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GENERAL ELECTRIC FUEL BUNDLE DESIGNS

Approved: [signature]

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NOTICE

Proprietary information of GNF has been removed from this non–proprietary version of GE Fuel Bundle Designs. The information removed was contained between opening double brackets ([[ ) and closing double brackets ( ]]). Change bars in the margin indicate the latest revision.

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1. INTRODUCTION AND SUMMARY

This document contains bundle-specific information for the General Electric fuel designs analyzed with the fuel rod thermal-mechanical performance model described in Reference 1. The fuel designs contained in this document have received specific USNRC review and approval or have been shown to meet the USNRC approved fuel licensing acceptance criteria documented in Reference 2. (References 2 and 3 have subsequently been incorporated into Reference 12). USNRC approval of these criteria is given in Reference 3. Fuel designs which meet these fuel licensing acceptance criteria are approved for use in U.S. BWRs and do not require separate regulatory agency review. A detailed description of these designs is given in Section 2. Descriptions of analyses and analyses results that are fuel design specific are presented in Section 3. Individual fuel bundles meeting these specifications are listed in Reference 21 and Reference 22. Any new bundle designs analyzed with the fuel rod thermal-mechanical performance model described in Reference 1 will be included in future revisions to this document.

2. FUEL DESIGNS

The fuel designs presently covered in this report include:

(1) Prepressurized 8x8 Retrofit (P8x8R) and Prepressurized 8x8 Retrofit with barrier cladding (BP8x8R);

(2) GE8 and GE8B - also designated as GE8x8E (non-barrier) and GE8x8EB (barrier option);

(3) GE9B - also designated as GE8x8NB;

(4) GE10 - also designated as GE8x8NB-1 (interactive channel - C-lattice plants), GE8x8NB-2 (offset lower tie-plate only - D-lattice plants) and GE8x8NB-3 (interactive channel with offset lower tieplate - D-lattice plants);

(5) GE11.

(6) GE13.

(7) GE12.

(8) GE14

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2.1 FUEL ASSEMBLY DESCRIPTION

The fuel assembly (Figure 2-1) consists of a fuel bundle and a channel which surrounds it. Fuel assembly parameters for each fuel bundle type are given in Tables 2-1 through 2-6. The P8x8R and BP8x8R fuel bundles contain 62 fuel rods and two water rods. The GE8/8B fuel designs provide for the use of more than two water rods. Details of this design option are presented in Subsection 2.1.2. The GE9B and GE10 fuel bundles contain 60 fuel rods and one large centrally located water rod. The rods in the above fuel designs are placed in an 8x8 lattice array. The GE11 and GE13 fuel designs are comprised of 74 fuel rods and two large central water rods in a 9x9 lattice array. Eight of these fuel rods are part length rods (seeSubsection 2.1.1). The GE12 and GE14 fuel is comprised of 92 fuel rods and two large central water rods in a 10x10 lattice array. Fourteen of these fuel rods are part length rods. The rods of all bundle types are spaced and supported by the upper and lower tieplates, as well as fuel rod spacers. The lower tieplate has a nose piece which has the function of supporting the fuel assembly in the reactor. The upper tieplate has a handle for transferring the fuel bundle from one location to another. The identifying assembly serial number is engraved on the top of the handle. No two assemblies bear the same serial number. A boss projects from one side of the handle to aid in ensuring proper fuel assembly orientation (see Figure 2-2). Finger springs located between the lower tieplate and the channel are utilized to control the bypass flow through that flow path.

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A schematic representation of this axial zoning of uranium enrichment and gadolinia concentration and number of gadolinia rods for the GE8 through GE14 fuel designs is shown in Figures 2-3 and 2-4. [[

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2.1.1 Fuel Rods

Three types of fuel rods are used in all of the fuel bundle designs included in this report: tie rods, standard rods, and part length rods. The tie rods in each bundle have lower end plugs which thread into the lower tieplate and threaded upper end plugs which extend through the upper tieplate. A nut and locking tab are installed on the upper end plug of the tie rods to hold the fuel bundle together. These tie rods support the weight of the bundle during fuel handling operations when the assembly is lifted by the handle. [[ ]] In the GE11, 12, 13 and GE14 fuel designs the third type of fuel rod, called a part length rod, is used. There are 8 part length rods in the GE11 and GE13 fuel designs and 14 part length rods in the GE12 and GE14 fuel design. [[

]] The location of these rods are shown in Figures 2-5 and 2-6.

During operation, the fuel assembly is supported by the lower tieplate. [[

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Each fuel rod consists of high density ceramic uranium dioxide fuel pellets stacked within Zircaloy cladding which is evacuated, backfilled with helium to a specified pressure and sealed with Zircaloy end plugs welded on each end. For the barrier fuel designs, the cladding consists of the same Zircaloy base material with the innermost part of the cladding replaced by a thin zirconium liner. [[

]] The barrier fuel designs include BP8x8R, GE8B, GE9B, GE10, GE11, GE12, GE13 and GE14.

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Adequate free volume is provided within each fuel rod in the form of a pellet-to-cladding gap and a plenum region at the top of the fuel rod to accommodate thermal and irradiation expansion of the UO_2 and the internal pressures resulting from the helium fillgas, impurities, and gaseous fission products liberated over the design life of the fuel. [[

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2.1.2 Water Rods

The P8x8R and BP8x8R fuel bundles contain two water rods. GE8/8B fuel designs provide for the use of more than two water rods. The GE9B and GE10 fuel designs contain one large centrally located water rod. This is increased to two large central water rods for the GE11, GE12, GE13 and GE14 fuel designs. A dimensional description of the water rods is included in Tables 2-1 through 2-6. [[

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2.1.3 Other Fuel Assembly Components

The primary function of the fuel spacer is to provide lateral support and spacing of the fuel rods. The P/BP8x8R and GE8/8B fuel designs utilize an egg-crate spacer. The ferrule spacer design is used for the GE9B through GE11 and in the GE 13 and GE14 fuel designs. The GE12 fuel design optionally employs either a ferrule or a unit cell spacer. There are seven (7) spacers in the fuel designs through GE11. GE12, GE13 and GE14 have an eighth spacer. In the GE11, GE12 and GE13 fuel design, the top two spacers do not have ferrules above the part length fuel rods, and the GE14 fuel design has no ferrules above the part length fuel rods in the top three spacers.

Finger springs are employed to control the bypass flow through the channel-to-lower tieplate flow path. These finger spring seals, which are located between the lower tieplate and the channel, provide control over the flow through this path due to channel wall deflections by maintaining a nearly constant flow area as the channel wall deforms.

The upper and lower tieplates support the weight of the fuel and position the rod ends during operation and handling. Two alternate path bypass flow holes are located in the lower tieplate (Figure 2-1). These holes are drilled to augment flow in the bypass region. A more detailed discussion of the GE10 lower tie-plate design is presented in Reference 4. A similar design is used for GE11, GE12, GE13 and GE14. There is an optional *Debris Filter* lower tie plate available for GE11, GE12 and GE13 fuel. The debris filter lower tie plate is standard for the GE14 design. This debris filter lower tie plate is very similar to the regular tie plate except for the upper portion, or the grid plate. [[

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2.1.4 Channels

The channel is open at the bottom [[

]] The upper end of each fuel assembly in a four-bundle cell is positioned in the corners of the cell against the top guide beams by the channel fastener springs. At the top of the channel, two diagonally opposite corners have welded tabs, one of which supports the weight of the channel from a threaded raised post and the upper tieplate. One of these raised posts has a threaded hole. The channel is attached using the threaded channel fastener assembly, which also includes the fuel assembly positioning spring. Channel-to-channel spacing is provided by means of spacer buttons located on the upper portion of the channel adjacent to the control rod passage area.

For the P/BP8x8R through GE9B fuel designs, the channels have a uniform thickness of 80 or 100 mils for BWR2-5 and ABWR plants and 120 mils for BWR6 plants. The channels for the GE10 options 1 and 3 (GE10-1,3), GE11, GE12, GE13 and GE14 fuel designs have, in most cases, thinner sides and thicker corners. A more detailed discussion of the GE10 through

GE14 channel design is presented in Reference 4. Channel dimensions for all fuel designs are given in Tables 2-1 through 2-7.

The BWR Zircaloy fuel channel performs the following functions:

(1) Forms the fuel bundle flow path outer periphery for bundle coolant flow.

(2) Provides surfaces for control rod guidance in the reactor core.

(3) Provides structural stiffness to the fuel bundle during lateral loadings applied from fuel rods through the fuel spacers.

(4) Minimizes, in conjunction with the finger springs and bundle lower tieplate, coolant bypass flow at the channel/lower tieplate interface.

