Generic Control Rod Design Methodology

ABB Combustion Engineering Nuclear Operations

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February 1994

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# 1 PURPOSE AND CONCLUSION

Purpose

The original ABB BWR Control Rod Design Licensing Topical Report, UR 85-225-A, (Reference 2) was approved by the NRC in February 1986. It described original ABB control rod mechanical design, design requirements, and supporting analyses for application in D-lattice BWR's.

Several Supplements to the original Licensing Topical Report (UR 85-225-A) have been submitted (Reference 4, 6, and 8), to address the use of ABB Control Rods in other GE BWR lattice configurations, the use of the CR-85 configuration (hafnium along the edges of the control rod), and the use of high worth control rods. These supplements describe relatively minor changes to geometry (i.e., hole pitch, hole depth, control rod thickness) from the ABB Control Rod design described in UR 85-225-A.

The purpose of this Licensing Topical Report is to present a set of Design Requirements for ABB BWR Control Rods to be used in GE BWR's. Given these Design Requirements, a set of quantifiably measurable Criteria is established which, if met for a new rod design or general design change, ensures that the Design Requirements are met. Taken together with the Design Requirements, these Criteria form a set of Design Bases for ABB Control Rods for use in GE designed BWR's.

A set of Critical Attributes has been established for previously NRC approved ABB Base Designs, which fully describe these designs. Critical Attributes of new, proposed designs are compared to those of the Base Designs and an evaluation against specified Criteria is made in any areas not clearly bounded by the Base Designs. If this evaluation shows all applicable Criteria are met, the proposed change can be used without formal NRC review. If the Criteria are not met, the change can be modified to meet the Criteria or a specific NRC review and approval can be sought. In no case will such a non-conforming proposed change be used outside the previous two constraints.

Conclusion

This Licensing Topical Report defines a comprehensive set of Design Requirements and a set of specific Acceptance Criteria which, if met, ensure that an ABB Control Rod will function as required in a General Electric built BWR. This report is a logical extension to the methods and analyses documented, reviewed, and approved in UR 85-225-A and subsequent Supplements (Reference 2, 4, 6, and 8). This will then allow various specific ABB Control Rod designs within the basic ABB design to be built to meet different plants' needs and desires without requiring explicit NRC approval for each and every specific design.

The above approach with respect to design, licensing, and use of ABB Control Rods is acceptable, given that:

- The Base Designs are proven, with a large experience base of successful operation.

- Changes allowed under this approach are relatively small, must improve operation in some respect, and must be able to draw upon the previous experience base, i.e. must fall under the Basic ABB Design described in Section 2.2.

- New designs will be subject to inspection of lead control rods to verify improved operation.

- The format of this Licensing Topical Report (See Sections 11, 12, Appendix B, and Appendix C) allows the NRC and customers to easily keep up-to-date on ABB experience and design.

- Changes that do not meet the specified rigorous Criteria do require NRC explicit approval prior to use.

Therefore, it can be seen that this approach gives ABB the flexibility to improve the design, as well as meet individual customer needs, without requesting explicit NRC review and approval for each and every change; while still meeting all NRC approved Criteria and Design Requirements.

In this Topical Report we have defined an explicit set of Design Requirements and Acceptance Criteria. Specific ABB Control Rod designs can then be evaluated using the methodology described in Section 10 against these requirements to ensure compliance. Appendices B and C will contain specific applications of this methodology. Appendices B-1 and C-1 are included as examples.

# 2 INTRODUCTION

## 2.1 Background

The initial design ABB Control Rod, designated as CR-70, is described in Reference 1. This design contained only $B_4C$ as a neutron absorber. Due to the potential for $B_4C$ swelling induced cracking in the rod tip when a control rod is fully withdrawn, subsequent designs have contained hafnium (which does not swell when irradiated) in the tips of the rods. The CR-70 design is no longer manufactured. Nevertheless, many of these rods have operated well, and are still in operation, in the Swedish built ABB reactors. Table 2-1 contains history data for this design.

Reference 2 describes the next ABB design, CR-82 for use in D-Lattice GE BWR's. This design contains hafnium in the top six inches of the rod, with a total rod worth within 5 percent of the original control rods. With the exception of the hafnium tip it is very similar to the rod described in Reference 1. Use of this rod design has been approved by the NRC in Reference 3. Many rods of this hafnium tipped design are currently operating in the US. Table 2-1 also contains history data for this design.

Reference 4 discusses the use of the CR-82 design in C-Lattice GE BWR's. This design is similar to the D-Lattice in concept, with differences in geometry and envelope dimensions due to the differences in the lattice designs. Use of this rod design has been approved by the NRC in Reference 5. Many rods of this design are also currently operating in the US. Table 2-1 also contains history data for this design.

Reference 6 discusses: (1) a design that incorporates hafnium along the outer edge of the rod as well as in the top six inches used in previous designs (CR-85) and (2) use of ABB Control Rods in BWR/6 reactors. Approval of the NRC is contained in Reference 7. Many rods of this design are also currently operating. Table 2-1 also contains history data for this design.

Reference 8 discusses the use of high worth control rods. This design differs from the others mainly in the depth of the absorber holes. This design uses deeper holes, allowing more boron carbide to be inserted in the rod, with a corresponding increase in rod worth.

## 2.2 Basic ABB Design

The basic ABB design for which the above described experience base is applicable and for which this Licensing Topical Report is intended to cover, consists of a control rod which:

a. Has horizontal absorber holes drilled in solid stainless steel wings,

b. Uses guide pads (buttons) rather than the upper pins and rollers used in the Original Equipment Manufacturer's control rods,

c. Uses boron and/or hafnium as the neutron absorbing material(s),

d. Has a velocity limiter,

e. Weighs less than the design weight for the control rod drive,

f. Has an initial worth within 5 percent of the initial worth of the control rod that it is replacing, and

g. Does not negatively impact the ability of the Core Monitoring System to monitor the core (i.e., [proprietary information deleted] ).

## 2.3 Current/Future Developments

ABB's extensive experience with the basic ABB control rod design encompasses over 20 years in BWR reactors of all vendors. The basic design discussed in the previous section has proven to be an excellent design and serves as the basis for future designs. Past improvements, as well as foreseeable future improvements will involve incremental changes on the basic design such that the large experience base of proven design can be applied to any new design.

