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Generic Guidelines for General Electric Boiling Water Reactor Extended Power Uprate

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LICENSING TOPICAL REPORT

GENERIC GUIDELINES FOR GENERAL ELECTRIC BOILING WATER REACTOR EXTENDED POWER UPRATE

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TABLE OF CONTENTS

ABSTRACT

This document presents the generic criteria, methodology and scope of evaluation required to provide sufficient information for use by the Nuclear Regulatory Commission (NRC) to grant approval to anticipated specific applications for increases in the authorized thermal power level (power uprate) of GE Boiling Water Reactors (BWRs). This document covers uprates up to nominally 20% of the original licensed thermal power. Implementation of this generic approach should reduce the uncertainty and level of effort for evaluation and approval by both the utilities and the NRC. An increase in the electrical output level at a BWR power station is primarily accomplished by the generation and supply of higher steam flow for the turbine-generator (usually at slightly higher pressure). Most BWR plants, as originally licensed, have an as-designed equipment and system capability to produce steam flow rates at least 5% above the original rating. In addition, continuing improvements in the analytical techniques based on more realistic assumptions and models, plant performance feedback, and the latest fuel designs have resulted in a significant increase in the calculated operational margins related to safety analyses. This available safety analysis margin, combined with the as-built equipment, system and component capability, provides most BWR plants with the potential for an increase in thermal power of about 15% without major Nuclear Steam Supply System (NSSS) hardware modifications. For some plant designs, uprates of up to 20% are feasible. Several BWR plants have already been authorized to increase their thermal power above the originally licensed power level. This generic guideline addresses power increases of up to nominally 20% of original licensed power which will produce about a 24% increase in steam flow to the turbine-generator.

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1.0 INTRODUCTION

This document presents the generic criteria, process and scope of work required to provide sufficient information for use by the Nuclear Regulatory Commission (NRC) to grant approval to anticipated specific applications for increases in the authorized thermal power levels of GE Boiling Water Reactors (BWR). This document covers uprates up to nominally 20% of the original licensed thermal power. (Previous submittals (Reference 20) have covered uprates of up to approximately 5% of original licensed thermal power.) NRC approval of this generic guideline is desired in order for utilities to move forward with power uprate programs. The specific criteria, methods, assumptions, and scope identified for approval are listed in the Appendices to this report. A mutually accepted approach will be beneficial for the NRC and licensees, in that an up-front basic understanding of the uprate licensing process will permit more efficient preparation and review of specific uprate applications. Such an increase in thermal power has proven to be a valuable source of additional electric power capacity with no significant modification to the existing plant and without compromise to the public health and safety. Additional submittals are also planned to provide bounding generic results for specific areas of BWR evaluation. Review and acceptance of those submittals will reduce the plant-specific review scope for all BWRs that are within the bounding evaluations.

1.1 BACKGROUND

An increase in the electrical output of a BWR plant is accomplished primarily by generation and supply of higher steam flow for the turbine-generator. Most BWR plants, as originally designed, have an as-built equipment and system capability to accommodate steam flow rates at least 5% above the original rating.

In addition, continuing improvements in the analytical techniques based on more realistic assumptions and models (computer codes), plant performance feedback, and the latest fuel designs have resulted in a significant increase in the difference between calculated safety analysis results and licensing limits. This available difference, combined with the as-built equipment, system and component capability, provides most BWR plants with the potential for an increase in thermal power rating of between 5 and 15% without major NSSS hardware modifications. For some plant designs, uprates of up to 20% are feasible.

1.2 HISTORY

Several BWR plants have already been authorized to increase their thermal power rating above the originally licensed power level. A representative list of these plants is provided in Table 1-1.

In addition to the plants that have authorized power increases, numerous BWR plants have the capability and margins for a potential plant uprating of 5 to 15% without major hardware modifications. GE and the responsible utilities are in the process of completing or initiating power uprating studies for several BWR plants, as shown in the table. During the next two years, it is anticipated that the NRC will receive license amendment applications for increasing the authorized thermal power more than 5% for at least two units. This generic guideline and the additional generic bounding evaluations will assist the NRC and the utilities in the preparation, review and approval of uprate requests.