(5) Transmits fuel assembly seismic loadings to the top guide and fuel support of the core internal structures.

(6) Provides a heat sink during loss-of-coolant accident (LOCA).

(7) Provides a stagnation envelope for in-core fuel sipping.

Table 2-1

FUEL ASSEMBLY DESIGN SPECIFICATIONS For The P/BP8x8R FUEL DESIGN

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Table 2-2

FUEL ASSEMBLY DESIGN SPECIFICATIONS FOR THE GE8/8B FUEL DESIGN

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Table 2-3
FUEL ASSEMBLY DESIGN SPECIFICATIONS FOR THE GE9B AND GE10 FUEL DESIGNS

	GE9B or GE10-1,3	GE9B	GE10-1
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Table 2-4
FUEL ASSEMBLY DESIGN SPECIFICATIONS FOR THE GE11 FUEL DESIGN

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Table 2-5
FUEL ASSEMBLY DESIGN SPECIFICATIONS FOR THE GE12 FUEL DESIGN

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Table 2-6
FUEL ASSEMBLY DESIGN SPECIFICATIONS FOR THE GE13 FUEL DESIGN (GE COMPANY PROPRIETARY)

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Table 2-7
FUEL ASSEMBLY DESIGN SPECIFICATIONS FOR THE GE14 FUEL DESIGN (GE COMPANY PROPRIETARY)

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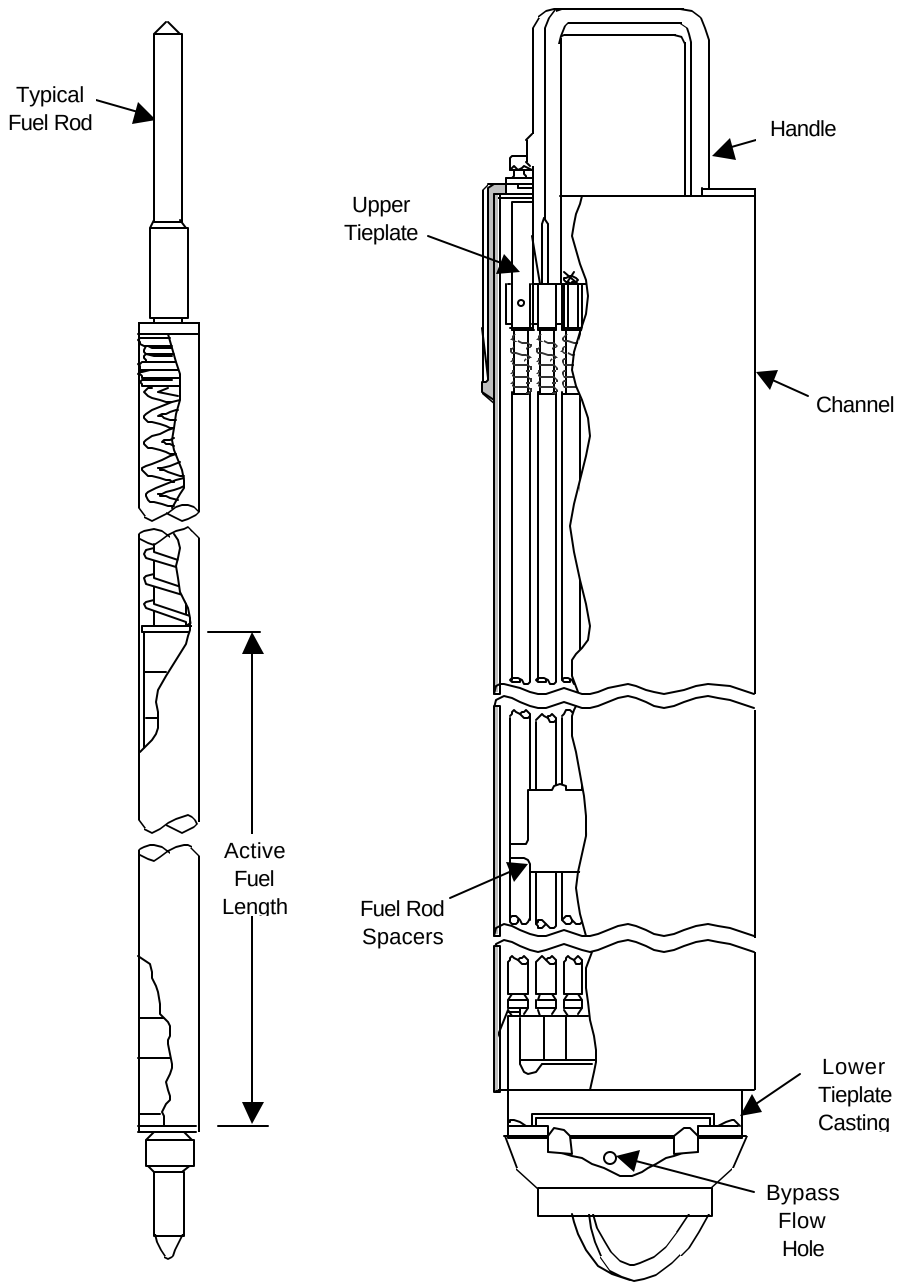

Figure 2-1. Typical GE BWR Fuel Assembly

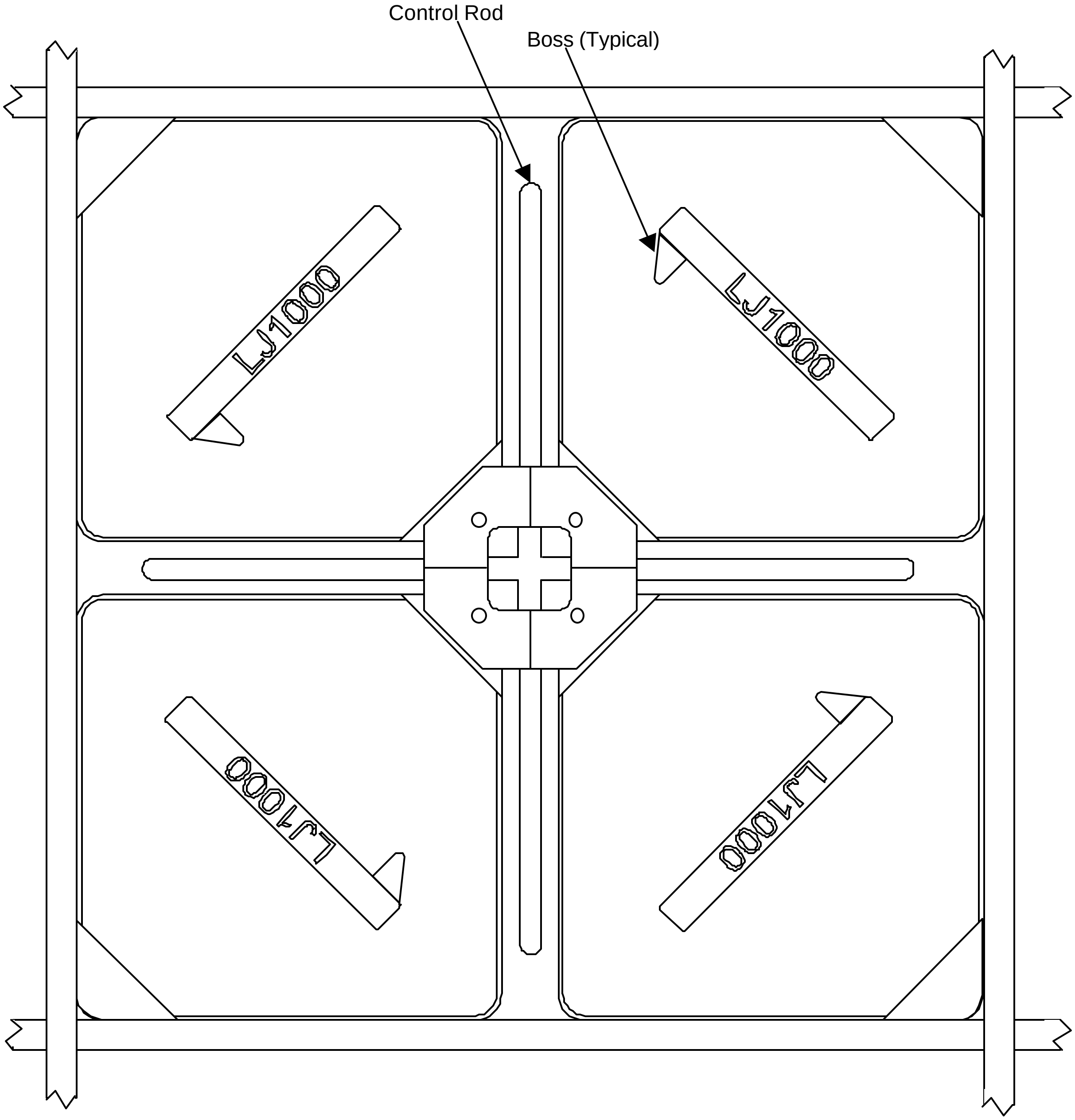

Figure 2-2. Typical Core Cell

Figure 2-3. Illustration of Axial Zoning in GE8 Through GE10 Fuel Designs

Figure 2-4. Illustrations of Typical Axial Zoning in GE11, GE12, GE13 and GE14 Fuel Design

Figure 2-5. GE11/13 Part Length Rod Locations

Figure 2-6. GE12/14 Part Length Rod Locations

3. ANALYSES

This section provides safety analyses results specific to the GE fuel designs described in Section 2. These analyses results are applicable to the Table 3-1 United States BWRs loading these fuel designs. These results are also applicable to international BWRs as noted in the country specific licensing documentation (GESTAR).