Recent control rod inspections (References 9 through 12) indicate an increased potential for control rod cracking for rods used in Mono-sequence positions in the core. This fuel management scheme uses a limited number of control rods deeply inserted into the core for a significant fraction of the cycle. Rods used in this manner receive a substantial fast neutron dose when inserted in highly voided regions (deeply inserted) of the core. This fast neutron dose is not measured by current core monitoring systems, but it is well known that fast neutron irradiation makes stainless steel susceptible to Irradiation Assisted Stress Corrosion Cracking (IASCC).

Thus, a new design, designated as CR-82M, has been developed to counteract this potential life shortening situation. This design modifies the hole parameters (pitch and diameter) such that more wall thickness between the hole and outside is obtained without unduly compromising the ligament between holes. Thus, Mechanical Lifetime will be greater than Nuclear Lifetime even for rods deeply inserted in the core for a substantial fraction of their lives.

Other reasons for variations in the basic control rod design described in Section 2.2 above include, but are not limited to:

a. The desire for long handles. These rods do not require the use of blade guides when fuel is removed from the cell and the rod is fully inserted. These rods are the same as the standard rods except for a longer handle.

b. Individual utilities' desire for differing rod worths in otherwise identical rods. [proprietary information deleted]

c. Use of improved materials. [proprietary information deleted]

## 2.4 Evaluation Methodology

Design Requirements for ABB Control Rods are listed in Section 4. Experience has shown that the previously approved NRC approved rods meet these requirements.

Each new, specific control rod design or general design change will be reviewed against the Base Designs already approved by the NRC (References 2 through 7). The critical attributes of the Base Designs have been designated in Sections 5 through 8.

Where differences exist, an evaluation against the applicable specific Criteria given in the appropriate section of this Topical Report will be made. This "Difference Evaluation" will ensure that any new, specific control rod design or general change will meet the Design Requirements specified in Section 4. This initial submittal contains Difference Evaluations for some currently marketed changes. They are included in Appendix B of this document, as examples, including applicable supporting information.

In addition, an Applicability Document is generated for each application of an ABB Control Rod design in a specific reactor. This document, discussed in Section 11, summarizes how and why the particular control rod design meets the generic requirements described in this document. Appendix C contains example Applicability Documents for selected reactors.

Future Applicability Documents and any future Difference Evaluations that may arise will be documented and sent to the NRC, for information, as per Section 12 of this Topical Report, to keep the NRC up-to-date with the ABB Control Rod design and technology.

## TABLE 2-1

## CONTROL ROD HISTORY

| Reactor | Country | Power | Number Per Type (CR-) 70 | 82 | 82M | 85 | Year |
|---|---|---|---|---|---|---|---|
| Oskarshamn 1 | Sweden | 460 | 124 | 40 | 16 | | 1970-1993 |
| Oskarshamn 2 | Sweden | 615 | 126 | 30 | 16 | 2 | 1974-1993 |
| Oskarshamn 3 | Sweden | 1100 | 169 | 31 | | | 1984-1987 |
| Ringhals 1 | Sweden | 750 | 163 | 71 | 20 | | 1973-1993 |
| Barsebäck 1 | Sweden | 615 | 115 | 81 | 3 | 2 | 1975-1993 |
| Barsebäck 2 | Sweden | 615 | 109 | 73 | 4 | | 1976-1993 |
| Forsmark 1 | Sweden | 970 | 165 | 42 | 18 | | 1977-1993 |
| Forsmark 2 | Sweden | 970 | 161 | 23 | 16 | | 1979-1993 |
| Forsmark 3 | Sweden | 1100 | 173 | 12 | 20 | | 1983-1993 |
| TVO I | Finland | 710 | 125 | 42 | | | 1978-1992 |
| TVO II | Finland | 710 | 121 | 92 | 6 | | 1979-1993 |
| KKB | F R G | 771 | 4 | 68 | | 13 | 1984-1990 |
| KKI 1 | F R G | 907 | 11 | 22 | | 24 | 1984-1989 |
| KKP 1 | F R G | 860 | 4 | 34 | | | 1984-1990 |
| KRB II B | F R G | 1250 | | | | 20 | 1988 |
| KRB II C | F R G | 1250 | 2 | | | 26 | 1984-1988 |
| KKK | F R G | 1260 | | 48 | 25 | 20 | 1986-1992 |
| KKL | Switzerland | 1054 | | | | 4 | 1987 |
| Sta Maria de G | Spain | 440 | | 5 | | | 1988 |
| Dresden 2 | USA | 800 | | 10 | | | 1986 |
| Dresden 3 | USA | 800 | 4 | 16 | | | 1982-1987 |
| Millstone 1 | USA | 660 | | 22 | | | 1985-1987 |
| Quad Cities 1 and 2 | USA | 809 | | 35 | | | 1985-1987 |
| La Crosse | USA | 50 | | 20 | | | 1986 |
| La Salle | USA | 1123 | | 14 | | | 1988-1990 |
| Hatch 1 | USA | 813 | | 4 | | | 1987 |
| Hope Creek | USA | 1067 | | 18 | 25 | | 1989-1992 |
| James A. Fitzpatrick | USA | 816 | | | 4 | | 1991 |
| Tokai 2 | Japan | 1056 | | | | 37 | 1988-1991 |
| Tsuruga | Japan | 340 | | | | 18 | 1988-1992 |
| Kashiwazaki 2 | Japan | 1067 | | | | 13 | 1989-1992 |
| Kashiwazaki 3 | Japan | 1067 | | | | 4 | 1992 |
| 1 Fuku-2 | Japan | 760 | | | | 19 | 1989-1992 |
| 1 Fuku-3 | Japan | 760 | | | | 24 | 1990-1993 |
| 1 Fuku-6 | Japan | 1067 | | | | 19 | 1989-1992 |
| 2 Fuku-1 | Japan | 1067 | | | | 27 | 1989-1993 |
| 2 Fuku-2 | Japan | 1067 | | | | 21 | 1990-1992 |
| 2 Fuku-3 | Japan | 1067 | | | | 23 | 1991-1993 |
| 2 Fuku-4 | Japan | 1067 | | | | 25 | 1989-1991 |
| **Laguna Verde** | **Mexico** | **654** | | | **20** | | **1993** |
| **Total:** | | | **1576** | **853** | **193** | **341** | |

Grand Total: 2963

# 3 DEFINITIONS

## 3.1 Applicability Document

A document that summarizes how and why any particular control rod meets the generic requirements contained in this document.

## 3.2 Base Designs

ABB Control Rod designs which have already received NRC approval. These designs are summarized in Table 3-1. Critical Attributes for these rods are presented in Sections 5 through 8 of this document and are summarized in Section 10. A large data base of operating experience shows these rods meet the Design Requirements for ABB Control Rods in GE BWR's, listed in Section 4.1.