1.3 STRATEGY TO ACHIEVE HIGHER POWER

Previous applications to expand the BWR operating domain (power versus core flow map) have been submitted and approved for many plants. Increased operational flexibility has been provided primarily by permitting operation at maximum licensed thermal power with core flow more than and/or less than original rated design flow (Figure 1-1). These changes have "widened" the BWR operating power vs. flow map, and significantly improved plant capacity factors. It is assumed that plant-specific submittals for introduction or expansion of these improvements have been processed or are processed in parallel with the power uprate submittal. The licensing process involved with these performance improvements has been previously determined, and is not addressed in this report, except to point out areas of power uprate which are covered in the operating domain extension application.

The strategy for power uprate increases the core flow along the Maximum Extended Load Line Limit Analysis (MELLLA) rod line. This allows attainment of up to 120% of original licensed thermal power in a range of core flow from slightly less than rated core flow to the maximum core flow (which may, in turn, be an Increased Core Flow (ICF) if the plant is so licensed). ICF is not required for power uprate operation, but it is beneficial, and will be included if previously licensed for a plant. The MELLLA rod line will be licensed with the power uprate applicaiton, if it has not been previously. Another BWR term, the Maximum Extended Operating Domain (MEOD), includes both the MELLLA and ICF extensions to the operating range. Control rod patterns are usually adjusted with less than rated core flow and are maintained near the current operating rod/flow control lines. The power increase is achieved by increasing core flow along existing flow control lines as shown in Figure 1-1. Generic power uprate will not increase the maximum licensed value of core flow.

Uprated operation may also involve slightly higher reactor vessel dome pressure to establish desired inlet pressure conditions at the turbine. The pressure will be chosen to account for the larger pressure drop through the steam lines at higher flow and to provide sufficient pressure control and turbine flow capability. Operating data for the as-built steamline will be incorporated into this determination. For a plant where higher dome pressure is chosen, new high pressure setpoints will be selected (e.g., high pressure scram and setpoints of the safety relief valves) to ensure that both safety and operating margins are maintained to provide protection while preventing unnecessary plant shutdowns and safety system challenges. The analysis described in Section 5 will bound the projected operating conditions.

Table 1-1

BWR POWER UPRATE STATUS

<=105% of Original Licensed Thermal Power	>105% of Original Licensed Thermal Power
SER Approved	
Duane Arnold Fermi 2 Susquehanna 1 & 2 Peach Bottom 2 & 3 KKL (Kernkraftwerk Leibstadt) Limerick 1 & 2	Oyster Creek Nine Mile Point 1 KKM (Kernkraftwerk Muhleburg)
Licensing Report Submitted	
FitzPatrick WNP-2 Nine Mile Point 2 Hatch 1 & 2	KKL (Kernkraftwerk Leibstadt)
Contractually Committed to Uprate	
Brunswick 1 & 2	Monticello
Interested in Uprate	
Clinton River Bend Grand Gulf Perry Hope Creek Browns Ferry 1, 2 & 3 LaSalle 1 & 2 Nuclenor Laguna Verde	Susquehanna 1 & 2 Fermi 2 WNP-2 Peach Bottom 2 & 3 Limerick 1 & 2 Hatch 1 & 2 Cofrentes