3.1 THERMAL-MECHANICAL EVALUATIONS

Subsection 2.2 of Reference 1 presents the thermal-mechanical design and safety analysis bases, limits and evaluations applicable to the fuel designs described in Section 2 of this report. The following subsections address the specific criteria listed in Subsection 2.2 of Reference 1. Meeting these criteria assures that the fuel licensing acceptance criteria documented in Subsection 1.1.2 of Reference 2 is met. For those plants in Table 3-1 which have eliminated the Linear Heat Generation Rate (LHGR) from their Technical Specifications, it should be noted that the fuel Local Peaking Factors (LPFs) are reported in their proprietary lattice-specific MAPLHGR report.

3.1.1 Stress/Strain

The thermal and mechanical evaluations described in Subsection 2.2.1.1.3 of Reference 1 have been performed for the fuel designs in Section 2, and it has been determined that the limits defined in Subsection 2.2.1.1.2 are met.

3.1.2 Fatigue

Fatigue evaluations of the fuel rod cladding, as described in Subsection 2.2.1.2.3 of Reference 1, have been performed for the fuel designs in Section 2, and it has been determined that the criteria presented in Subsection 2.2.1.2.2 of Reference 1 are satisfied.

3.1.3 Fretting Wear

The results of evaluations of fuel assemblies with respect to fretting wear, as described in Subsection 2.2.1.3.3 of Reference 1, are applicable to the fuel designs described in Section 2.

3.1.4 Oxidation and Corrosion Products

The effects of cladding oxidation and corrosion product buildup on the fuel rod surface are included in fuel rod thermal-mechanical design evaluations with results indicating that all the fuel designs in Section 2 meet the limits described in Subsections 2.2.1.1.2, 2.2.1.2.2, 2.2.1.5.2, 2.2.1.6.2, 2.2.2.2.2, 2.2.2.5.2, 2.2.2.7.2 and 2.2.2.9.2 of Reference 1.

3.1.5 Hydriding

Evaluation conclusions relative to hydriding of the fuel rod cladding are presented in Subsection 2.2.1.4.2.3 of Reference 1 and are applicable to the fuel designs of Section 2.

3.1.6 Dimensional Changes

Operational fuel rod deflection evaluations described in Subsection 2.2.1.5.3 of Reference 1 have been performed for the fuel designs presented in Section 2, and the spacing deflection limits given in Subsection 2.2.1.5.2 of Reference 1 are met for all these designs.

3.1.7 Internal Gas Pressure

Subsection 2.2.1.6.3 of Reference 1 describes evaluations of the fuel rod internal gas pressure during normal operation. The fuel designs described in Section 2 have been demonstrated to meet the internal gas pressure limits described in Subsection 2.2.1.6.2 of Reference 1.

3.1.8 Hydraulic Loads

Fuel assembly evaluations conservatively bounding the worst case hydraulic loads possible during normal operation are described in Subsection 2.2.1.7.3 of Reference 1. The fuel designs described in Section 2 meet the limits specified in Subsection 2.2.1.7.2 of Reference 1.

3.1.9 Cladding Collapse

The cladding collapse evaluations described in Subsection 2.2.2.2.3 of Reference 1 have been performed for the fuel designs presented in Section 2, and it is concluded that these fuel designs meet the limits specified in Subsection 2.2.2.2.2 of Reference 1.

3.1.10 Overheating of Pellets

Evaluations of fuel pellet overheating have been performed for the fuel designs listed in Section 2 as described in Subsection 2.2.2.5.3 of Reference 1. The results of these evaluations confirm that the Section 2 fuel designs satisfy the limits presented in Subsection 2.2.2.5.2 of Reference 1.

3.1.11 Pellet-Cladding Interaction

The evaluations described in Subsection 2.2.2.7.3 of Reference 1 have been performed for the fuel designs presented in Section 2, and it is concluded that these designs meet the criteria presented in Subsection 2.2.2.7.2 of Reference 1.

3.1.12 Mechanical Fracturing

The fuel designs contained in Section 2 have been evaluated under combined safe shutdown earthquake and loss-of-coolant accident loading conditions as described in Subsection 2.2.2.9.3 of Reference 1, and it is concluded that the Subsection 2.2.2.9.2 limits of Reference 1 are met.

3.2 THERMAL-HYDRAULIC DESIGN

The core hydraulic descriptions, models, assumptions and correlations presented in Subsection 4.2 of Reference 1 are applicable to the fuel designs of Section 2. Specifically, the applicability of the single-phase and two-phase hydraulic models (discussed in Subsections 4.2.4.1 and 4.2.4.2 of Reference 1) to the fuel designs in Section 2 was confirmed by prototype (8x8, 9x9 and 10x10 array bundles) flow tests.

3.3 FUEL CLADDING INTEGRITY SAFETY LIMIT

As discussed in Subsection 4.3.1.1 of Reference 1, a statistical analysis is used to derive the fuel cladding integrity Safety Limit MCPR value for each reload core near the limiting MCPR condition.

The uncertainty inputs used in the bounding statistical analyses are listed in Table 3-3 (Reference 23 and 24). Although some of the plant-unique uncertainties may be greater for some plants, other uncertainties for these plants are smaller; therefore, the analysis is applicable. Critical power correlation uncertainties, are discussed in Subsection 3.4.

3.4 CRITICAL POWER CORRELATIONS

Acceptable critical power correlations are those which have been specifically approved by the USNRC or have been derived using the criteria documented in Subsection 1.1.7 of Reference 2. Critical power correlations that have received specific USNRC review and approval are presented in References 5, 6, and 7. The GE11, GE12, GE13 and GE14 correlations were derived using the above criteria per References 17, 19 and 18, respectively. These criteria also establish the basis for the uncertainty associated with a correlation. Actual critical power correlation uncertainties for GE fuel designs up to GE10 are documented in References 4 and 6 through 9. The uncertainty for the GE11, GE12, GE13 and GE14 critical power correlation was established using the acceptable fuel licensing criteria. [[

]] The correlation uncertainties input to the fuel cladding integrity Safety Limit MCPR bounding statistical analyses are listed in Table 3-3.

The Reference 5 and 6 critical power correlations are applicable to the P/BP8x8R and GE8/8B fuel designs described in Section 2. The Reference 7 correlation is applied to the GE9B and GE10 fuel designs described in Section 2. Requirements for applying the Reference 6 and 7 correlations are presented in References 10 and 11. The GE11, GE12, GE13 and GE14 critical power correlations developed in accordance with the acceptable licensed criteria are given in Tables 3-4, 3-5, 3-6 and 3-7, respectively. All of the terms in the correlation have been previously approved by the USNRC. Applicable range of application is also documented.

3.5 GENERIC CRITICAL POWER RATIO ANALYSES

Subsection 1.1.6 of Reference 2 presents the fuel licensing acceptance criteria for establishing the MCPR Operating Limit for specific fuel designs. Some of these MCPR event analyses have been performed generically for certain fuel designs to eliminate the need for plant/cycle-specific evaluations of these events. These generic analyses are described in Section 4 of Reference 1 and Subsection S.2.2 of Reference 12. The following subsections address the applicability of the generic MCPR analyses to the fuel designs described in
Section 2.

3.5.1 Generic Rod Withdrawal Error Analysis (BWR/3-5 non-ARTS Plants only)

Subsection S.2.2.1.5 of Reference 12 describes a statistical analysis performed to calculate generic (i.e., plant/cycle-independent) bounding values of delta-CPR as a function of rod block monitor setpoint during a RWE event. These bounding delta-CPR values are applicable to BWR/3-5 non-ARTS plants loading the B/P8x8R fuel designs described in Section 2.