## 3.3 Conformance Methods

Various means by which it is possible to check that a proposed change meets specific Criteria. These methods include experience, testing, analyses, and inspection.

## 3.4 Criteria

A set of quantifiable, measurable standards which, if met, ensure that the Design Requirements are met.

## 3.5 Critical Attributes

Those attributes (dimensions, materials, design values, etc.) which, if changed, have the potential to affect fit, form, or function of the control rod.

## 3.6 Design Requirements

A set of general guidelines for the design of ABB Control Rods which, if met, ensure that ABB Control Rods will operate as required in D-, C-, and S-Lattice GE BWR's.

### 3.7 Difference Evaluation

An evaluation to applicable specific Criteria of differences in Critical Attributes in a proposed new rod design or general design change relative to a comparable Base Design. Where this evaluation shows that the Criteria is met, no specific NRC review and approval of the specific design or change is required prior to use. Where the Criteria are not met, the design or change must either:

a. Be further modified to meet the Criteria, or

b. Receive NRC review and approval prior to use, or

c. Not be used.

## TABLE 3-1

## BASE DESIGNS

| BASE DESIGN | NRC APPROVAL | TYPICAL OUTLINE DRAWING |
|---|---|---|
| D-Lattice CR-82 | Reference 3 | AA 263 053 |
| C-Lattice CR-82 | Reference 5 | AA 263 055 |
| S-Lattice CR-82 | Reference 7 | AA 263 057 |
| D-Lattice CR-85 | Reference 7 | AA 263 054 |
| C-Lattice CR-85 | Reference 7 | AA 263 056 |
| S-Lattice CR-85 | Reference 7 | AA 263 058 |

# 4 DESIGN REQUIREMENTS

## 4.1 General

The general Design Requirements for ABB BWR Control Rods to be used in GE BWR's are as follows:

(1) The Control Rod is compatible with the Control Rod Drive (CRD) system, coupling device, fuel, fuel channels, associated core internals, and rod handling equipment.

(2) The Control Rod is designed such that rod worth and transient operation (e.g., scram and free fall velocity) are consistent with the Plant Safety Analyses.

(3) The Control Rod is designed with mechanical stability and materials choices such that the safety related mechanical function, scram capability, is maintained throughout the life of the Control Rod.

(4) The Control Rod is designed such that core power distribution monitoring, as well as burn-up monitoring can use the same tool(s) as is being currently used at the site.

(5) The Control Rod is designed such that total life cycle dose due to its use (activation products, direct dose, and disposal dose) is minimized.

(6) The design and manufacture of the Control Rod fulfill applicable codes and standards. In the US, this means applicable parts of the ASME Boiler and Pressure Vessel Code.

Given the above Design Requirements, a set of quantifiably measurable Criteria is established which, if met for a new Control Rod design or general design change, ensure that the Design Requirements are met. These specific Criteria are given in the following sections. Table 4-1 lists the Design Requirements along with their related specific Acceptance Criteria.

Taken together with the Design Requirements, these Criteria form a set of Design Bases for ABB Control Rods for use in GE designed BWR's.

## 4.2 Conformance Methods

Conformance to the Acceptance Criteria (and ultimately the Design Requirements) is ensured by at least one of the following methods:

(1) Experience with the identical or similar design(s)

(2) Testing of prototypes, specific features, etc.

(3) Analyses

(4) Inspection

Of these Conformance Methods, experience is the preferred approach. The experience approach provides the most applicable, directly comparable method for verification to criteria. This is why, in general, design changes are made in small, incremental steps so that the experience base of previous designs remains valid and can be used.

Where the experience base does not exist or the time to obtain such a base is too long, testing of prototypes as well as specific features may be undertaken. Analyses are used (1) to supplement testing, (2) to extend test results to other product lines or designs, or (3) in lieu of testing when testing is not practical or is prohibitively expensive, and the analytical tools available are known to give credible results.

Inspection is used more as a verification of the first three methods rather than directly as a Conformance Method. Inspection allows for increasing the accuracy of analyses, verifying results of tests, and updating of the experience base. Inspections may also lead to improved designs through detection of previously unknown or unanticipated problems that would not be otherwise seen if no inspections had been done.

## TABLE 4-1

## DESIGN REQUIREMENTS/CRITERIA MATRIX

| DESIGN REQUIREMENT | APPLICABLE CRITERIA [1] |
|---|---|
| (1) The Control Rod is compatible with the CRD system, coupling device, fuel, fuel channels, and rod handling equipment. | [ proprietary information deleted] |
| (2) The Control Rod is designed such that rod worth and transient operation (e.g., scram and free fall velocity) are consistent with the Plant Safety Analyses. | [proprietary information deleted] |
| (3) The Control Rod is designed with mechanical stability and materials choices such that mechanical function is maintained throughout the life of the Control Rod. | [proprietary information deleted] |
| (4) The Control Rod is designed such that core power distribution monitoring, as well as burn-up monitoring can use the same tool(s) as is currently being used at the site. | [proprietary information deleted] |

NOTES:

1. Criteria Nomenclature is as follows:
   MA-xx Materials Criteria (See Section 5)
   ME-xx Mechanical Criteria (See Section 6)
   PH-xx Physics Criteria (See Section 7)
   OP-xx Operational Criteria (See Section 8)

TABLE 4-1 (CONTINUED)

DESIGN REQUIREMENTS/CRITERIA MATRIX

| DESIGN REQUIREMENT | APPLICABLE CRITERIA [1] |
|---|---|
| (5) The Control Rod is designed such that total life cycle dose due to its use (activation products, direct dose, and disposal dose) is minimized. | [proprietary information deleted] |
| (6) The design and manufacture of the Control Rod fulfill applicable codes and standards. In the US, this means applicable parts of the ASME Boiler and Pressure Vessel Code. | [proprietary information deleted] |

NOTES:
1. Criteria Nomenclature is as follows:
   MA-xx Materials Criteria (See Section 5)
   ME-xx Mechanical Criteria (See Section 6)
   PH-xx Physics Criteria (See Section 7)
   OP-xx Operational Criteria (See Section 8)

# 5 MATERIALS EVALUATION

## 5.1 Critical Attributes

The Critical Attributes for materials related items are given in Table 5-1. The materials used in the previously NRC approved CR-82 and CR-85 Base Designs are also included in the table.