3.5.2 Generic BWR/6 Rod Withdrawal Error Analysis

The generic RWE analysis for BWR/6 plants is described in Reference 13. [[

]] Applicability of this analysis for the GE9 through GE14 fuel designs will be determined on a cycle specific basis until a sufficient database is established to determine generic applicability.

3.5.3 Generic ARTS Rod Withdrawal Error Analysis (BWR/2-5)

The generic ARTS RWE analysis is a statistical evaluation of randomly occurring realistic RWE conditions. This analysis is applicable for fuel designs through GE8/8B. Applicability of the analysis to the GE9B through GE14 fuel designs will be determined on a cycle specific bases until a sufficient database is established to determine generic application.

NOTE: The ABWR is equipped with an automated rod block monitoring system (ARBM) that prevents further control rod withdrawal if either the MCPR Operating Limit, MCPR Safety Limit, or MAPLHGR is violated. Cycle-specific evaluations of this event are therefore not performed for ABWR because there is no postulated set of circumstances for which this event could occur and a fuel thermal limit be exceeded.

3.5.4 Mislocated and Misoriented Fuel Bundle Loading Error Analysis

As described in Subsection S.2.2.3.6 of Reference 12, the mislocated fuel bundle loading error is analyzed for initial cores and for reload cores where the resultant CPR response may establish the operating limit CPR for fuel designs through GE14. The misoriented fuel bundle event is evaluated on a cycle-specific basis as described in Subsection S.2.2.3.7 of Reference 12.

3.5.5 Power and Flow-Dependent MCPR Limits

The effect on MCPR Operating Limits of steady-state plant operation at less than rated power/flow conditions is described in Subsection 4.3.1.2.8 of Reference 1. The required generic power- and flow-dependent MCPR adjustments (K_p/$MCPR_p$ and K_f/$MCPR_f$, respectively) are dependent upon the plant type, critical power correlation, and analytical options.

BWR/2-5 plants without the ARTS or MEOD operating options utilize the K_f low flow MCPR correlation factors shown in Figures 3-1 and 3-2 when the operating limit MCPR is determined using the Reference 5 and the GE11, GE12, GE13 or GE14 critical power correlation. [[

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BWR/6 and ABWR plants use a flow dependent $MCPR_f$ in which the K_f for the plant is pre-multiplied with the operation limit MCPR at 100% power and flow. This relationship is shown in Figure 3-3 for the initial BWR/6 core MCPR Operating Limit. Flow-dependent MCPR limits for ABWR will be submitted for NRC review at a later date. For reload cores, these values are adjusted to reflect the cycle specific MCPR Operating Limit. However, the slope of the line remains the same. Plants analyzed with the Reference 6 and 7 critical power correlation have the same correction below 40% flow as shown above. Plants with ARTS or MEOD also utilize a flow dependent $MCPR_f$ based on a specific plant analysis. (See Figure 3-4.) As with BWR/6 plants, this limit is adjusted to reflect the cycle specific MCPR Operating Limit and critical power correlation.

BWR/6 and ABWR plants also have a power dependent $MCPR_p$ which adjusts the MCPR Operating Limit for operation at less than 100% power. The $MCPR_p$ for the initial BWR/6 core is shown in Figure 3-5. Power-dependent MCPR limits for ABWR will be submitted for NRC review at a later date. For reload cores, these values are adjusted to reflect the cycle specific MCPR Operating Limit. Plants with the ARTS or MEOD operating options also have a low power correction factor. The factor used is a K_p multiplier to the MCPR Operating Limit for powers down to the scram bypass power and a flow/power dependent MCPR below the scram bypass power. These power dependent adjustment factors are determined from a plant specific analysis. An example of these adjustments is given in Figure 3-6. There is no low power correction factor required for BWR/2-5 plants which do not have ARTS or MEOD.

3.5.6 End-of-Cycle Coastdown

Once a plant reaches an all-rods-out, end-of-full power condition, it may be shut down for refueling or placed in a coastdown mode of operation. Subsection 4.3.1.2.9 of Reference 1 presents justification for conservatively bounding this type of operation with analyses performed at the full power, end-of-cycle, all-rods-out condition. This conclusion is confirmed for plants operating in a coastdown mode that have loaded any of the 8x8 fuel designs described in Section 2. The transient analyses for the GE11, GE12, GE13 and GE14 fuel designs show similar sensitivities to the analyses for the 8x8 fuel design. Therefore, this conclusion is also valid for the GE11, GE12, GE13 and GE14 fuel designs.

3.6 STABILITY

The NRC required adherence to specific surveillance and exclusion zones documented in Reference 14 to provide additional assurance that regional instabilities will not occur. These surveillance and exclusion zones were determined for the P/BP8x8R and GE8/8B fuel designs.

Subsequent analyses have shown that these zones are applicable to all the fuel designs described in Section 2.

All US BWRs have selected one of the NRC approved BWROG long–term stability solutions described in Reference 25 to meet the GDC criteria. Long–term solutions are of the prevention type (i.e., power oscillations are not possible), of the detect and suppress type (i.e., power oscillations can be reliably and readily detected and suppressed), or are a combination of the two types. Stability compliance with GDC–12 must be demonstrated on a plant and cycle–specific basis for each of the long–term solutions. Stability compliance of GE BWR fuel designs is demonstrated on a generic basis only to provide assurance that plant and cycle–specific stability compliance will be provided under the applicable long–term solution. The generic stability calculation and methodology are described in Section S.4 of Reference 1. The plant and cycle–specific calculations required for each long–term stability solution are described in Section S.4.1 of Reference 1.

3.7 CONTROL ROD DROP DESIGN BASIS ACCIDENT

A description of the control rod drop design basis accident and analysis methodology is provided in Subsection S.2.2.3.1 of Reference 12. Subsection 1.1.11 of Reference 12 presents the acceptance criteria for this accident. The results and consequences of this accident are dependent on the fuel bundle designs loaded into the core.

Subsection S.2.2.3.1 of Reference 12 also describes a generic bounding control rod drop accident analysis for plants that have implemented the Banked Position Withdrawal Sequence (BPWS) strategy for control rod withdrawal or insertion during plant startup or shutdown. This bounding analysis is applicable to BPWS plants loading any of the fuel designs described in Section 2.

Results of radiological analyses for initial cores are reported in the FSAR. [[

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3.8 REFUELING ACCIDENT

Subsection S.2.2.3.5 of Reference 12 describes a fuel handling accident that could result in the release of radioactive materials directly to the containment. The number of fuel rods estimated to fail in the event of a refueling accident was conservatively determined to be 104 or less for the 8x8 fuel designs. For both GE11 and GE13, 123 rods are calculated to fail and for GE12 and GE14, 151[1] rods are calculated to fail. All of these designs have a lower plenum activity than the 7x7 fuel designs resulting in a relative radioactivity release of 0.73 of that calculated for the 7x7 fuel. As identified in FSARs, the radiological exposures for the 7x7 fuel are well below those guidelines set forth in 10CFR100; therefore, it can be concluded that the consequences of this accident for all the fuel designs described in Section 2 will also be well below these guidelines.

For some plants, the analysis in the FSAR is based on 8x8 fuel. The radiological consequences described in these FSARs assumes at least 111 rods fail. Failure of 111 rods of 8x8 fuel is equivalent to 123 rods of 9x9 fuel and 151[1] rods of 10x10 fuel and the radiological consequences will be no worse than described in the FSAR.

[1] Plants equipped with the heavier NF500 cylindrical mast are predicted to have 172 rods fail. If, for these plants, the FSAR basis for this calculation is an 8x8 (rather than 7x7) core, there may be need for a reanalysis of this accident.

3.9 ANTICIPATED TRANSIENTS WITHOUT SCRAM

Fuel designs earlier than GE11 (GE1 through GE10) were reviewed and approved by the NRC for generic use. This review and approval implied acceptability for ATWS requirements. GE11 and later designs may be qualified as a licensed design by GE by showing conformance to the Fuel Licensing Acceptance Criteria described in Section 1 of Reference 1.

Compliance with the generic ATWS criterion documented in References 15 and 16 must be demonstrated by a negative void coefficient within the range of –8 to –14 cents/% voids for the fuel design or by a plant evaluation. All of the fuel designs documented in Section 2 and licensed by qualification to the Fuel Licensing Acceptance Criteria, meet the generic ATWS criterion.

Table 3-1
Applicable Reactors

Domestic Plants	Reactor Power (MWt)	Number of Fuel Bundles	Lattice Type
BWR/2			
Nine Mile Point 1	1850	532	D
Oyster Creek	1930	560	D
BWR/3			
Monticello	1670	484	D
Pilgrim	1998	580	D
Dresden 2	2527	724	D
Dresden 3	2527	724	D
Quad Cities 1	2511	724	D
Quad Cities 2	2511	724	D
BWR/4			
Vermont Yankee	1593	368	D
Duane Arnold	1658	368	D
Cooper	2381	548	D
Fitzpatrick	2436	560	D
Hatch 1	2763	560	D
Hatch 2	2763	560	D
Brunswick 1	2558	560	D
Brunswick 2	2558	560	D
Peach Bottom 2	3458	764	D
Peach Bottom 3	3458	764	D
Browns Ferry 1	3458	764	D
Browns Ferry 2	3458	764	D
Browns Ferry 3	3458	764	D
Fermi 2	3430	764	C
Hope Creek 1	3293	764	C
Limerick 1	3458	764	C
Limerick 2	3458	764	C
Susquehanna 1	3441	764	C
Susquehanna 2	3441	764	C
BWR/5			
WNP-2	3323	764	C
LaSalle 1	3323	764	C
LaSalle 2	3323	764	C
Nine Mile Point 2	3323	764	C
BWR/6			
Clinton 1	2894	624	S/C
Grand Gulf 1	3833	800	S/C
Perry 1	3579	748	S/C
River Bend 1	2894	624	S/C
GESSAR	3579	748	S/C

Table 3-1a
Applicable Reactors - P/BP8x8R

Domestic Plants		Active Fuel Length (in.)	Power Density (kw/l)
BWR/2	Nine Mile Point 1	145.24	40.58
	Oyster Creek	145.24	40.22
BWR/3	Monticello	145.24	40.27
	Pilgrim	145.24	40.20
	Dresden 2	145.24	40.74
	Dresden 3	145.24	40.74
	Quad Cities 1	145.24	40.48
	Quad Cities 2	145.24	40.48
BWR/4	Vermont Yankee	150	48.92
	Duane Arnold	150	50.91
	Cooper	150	49.10
	Fitzpatrick	150	49.16
	Hatch 1	150	55.76
	Hatch 2	150	55.76
	Brunswick 1	150	51.62
	Brunswick 2	150	51.62
	Peach Bottom 2	150	51.15
	Peach Bottom 3	150	51.15
	Browns Ferry 1	150	51.15
	Browns Ferry 2	150	51.15
	Browns Ferry 3	150	51.15
	Fermi 2	150	50.73
	Hope Creek 1	150	48.71
	Limerick 1	150	51.15
	Limerick 2	150	51.15
	Susquehanna 1	150	50.90
	Susquehanna 2	150	50.90
BWR/5	WNP-2	150	49.15
	LaSalle 1	150	49.15
	LaSalle 2	150	49.15
	Nine Mile Point 2	150	49.15
BWR/6	Clinton 1	150	52.41
	Grand Gulf 1	150	54.14
	Perry 1	150	54.07
	River Bend 1	150	52.41
	GESSAR	150	54.07

Table 3-1b
Applicable Reactors - GE8/8B, GE9B, GE10

	Domestic Plants	Active Fuel Length (in.)*	Power Density (kw/l)
BWR/2	Nine Mile Point 1	145.24	40.58
	Oyster Creek	145.24	40.22
BWR/3	Monticello	142.24/145.24	41.12/40.17
	Pilgrim	142.24/145.24	41.05/40.20
	Dresden 2	142.24/145.24	41.60/40.74
	Dresden 3	142.24/145.24	41.60/40.74
	Quad Cities 1	142.24/145.24	41.34/40.48
	Quad Cities 2	142.24/145.24	41.34/40.48
BWR/4	Vermont Yankee	147/150	49.92/48.92
	Duane Arnold	147/150	51.95/50.91
	Cooper	147/150	50.10/49.10
	Fitzpatrick	147/150	50.16/49.16
	Hatch 1	147/150	56.89/55.76
	Hatch 2	147/150	56.89/55.76
	Brunswick 1	147/150	52.67/51.62
	Brunswick 2	147/150	52.67/51.62
	Peach Bottom 2	147/150	52.19/51.15
	Peach Bottom 3	147/150	52.19/51.15
	Browns Ferry 1	147/150	52.19/51.15
	Browns Ferry 2	147/150	52.19/51.15
	Browns Ferry 3	147/150	52.19/51.15
	Fermi 2	147/150	51.77/50.73
	Hope Creek 1	147/150	49.70/48.71
	Limerick 1	147/150	52.19/51.15
	Limerick 2	147/150	52.19/51.15
	Susquehanna 1	147/150	51.94/50.90
	Susquehanna 2	147/150	51.94/50.90
BWR/5	WNP-2	147/150	50.15/49.15
	LaSalle 1	147/150	50.15/49.15
	LaSalle 2	147/150	50.15/49.15
	Nine Mile Point 2	147/150	50.15/49.15
BWR/6	Clinton 1	147/150	53.48/52.41
	Grand Gulf 1	147/150	55.24/54.14
	Perry 1	147/150	55.17/54.07
	River Bend 1	147/150	53.48/52.41
	GESSAR	147/150	55.17/54.07

*The fuel length may be either of the values shown. The first value of power density corresponds to the shorter fuel length, the second value to the longer.

Table 3-1c
Applicable Reactors - GE11, GE13

Domestic Plants		Active Fuel Length (in.)	Power Density (kw/l)
BWR/2	Nine Mile Point 1	145.24	40.58
	Oyster Creek		
BWR/3	Monticello		
	Pilgrim		
	Dresden 2		
	Dresden 3		
	Quad Cities 1		
	Quad Cities 2		
BWR/4	Vermont Yankee	146	50.26
	Duane Arnold	146	52.31
	Cooper	146	50.45
	Fitzpatrick	146	50.50
	Hatch 1	146	57.28
	Hatch 2	146	57.28
	Brunswick 1	146	53.03
	Brunswick 2	146	53.03
	Peach Bottom 2	146	52.54
	Peach Bottom 3	146	52.54
	Browns Ferry 1	146	52.54
	Browns Ferry 2	146	52.54
	Browns Ferry 3	146	52.54
	Fermi 2	146	52.12
	Hope Creek 1	146	50.04
	Limerick 1	146	52.54
	Limerick 2	146	52.54
	Susquehanna 1	146	52.29
	Susquehanna 2	146	52.29
BWR/5	WNP-2	146	50.50
	LaSalle 1	146	50.50
	LaSalle 2	146	50.50
	Nine Mile Point 2	146	50.50
BWR/6	Clinton 1	146	53.85
	Grand Gulf 1	146	55.63
	Perry 1	146	55.55
	River Bend 1	146	53.85
	GESSAR	146	55.55

Table 3-1d
Applicable Reactors - GE12

	Domestic Plants	Active Fuel Length (in.)	Power Density (kw/l)
BWR/2	Nine Mile Point 1		
	Oyster Creek		
BWR/3	Monticello		
	Pilgrim		
	Dresden 2		
	Dresden 3		
	Quad Cities 1		
	Quad Cities 2		
BWR/4	Vermont Yankee	150	48.92
	Duane Arnold	150	50.91
	Cooper	150	49.10
	Fitzpatrick	150	49.16
	Hatch 1	150	55.76
	Hatch 2	150	55.76
	Brunswick 1	150	51.62
	Brunswick 2	150	51.62
	Peach Bottom 2	150	51.15
	Peach Bottom 3	150	51.15
	Browns Ferry 1	150	51.15
	Browns Ferry 2	150	51.15
	Browns Ferry 3	150	51.15
	Fermi 2	150	50.73
	Hope Creek 1	150	48.71
	Limerick 1	150	51.62
	Limerick 2	150	51.62
	Susquehanna 1	150	50.90
	Susquehanna 2	150	50.90
BWR/5	WNP-2	150	49.15
	LaSalle 1	150	49.15
	LaSalle 2	150	49.15
	Nine Mile Point 2	150	49.15
BWR/6	Clinton 1	150	52.41
	Grand Gulf 1	150	54.14
	Perry 1	150	54.07
	River Bend 1	150	52.41
	GESSAR	150	54.07