## 5.2 Attributes Discussion

The information in this section is considered Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

TABLE 5-1

MATERIALS RELATED CRITICAL ATTRIBUTES
FOR BOTH CR-82 AND CR-85 BASE DESIGNS

| MATERIALS CRITICAL ATTRIBUTE | BASE DESIGN D, C, AND S-LATTICE MATERIAL OR VALUE |
|---|---|
| [proprietary information deleted] | [proprietary information deleted] |
| [proprietary information deleted] | [proprietary information deleted] |
| [proprietary information deleted] | [proprietary information deleted] |
| [proprietary information deleted] | [proprietary information deleted] |
| [proprietary information deleted] | [proprietary information deleted] |

**TABLE 5-2**

**MATERIALS CRITERIA**

| CRITERION | CONFORMANCE METHOD(S) [1] |
|---|---|
| [proprietary information deleted] | [proprietary information deleted] |
| [proprietary information deleted] | [proprietary information deleted] |
| [proprietary information deleted] | [proprietary information deleted] |

NOTES

1. See Section 4.2 for a discussion on Conformance Methods.

# 6 MECHANICAL EVALUATION

## 6.1 Critical Attributes

The Critical Attributes for mechanical related items are given in Table 6-1. The values used in the previously NRC approved CR-82 and CR-85 Base Designs are also included in the table.

## 6.2 Attributes Discussion

The material in this section is considered Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

### 6.3.5 Mechanical Criterion 5 (ME-5)

Criterion

The material in this section is considered Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

Discussion

The material in this section is considered Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

TABLE 3-1
MECHANICAL RELATED CRITICAL ATTRIBUTES FOR BOTH CR-82 AND CR-85 BASE DESIGNS

| MECHANICAL CRITICAL ATTRIBUTE | D-LATTICE BASE DESIGN VALUE OR RANGE | C-LATTICE BASE DESIGN VALUE OR RANGE | S-LATTICE BASE DESIGN VALUE OR RANGE |
|---|---|---|---|
| Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted |
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| Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted |

**TABLE 6-1 (CONTINUED)**
**MECHANICAL RELATED CRITICAL ATTRIBUTES FOR BOTH CR-82 AND CR-85 BASE DESIGNS**

| MECHANICAL CRITICAL ATTRIBUTE | D-LATTICE BASE DESIGN VALUE OR RANGE | C-LATTICE BASE DESIGN VALUE OR RANGE | S-LATTICE BASE DESIGN VALUE OR RANGE |
|---|---|---|---|
| Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted |
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| Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted |
| Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted |

## TABLE 6-2

## MECHANICAL CRITERIA

| CRITERION | CONFORMANCE METHOD(S) [1] |
|---|---|
| [proprietary information deleted] | [proprietary information deleted] |
| [proprietary information deleted] | [proprietary information deleted] |
| [proprietary information deleted] | [proprietary information deleted] |
| [proprietary information deleted] | [proprietary information deleted] |
| [proprietary information deleted] | [proprietary information deleted] |

NOTES

1. See Section 4.2 for a discussion on Conformance Methods.

This figure is considered Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

Figure 6-1 FEM Model of Handle

This figure is considered Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

Figure 6-2 Helium Release Rate

This figure is considered Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

Figure 6-3 Gas Pressure Build-up

This figure is considered Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

Figure 6-4 Finite Element Model of ABB Control Rod Outer Edge

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Figure 6-5 Finite Element Model of ABB Control Rod Away from the Outer Edge

This figure is considered Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

Figure 6-6 Results of Seismic Insertion Tests

# 7 PHYSICS EVALUATION

## 7.1 Critical Attributes

The Critical Attributes for physics related items are given in Table 7-1 for the CR-82 Base Designs. The values used in the previously NRC approved Base Designs are also included in the table. For the CR-85 design, actual values are not available since this design has not been installed in GE built reactors in the US.

## 7.2 Attributes Discussion

The information in this section is considered Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

**TABLE 7-1**
**PHYSICS RELATED CRITICAL ATTRIBUTES FOR CR-82 BASE DESIGN**

| PHYSICS CRITICAL ATTRIBUTE | D-LATTICE BASE DESIGN VALUE OR RANGE | C-LATTICE BASE DESIGN VALUE OR RANGE | S-LATTICE BASE DESIGN VALUE OR RANGE |
|---|---|---|---|
| Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted |
| Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted |
| Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted |
| Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted |

## TABLE 7-2

## PHYSICS CRITERIA

| CRITERION | CONFORMANCE METHOD(S) [1] |
|---|---|
| [Proprietary Information Deleted] | [Proprietary Information Deleted] |
| [Proprietary Information Deleted] | [Proprietary Information Deleted] |
| [Proprietary Information Deleted] | [Proprietary Information Deleted] |
| [Proprietary Information Deleted] | [Proprietary Information Deleted] |

NOTES

1. See Section 4.2 for a discussion on Conformance Methods.

# 8 OPERATIONAL EVALUATION

## 8.1 Critical Attributes

The Critical Attributes for operational related items are given in Table 8-1. The values used in the previously NRC approved CR-82 and CR-85 Base Designs are also included in the table.

## 8.2 Attributes Discussion

The information in this section is considered Combustion Engineering, Inc Proprietary Information and has been deleted from this document.

**TABLE 8-1**
**OPERATIONAL RELATED CRITICAL ATTRIBUTES FOR BOTH CR-82 AND CR-85 BASE DESIGNS**

| OPERATIONAL CRITICAL ATTRIBUTE | D-LATTICE BASE DESIGN VALUE OR RANGE | C-LATTICE BASE DESIGN VALUE OR RANGE | S-LATTICE BASE DESIGN VALUE OR RANGE |
|---|---|---|---|
| Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted |
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| Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted |
| Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted | Proprietary Information Deleted |

TABLE 8-2

OPERATIONAL CRITERIA

| CRITERION | CONFORMANCE METHOD(S) [1] |
| --- | --- |
| [Proprietary Information Deleted] | [Proprietary Information Deleted] |
| [Proprietary Information Deleted] | [Proprietary Information Deleted] |
| [Proprietary Information Deleted ] | [Proprietary Information Deleted] |
| [Proprietary Information Deleted] | [Proprietary Information Deleted] |
| [Proprietary Information Deleted] | [Proprietary Information Deleted] |
| [Proprietary Information Deleted] | [Proprietary Information Deleted] |

NOTES

1. See Section 4.2 for a discussion on Conformance Methods.

TABLE 8-2 (CONTINUED)

OPERATIONAL CRITERIA

| CRITERION | CONFORMANCE METHOD(S) [1] |
|---|---|
| [Proprietary Information Deleted] | [Proprietary Information Deleted] |
| [Proprietary Information Deleted] | [Proprietary Information Deleted] |

NOTES

1. See Section 4.2 for a discussion on Conformance Methods.

This figure is considered Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

Figure 8-1 Control Rod Tolerance Envelope D-Lattice, Base Design

This figure is considered Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

Figure 8-2 Control Rod Tolerance Envelope C-Lattice, Base Design

This figure is considered Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

Figure 8-3 Control Rod Tolerance Envelope S-Lattice, Base Design

# 9 SURVEILLANCE PROGRAM

## 9.1 General

An experimental program has been carried out in order to obtain data regarding the control rod failure mechanism and the mechanical service life limit of ABB Atom control rods.

The experimental program carried out at Studsvik on four blade segments cut out from two different control rods in Oskarshamn 2 covered the following items:

- Visual inspection and liquid penetrant examination
- Neutron radiography
- Metallographical examination of cracked areas and crack surfaces
- Examination of material structure

The results and conclusions from this examination program (Reference 31) regarding the use of visual examinations as an inspection method for ABB Control rods can be summarized as follows:

- Visual inspection with up to 72 times magnification using a stereo-periscope and liquid penetrant examinations has verified that a simple visual inspection can detect all cracks. Thus a visual inspection program can be used to check the integrity of ABB Atom control rods.

Inspection Programs (for example see Reference 9 through 12) have lead to improvements in control rod design and performance. In fact, the referenced programs have had direct impact on the design of the CR-82M and CR-85M control rods.

## 9.2 Program for Base Design ABB Control Rods

The inspection program for all previously approved NRC ABB Control Rods (Base Designs) will follow the program laid out in Reference 12. These guidelines are presented in Appendix A of this document.

## 9.3 Program for ABB Advanced Rod Designs and Features

The four lead burn-up control rods for advanced designs or features substantially different from the previously NRC approved (Base

Designs) control rods will also be subject to the Appendix A inspection program. This is acceptable given that:

a. No changes will be made which will degrade rod performance below that of the current rods (Base Designs).

b. The inspection threshold given in Appendix A is the crack threshold for Base Design Rods in deep locations for a substantial fraction of the cycle.

c. This threshold and inspection program is thus very conservative for improved designs (such as the CR-82M).

Examples of changes that do fit the lead control rod program include the CR-82M design and the switch to the use of 316L stainless steel from the Base Design 304L steel. Both of these changes will improve rod performance with respect to cracking, but nonetheless will be subject to the inspection program described in Appendix A. It is possible that a control rod may incorporate more than one of these types of changes and thus may serve as a lead control rod for each of the changes.

Examples of changes that do not require lead control rod surveillance include control rods identical to previous designs except for (1) hole depth (reactivity worth), (2) addition of a long handle, or (3) other changes that have negligible potential impact on fit, form, or function.

The Difference Evaluation as discussed in Section 10 of this document will identify if the new design or feature will be subject to the Appendix A inspection program. If not, it will identify which other design leads or that the change is one of those not requiring a specific program.

As part of any NRC updates discussed in Section 12 below, lead control rods will be identified as well as results of any inspections performed since the last update.

# 10 DIFFERENCE EVALUATION METHODOLOGY

## 10.1 General Format

The first step in the determination of the acceptability of a new control rod design or general design change is to determine the differences in the Critical Attributes between the proposed change and the applicable Base Design. Certain changes apply to only one of the Base Designs (a change in hole pitch for a D-Lattice rod, for example) while other changes may apply to more than one Base Design (general change in one of the materials, for example). Thus, once all affected rod types are identified, the Critical Attributes are determined and compared to the applicable Base Design(s). Blank forms which show the Critical Attributes for each of the Base Designs are included as Tables 10-1 through 10-3 for the D-, C-, and S-Lattice rods, respectively. As indicated on Table 3-1, there are 6 Base Designs; however, for purposes of Critical Attribute comparisons, it may be possible to combine the CR-82 and CR-85 Base Designs for each lattice type.

For those Critical Attributes of the proposed change that are identical or clearly bounded by the Base Design(s), no further evaluation is needed with respect to those Attributes.

For those Attributes not clearly bounded by the Base Designs or for values that are not explicitly specified (CR-85 Physics Attributes), a Difference Evaluation against applicable specific Criteria will need to be performed to show acceptability of the change. Tables 10-1 through 10-3 also identify which Criteria need to addressed for each Attribute. The section of this document that contains the applicable Criteria gives details concerning the Criteria as well as the Conformance Method(s) that can be used to show that the Criteria are met.

If the Difference Evaluation shows all applicable Criteria are met, the proposed change can be used without formal NRC review. If the Criteria are not met, the change can be modified to meet the Criteria or a specific NRC review and approval can be sought. In no case will such a non-conforming proposed change be used outside the previous two constraints.

## 10.2 Specific Changes

### 10.2.1 Completion of Forms

There are 3 GE BWR lattice designs: C, D, and S. There is one form for each, with Critical Attributes for ABB Base Designs included. A typical outline drawing and envelope drawing for each is also included.

For any proposed change, a form for each of the potentially affected lattice type is filled out. For changes that affect all designs the Critical Attribute part of the forms for each lattice type is filled out. However, in the Criterion Discussion part, it is necessary to only fill out one of the forms and reference this evaluation on the other forms.

See Appendix B for examples of how these forms are used.

### 10.2.2 Submittal

Completed form(s) for an acceptable Difference Evaluation (including necessary back-up documentation) will be gathered into one package. Completed packages will be included as Addenda to Appendix B, for information, in NRC updates, as discussed in Section 12.

**FORM 10.1**
**D-Lattice**
**Difference Evaluation Worksheet**

A. CHANGE INFORMATION

A.1 Appendix No. ________

A.2 Change Title ________________________________________________

A.3 Purpose

A.4 Brief Description

**FORM 10.1**
**D-Lattice**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON Base Design _______________

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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**D-Lattice**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON (Cont.)

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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**D-Lattice**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON (Cont.)

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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**D-Lattice
Difference Evaluation
Worksheet**

B. ATTRIBUTES COMPARISON (Cont.)

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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**D-Lattice**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON (Cont.)