Table 3-1e
Applicable Reactors - GE14

Domestic Plants		Active Fuel Length (in.)	Power Density (kw/l)
BWR/2	Nine Mile Point 1		
	Oyster Creek		
BWR/3	Monticello		
	Pilgrim		
	Dresden 2		
	Dresden 3		
	Quad Cities 1		
	Quad Cities 2		
BWR/4	Vermont Yankee	150	50.25
	Duane Arnold	150	52.30
	Cooper	148	49.76
	Fitzpatrick	150	50.49
	Hatch 1	150	57.27
	Hatch 2	150	57.27
	Brunswick 1	150	53.03
	Brunswick 2	150	53.03
	Peach Bottom 2	150	52.54
	Peach Bottom 3	150	52.54
	Browns Ferry 1	150	52.54
	Browns Ferry 2	150	52.54
	Browns Ferry 3	150	52.54
	Fermi 2	150	52.11
	Hope Creek 1	150	50.04
	Limerick 1	150	52.54
	Limerick 2	150	52.54
	Susquehanna 1	150	52.29
	Susquehanna 2	150	52.29
BWR/5	WNP-2	150	50.49
	LaSalle 1	150	50.49
	LaSalle 2	150	50.49
	Nine Mile Point 2	150	50.49
BWR/6	Clinton 1	150	53.84
	Grand Gulf 1	150	55.62
	Perry 1	150	55.54
	River Bend 1	150	53.84
	GESSAR	150	55.54

Table 3-2

[DELETED]

Table 3-3
UNCERTAINTIES USED IN STATISTICAL ANALYSIS

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Table 3-3 (Continued)
UNCERTAINTIES USED IN STATISTICAL ANALYSIS

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Table 3-4
GE11 CRITICAL POWER CORRELATION

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Table 3-5
GE12 CRITICAL POWER CORRELATION

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Table 3-6
GE13 CRITICAL POWER CORRELATION

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Table 3-7
GE14 CRITICAL POWER CORRELATION

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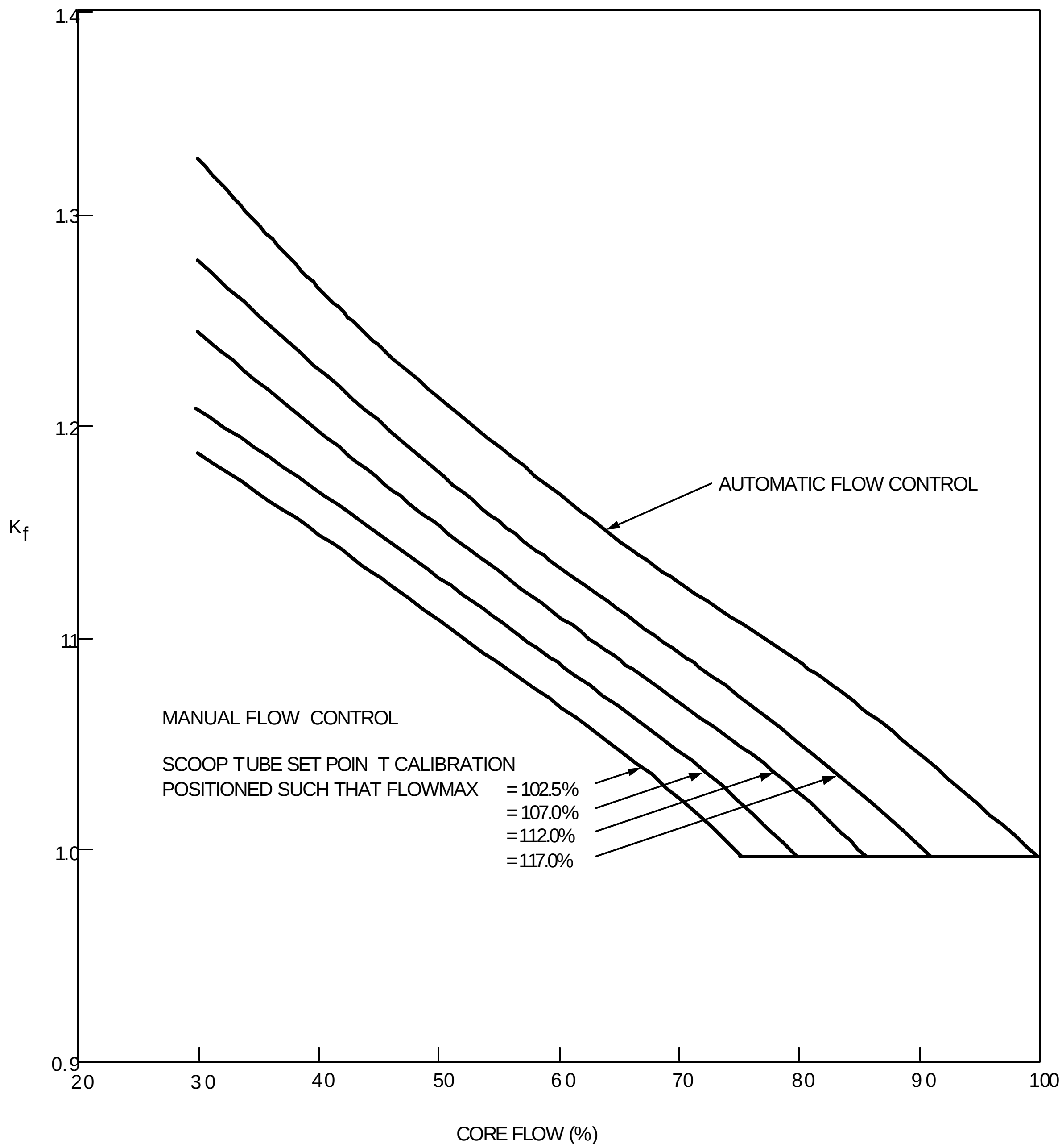

Figure 3-1. BWR/2-4 Flow Factor, K_f*

* DOES NOT INCLUDE LOW FLOW CORRECTION

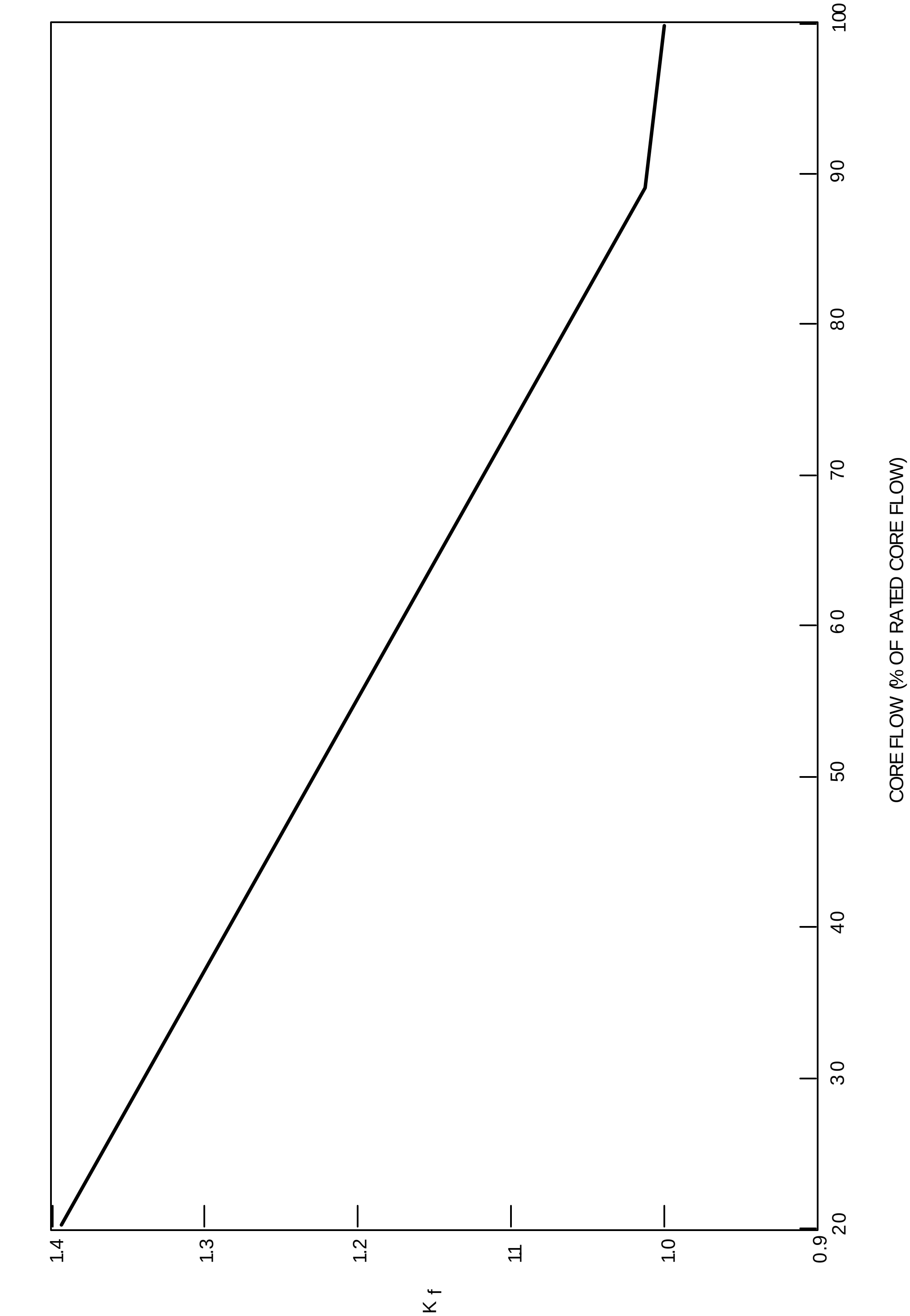

Figure 3-2. BWR/5 Flow Factor, K_f *

* DOES NOT INCLUDE LOW FLOW CORRECTION

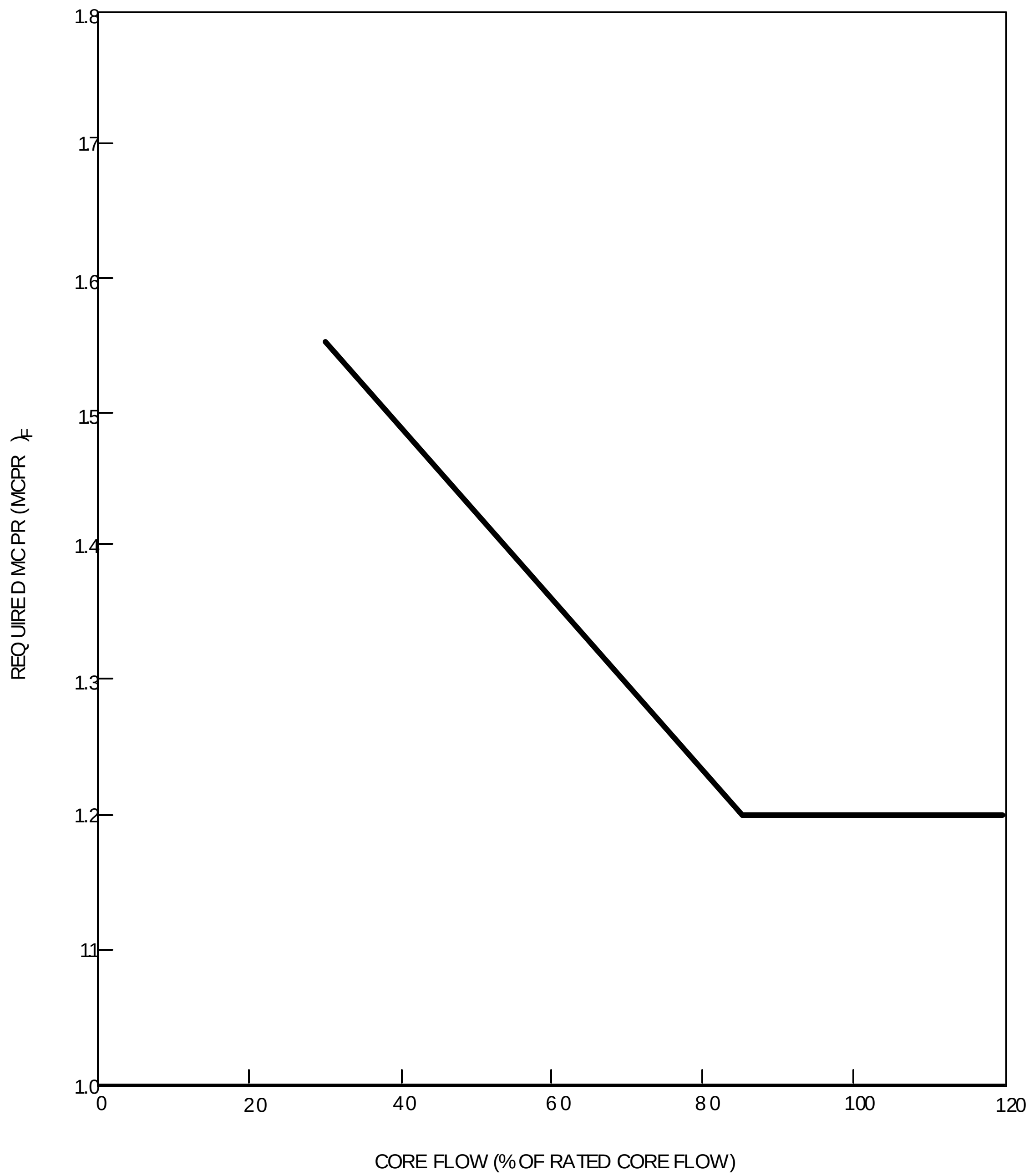

Figure 3-3. BWR/6 Initial* Core Required MCPR vs Core Flow

* FOR RELOAD CORE, ADJUST MCPR VALUES TO REFLECT THE MCPR OPERATING LIMIT

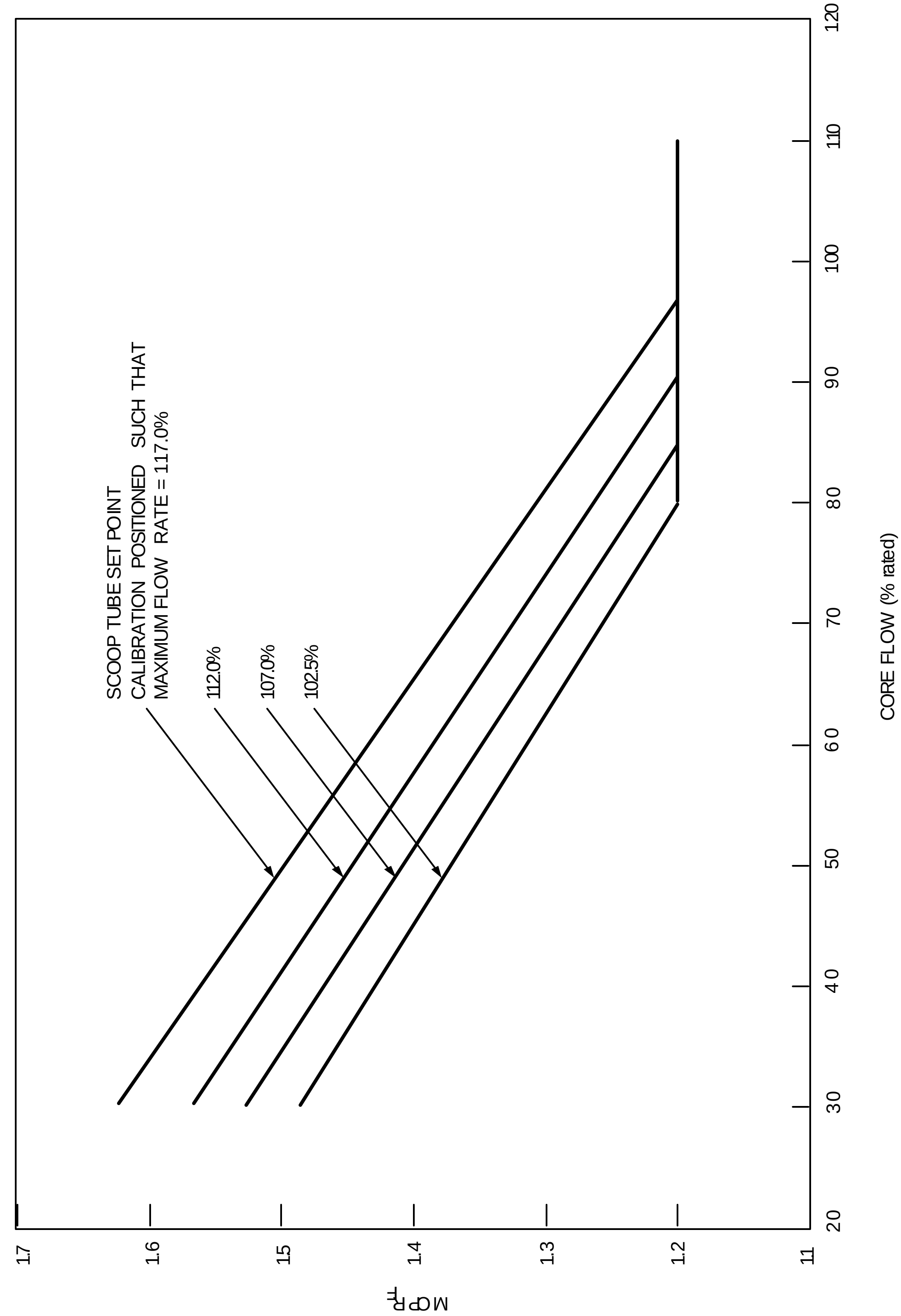

Figure 3-4. Typical Example of Flow-Dependent MCPR for ARTS and MEOD Plants*