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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**FORM 10.1**
**D-Lattice**
**Difference Evaluation Worksheet**

C. CRITERIA EVALUATION

I. Materials Criteria (Attach sheets as necessary)

II. Mechanical Criteria (Attach sheets as necessary)

III. Physics Criteria (Attach sheets as necessary)

IV. Operational Criteria (Attach sheets as necessary)

**FORM 10.1**
**D-Lattice**
**Difference Evaluation Worksheet**

D. REFERENCES (Attach as Required)

E. OUTLINE DRAWING (If not required, state applicable Outline Dwg)

F. ENVELOPE DRAWING (If not required, state applicable Outline Dwg)

G. SURVEILLANCE REQUIREMENTS

H. SUMMARY

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Control Rod Tolerance Envelope D-Lattice, Base Design

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Drawing AA 263 054 is considered Combustion Engineering, Inc Proprietary Information and has been deleted from this document.

**FORM 10.2**
**C-Lattice**
**Difference Evaluation Worksheet**

A. CHANGE INFORMATION

A.1 Appendix No. ________

A.2 Change Title ________________________________

A.3 Purpose

A.4 Brief Description

**FORM 10.2**
**C -Lattice**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON

Base Design ______________

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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**C -Lattice**
**Difference Evaluation Worksheet**

B. <u>ATTRIBUTES COMPARISON (Cont.)</u>

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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**C -Lattice**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON (Cont.)

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**C -Lattice**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON (Cont.)

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**C -Lattice**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON (Cont.)

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**FORM 10.2**
**C-Lattice**
**Difference Evaluation Worksheet**

C. CRITERIA EVALUATION

I. Materials Criteria (Attach sheets as necessary)

II. Mechanical Criteria (Attach sheets as necessary)

III. Physics Criteria (Attach sheets as necessary)

IV. Operational Criteria (Attach sheets as necessary)

**FORM 10.2**
**C-Lattice**
**Difference Evaluation Worksheet**

D. REFERENCES (Attach as Required)

E. OUTLINE DRAWING (If not required, state applicable Outline Dwg)

F. ENVELOPE DRAWING (If not required, state applicable Outline Dwg)

G. SURVEILLANCE REQUIREMENTS

H. SUMMARY

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Control Rod Tolerance Envelope C-Lattice, Base Design

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**FORM 10.3**
**S-Lattice**
**Difference Evaluation Worksheet**

A. CHANGE INFORMATION

A.1 Appendix No. ________

A.2 Change Title ______________________________________________

A.3 Purpose

A.4 Brief Description

**FORM 10.3**
**S-Lattice**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON

Base Design ____________

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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**S-Lattice**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON (Cont.)

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**S-Lattice**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON (Cont.)

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**S-Lattice**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON (Cont.)

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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**S-Lattice**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON (Cont.)

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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**FORM 10.3**
**S-Lattice**
**Difference Evaluation Worksheet**

C. CRITERIA EVALUATION

I. Materials Criteria (Attach sheets as necessary)

II. Mechanical Criteria (Attach sheets as necessary)

III. Physics Criteria (Attach sheets as necessary)

IV. Operational Criteria (Attach sheets as necessary)

**FORM 10.3**
**S-Lattice**
**Difference Evaluation Worksheet**

D. REFERENCES (Attach as Required)

E. OUTLINE DRAWING (If not required, state applicable Outline Dwg)

F. ENVELOPE DRAWING (If not required, state applicable Outline Dwg)

G. SURVEILLANCE REQUIREMENTS

H. SUMMARY

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Control Rod Tolerance Envelope S-Lattice, Base Design

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# 11 APPLICABILITY DOCUMENT

## 11.1 General

The Applicability Document provides a concise summary of how and why a specific design for a particular reactor meets the Criteria and thus, the Design Requirements for ABB Control Rods.

As part of the Design Review process prior to the start of manufacturing, a completed Applicability Document (See Form 11.1 for format and content) will be supplied to the customer.

## 11.2 Submittal

Completed Applicability Documents will be included as Addenda to Appendix C, for information, in NRC updates, as discussed in Section 12.

# FORM 11.1

## APPLICABILITY DOCUMENT

**I. General**

Reactor ____________________

Lattice Type ________________

ABB Rod Type _______________

**II. This design is covered by the following Base Designs and/or Appendices:**

**III. Critical Parameters**

| Parameter | Value | Bounded By |
|---|---|---|
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## 12 NRC UPDATES

NRC updates, for information only, will consist of:

a. All Appendix B and C Addenda since the previous NRC update,

b. Summary of any inspections performed, and results, since the last update,

c. Summary of lead control rod exposures,

d. Qualitative results of scram testing as well as confirmation of proper operation.

These updates will be submitted as needed to keep the NRC current of the ABB Control Rod design(s), use, and experience.

## 13 REFERENCES

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2. Topical Report, ASEA-ATOM BWR Control Rods for US BWR's, TR UR 85-225, October 1985 (proprietary).

3. Letter, H. N. Berkow (NRC) to E. Tenerz (ASEA-ATOM), Subject: Acceptance for Referencing of Licensing Topical Report TR UR 85-225, 'ASEA-ATOM Control Rods for US BWRs,' February 20, 1986.

4. Supplement 1 to TR UR 85-225A, ASEA-ATOM Control Rods for US BWRs, October 1987 (proprietary).

5. Letter, A. C. Thadani (NRC) to E. Tenerz (ASEA-ATOM), Subject: Acceptance as a Reference Document of Supplement 1 to Topical Report TR UR 85-225 'ASEA-ATOM Control Rods for US BWRs,' May 5, 1988.

6. Supplement 2 to TR UR 85-225-A, ASEA-ATOM Control Rods for US BWRs, March 1988 (proprietary).

7. Letter, A. C. Thadani (NRC) to E. Tenerz (ABB ATOM), Subject: Acceptance of Supplement 2 to Topical Report UR-85-225A 'ASEA-ATOM Control Rods for US BWRs' as a Reference Document,' August 8, 1989.

8. Supplement 3 to TR UR 85-225-A, ASEA-ATOM Control Rods for US BWRs, Concerning High Worth Control Rods, November 1988 (proprietary).

9. ABB Report BX 90-37, Meeting with the NRC Regarding Cracks in the Dresden 3 Control Rods, March 27, 1990 (proprietary).

10. Letter, ABB-90-520, J. Lindner (ABB) to R. C. Jones (NRC), Subject: Meeting with NRC Regarding Update on Results of ABB Atom BWR Control Rod Inspections and Summary of Forthcoming Actions, December 14, 1990.

11. Letter, ATOF-91-130, J. Lindner (ABB) to L. Phillips (NRC), Subject: Meeting Between NRC and ABB Atom Regarding Control Rod Inspection Results at Millstone, May 29, 1991.