* FOR RELOAD CORES, ADJUST MCPR VALUES TO REFLECT MCPR OPERATING LIMIT

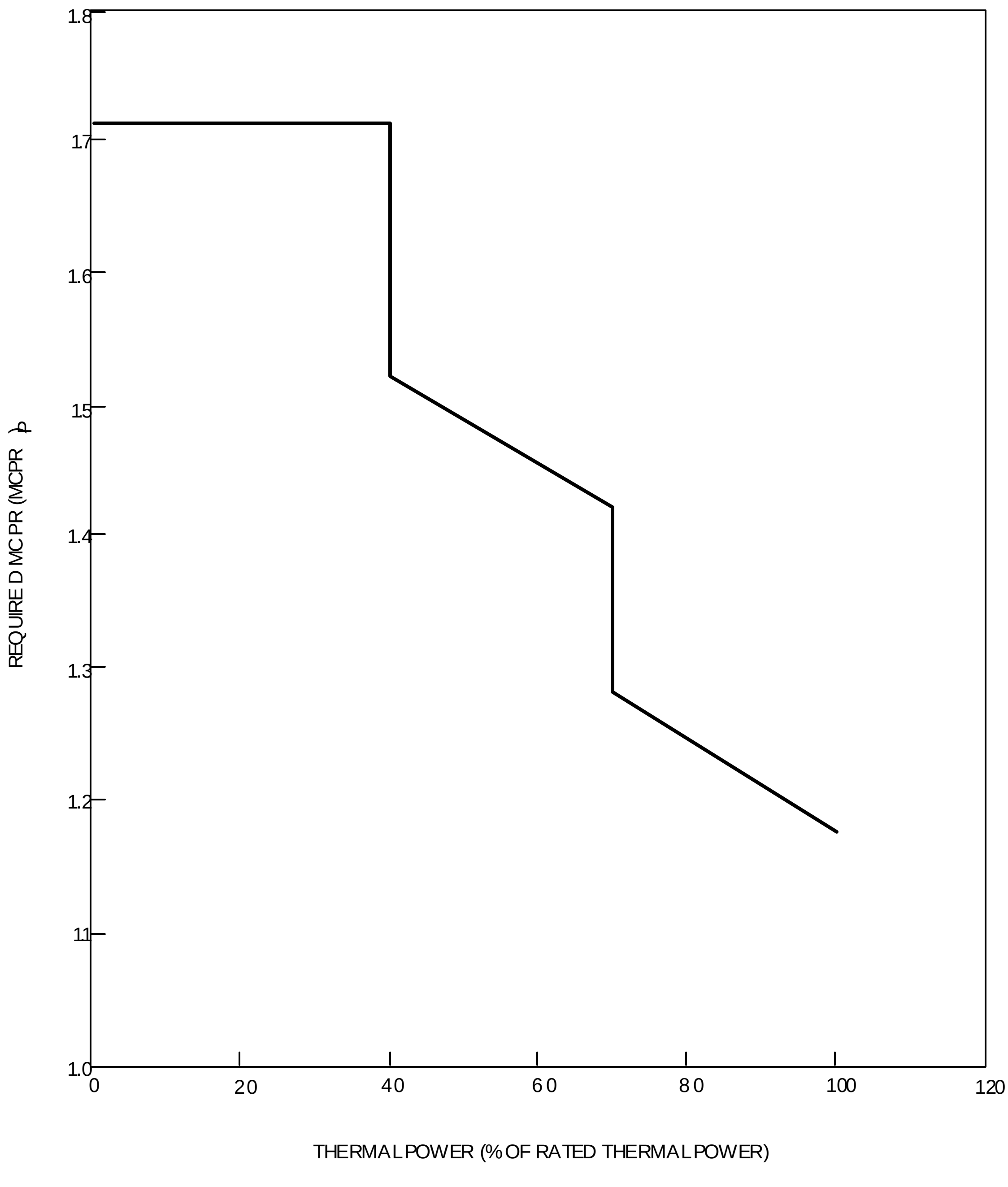

Figure 3-5. BWR/6 Initial* Core Required MCPR vs Thermal Power

* FOR RELOAD CORES, ADJUST MCPR VALUES TO REFLECT THE CYCLE DEPENDENT MCPR OPERATING LIMIT

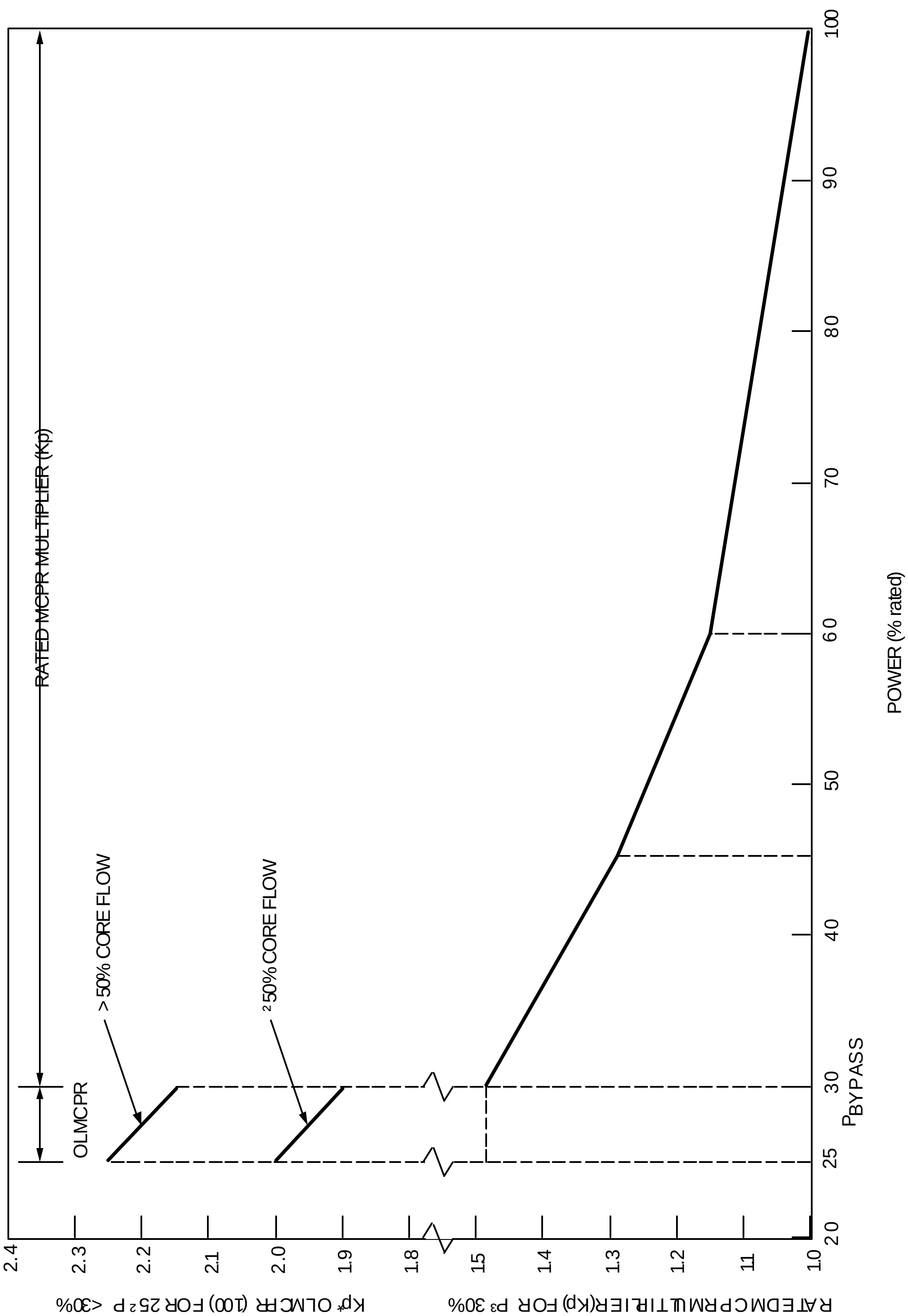

Figure 3-6. Typical Example of Power-Dependent MCPR for ARTS and MEOD Plants

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