12. Letter, ATOF-91-273, J. Lindner (ABB) to L. Phillips (NRC), Subject: Meeting Between NRC and ABB Atom Regarding Inspection Results and Service Life Guidelines for CR-82 Rods in US Plants, December 27, 1991 (proprietary).

13. ABB Report RM 88-1014, The ABB ATOM Computer Model BKM-CRUD (proprietary).

14. A Strasser et al, Control Rod Materials and Burnable Poisons, EPRI Report NP-1974, Palo Alto, 1981.

15. ABB memo BR 83-265, L. Holm and J. Lindner, $B_4C$ Temperature in AA Control Blades (proprietary).

16. G. J. De Salvo and R. W. Gorman, ANSYS Users Manual, Vols I & II, Swanson Analysis System Inc, Houston, 1989.

17. ASME Boiler and Pressure Vessel Code, Section III, Division 1, Edition 1986 (ASME III).

18. S. R. MacEwen et al, Calculating of Irradiation Growth in Zirconium, J. Nucl. Mater. 90 (1980) 108 - 132.

19. ABB Report UK 89-321, Calculations of Hydrogen Uptake in Hafnium in ABB Atom Control Rods, April 14, 1989 (proprietary).

20. ABB Report UK 89-441, Hydrogen Uptake in Hafnium in ABB Atom Control Rods: Model Calculations, June 14, 1989 (proprietary).

21. A. Bleier et al, Evaluation of Tritium Content in LWR Control Rod and Absorber Rods to Obtain Data for Fuel Cycle Backend Nuclear Technology, 74, 152-163 (1986).

22. G. Bart, P. C. Cripps and R. Hofer, Hf Control Rod Analysis for ABB Atom, Paul Scherrer Institute Report TM-43-90-41, 1990.

23. ABB Report BK 92-644, Tsurga-1 Scram Insertion During Earthquake Conditions, August 3, 1992 (proprietary).

24. ABB Report UK 87-672, Test of ASEA-ATOM Control Rod for BWR/5 Dropping Speed, Normal and Seismic Scram Insertion, February 2, 1988 (proprietary).

25. ABB Report UR 87-101, Nuclear Design Characteristics of ASEA-ATOM Control Blade with Hafnium Tip for Dresden-2, January 26, 1987 (proprietary).

26. ABB Report UR 88-032, Nuclear Design Characteristics of ASEA-ATOM Control Blade with Hafnium Tip for La Salle, February 12, 1988 (proprietary).

27. ABB Report UR 89-222, Nuclear Design Characteristics of ABB Atom Control Blade with Hafnium Tip for Hope Creek, June 19, 1989 (proprietary).

28. ABB Report UR 87-102, ASEA-ATOM Control Rods for BWR 2/3/4/5/6 Service Life Recommendations, Revision 1, April 4, 1987 (proprietary).

29. ABB Report BR 93-029, Standard Design of a Matched Control Rod CR-82M in BWR 2/3/4/5/6 Reactors of GE Type, January 13, 1993 (proprietary).

30. ABB Report BR 93-454, Nuclear End-of-Life for the ABB Atom Control Rod CR-82 in BWR 2/3/4/5 Reactors, June 9, 1993 (proprietary).

31. ABB Report UK 86-203, PIE of Failed Oskarshamn 2 Control Rod, April 2, 1986 (proprietary).

# APPENDIX A - INSPECTION GUIDELINES

## A.1 Mechanical Integrity

The mechanical integrity of ABB control rods can be easily checked by simple visual inspections carried out in the core. Hot-cell examinations and neutron radiography have verified this visual inspection procedure. All B-10 depletion leading ABB control rods have been visually inspected and the results form the basis for the proposed ABB control rod service life guidelines.

The fact that the mechanical integrity of ABB rods can be checked easily allows the introduction of an experience based inspection limit instead of a mechanical lifetime limit. In this way control rods can be used up to their Nuclear End-Of-Life (NEOL).

The advantage of the visual inspection based guidelines is that the control rods can be operated at all times within their proven performance envelope, i.e., they are not used more than one operating cycle with cracks. ABB has proven earlier that there is no significant safety impact on reactivity worth, insertion rate, or blade integrity if control rods are operated less than three annual cycles with cracks.

## A.2 Inspection Program

Proprietary Information Deleted

The Inspection Program consists of a visual exam that can be performed in-reactor with a minimum of equipment, i.e. camera, monitor, and a means of holding the camera steady. The inspection requirements are summarized in Tables A-1 and A-2. It is sufficient to inspect the upper 1 meter (3 feet) of a control rod, since all primary cracks occur in that zone. It is also sufficient to inspect only half of all surfaces each time, since experience has shown that if significant cracking occurs it shows up on more than one surface of a wing of a control rod.

## TABLE A-1

## ABB CR-82 CONTROL RODS INSPECTION REQUIREMENTS

This table contains Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

NOTES:

1. Sides A-H are shown on Figure A-2.

## TABLE A-2

## ABB CR-82 CONTROL RODS INSPECTION REQUIREMENTS

This table contains Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

NOTES:

1. Sides A-H are shown on Figure A-2.
2. Following the first inspection, top 3' of the other four sides must be inspected in subsequent inspections, e.g. ABEF followed by CDGH followed by ABEF etc.

This figure contains Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

Figure A-1 ABB Control Rod Service Life Guidelines

Below is a figure showing Inspection Positions relative to the orientation of the serial number and the control rod handle.

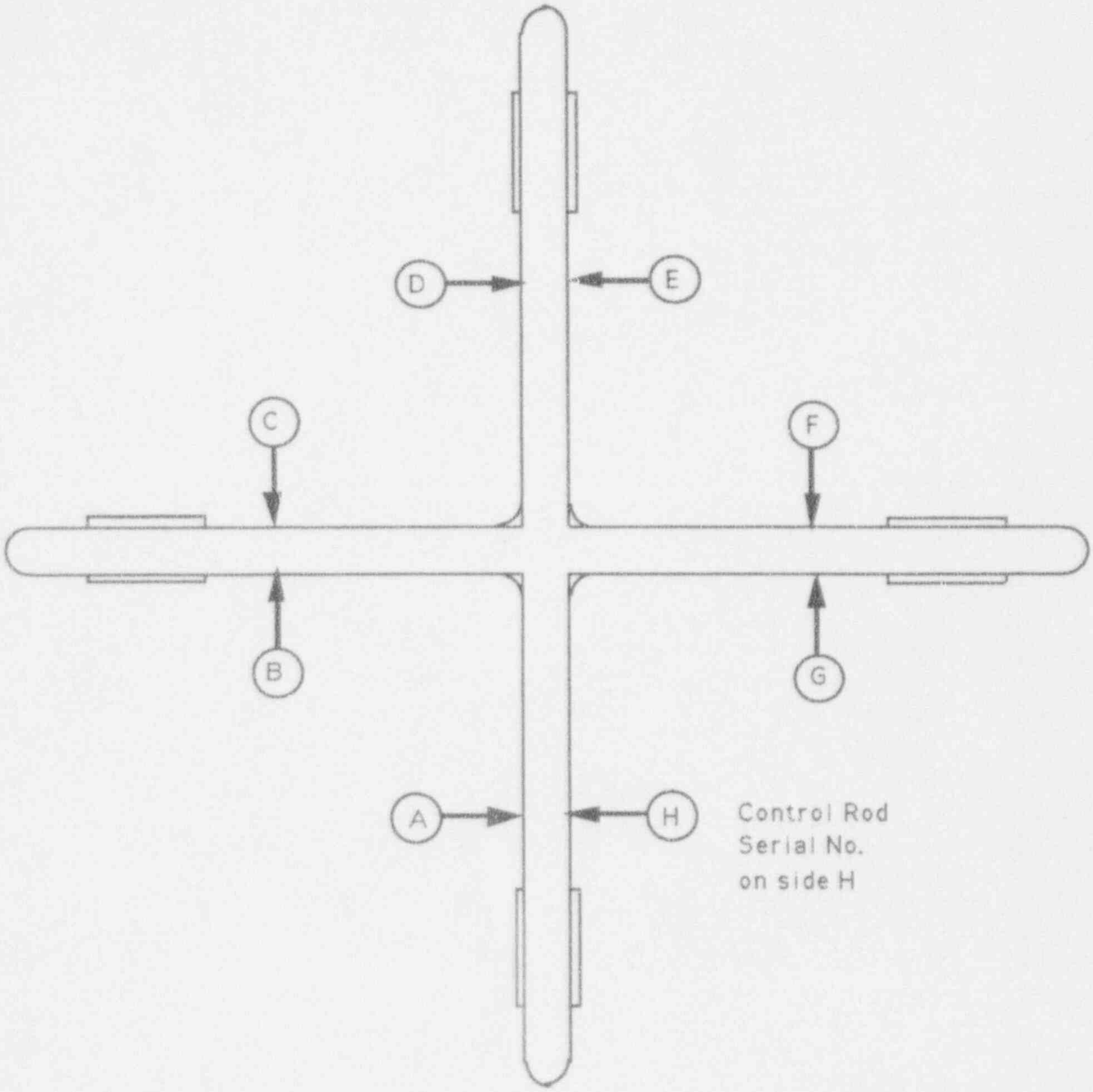


Figure A-2 Identification of Inspection Positions

## APPENDIX B - DIFFERENCE EVALUATION PACKAGES

### TABLE OF CONTENTS

## B1 Difference Evaluation Worksheet for S-Lattice 316L Stainless Steel CR 82M

A. CHANGE INFORMATION

The information contained in this section is considered to be Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

**B1**
**CR82M, S-Lattice, 316L ss**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON

Base Design S-Lattice CR82

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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## CR82M, S-Lattice, 316L ss
## Difference Evaluation Worksheet

B. ATTRIBUTES COMPARISON (Cont.)

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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**CR82M, S-Lattice, 316L ss**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON (Cont.)

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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**CR82M, S-Lattice, 316L ss**
**Difference Evaluation Worksheet**

B. ATTRIBUTES COMPARISON (Cont.)

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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## CR82M, S-Lattice, 316L ss
## Difference Evaluation Worksheet

B. ATTRIBUTES COMPARISON (Cont.)

| ATTRIBUTE | BASE DESIGN VALUE/RANGE | CHANGE VALUE/RANGE | CHANGE BOUNDED BY BASE ? (YES/NO) | CRITERIA TO BE EVALUATED IF NO |
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## C. CRITERIA EVALUATION

### I. Materials Criteria

The information contained in this section is considered to be Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

II. Mechanical Criteria

The information contained in this section is considered to be Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

III. Physics Criteria

The information contained in this section is considered to be Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

IV. Operational Criteria

The information contained in this section is considered to be Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

D. REFERENCES

B1.1 ABB Report 93-820, River Bend CR-82M Stress Analysis of Control Rod, dated September 29, 1993.

B1.2 ABB Report BR 93-029, Standard Design of a Matched Control Rod CR-82M in BWR 2/3/4/5/6 Reactors of GE Type, dated January 13, 1993 (proprietary).

B1.3 ABB Report BK 92-139, Support for Introducing Type 316L SS as Control Rod Blade Material, dated February 19, 1992 (proprietary).

E. OUTLINE DRAWING (If not required, state applicable Outline Dwg)

See ABB Drawing AA 263 159, attached.

F. ENVELOPE DRAWING (If not required, state applicable Envelope Dwg)

Not Required - Figure 8.3 is applicable

G. SURVEILLANCE REQUIREMENTS

The lead four control rods of this type may require inspections consistent with Section 9, Surveillance Program, of the ABB Generic Control Rod Methodology Report (CENPD-290-P).

Proprietary Information Deleted

Lead blade identification and results of inspections are given in updates sent per Section 12 of CENPD-290-P.

H. SUMMARY

This evaluation has been performed in accordance with Section 10, Difference Evaluation Methodology, of the ABB Generic Control Rod Methodology Report (CENPD-290-P).

As can be seen in this Appendix B1 Evaluation, the ABB S-Lattice 316L CR-82M control rod design meets all the Design Criteria, and hence the Design Requirements, described in ABB Generic Control Rod Methodology Report (CENPD-290-P).

Therefore, this control rod type can be used in GE type S-Lattice reactors without formal, site specific, NRC review and approval.

Drawing AA 263 159 is considered Combustion Engineering, Inc. Proprietary Information and has been deleted from this document.

## APPENDIX C - APPLICABILITY DOCUMENTS

### TABLE OF CONTENTS

# FORM C-1
# APPLICABILITY DOCUMENT

## I. General

Reactor River Bend

Lattice Type S-Lattice

ABB Rod Type CR-82M, 316 ss

## II. This design is covered by the following Base Designs and/or Appendices:

Base Design - S-Lattice CR-82
Appendix B1 - S-Lattice 316L ss CR-82M

## III. Critical Parameters

| Parameter | Value | Bounded By |
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