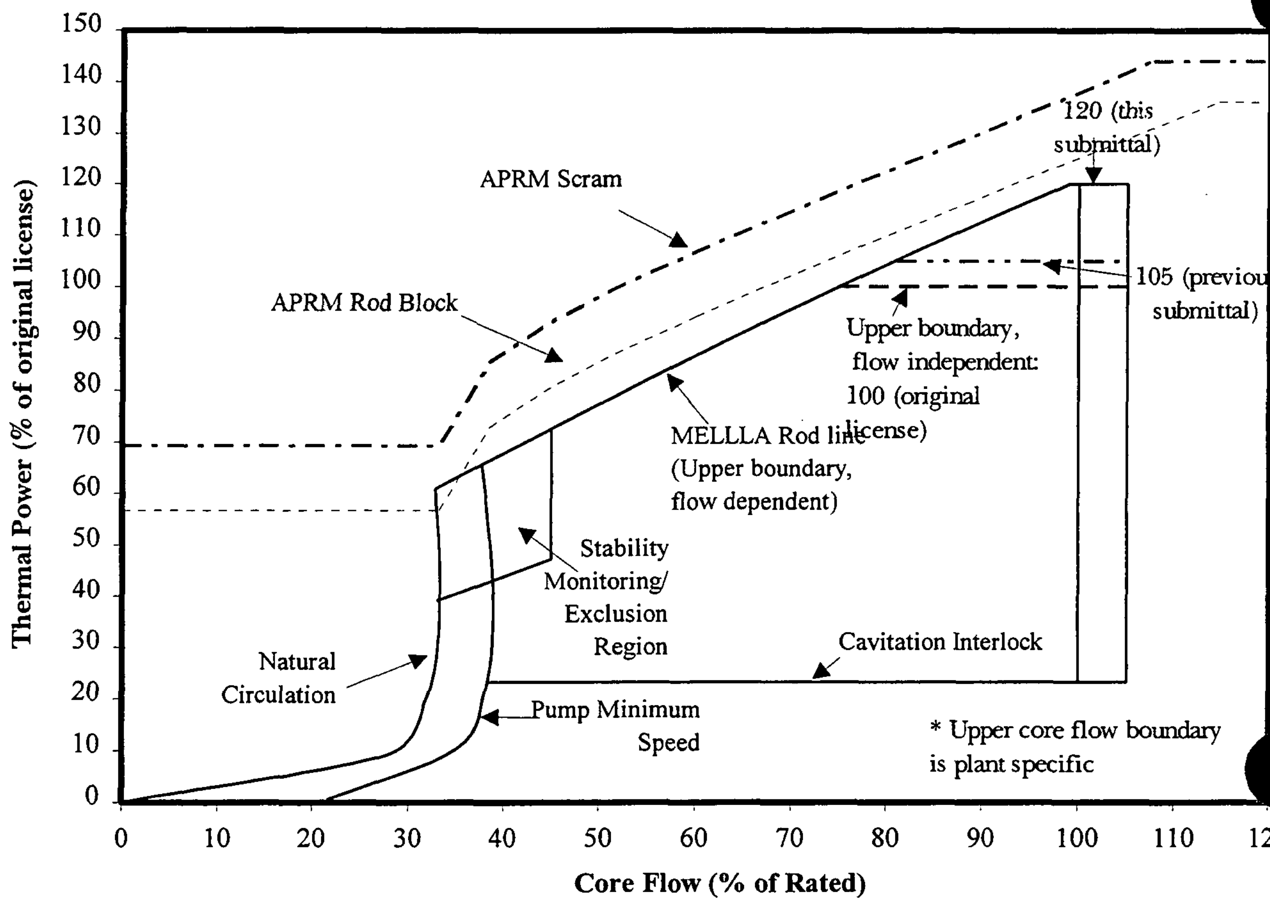

Figure 1-1. Typical Power Uprate (+20 % Thermal Power) Power/Flow Map

2.0 PURPOSE

The purpose of this document is to define generic guidelines for the process of preparing and submitting license amendments to the NRC for uprating GE BWRs. It provides a generic approach for the licensing criteria, uprating process, evaluation methodology and scope of plant-unique submittals.

These guidelines, have been formulated to minimize uncertainties in the regulatory area, and are based on:

- Uprate studies of several different BWR product lines to 105% of the original steam flow rating (several of which have already obtained NRC approval).
- Feasibility studies of uprate to greater than 105%.
- One complete uprate analysis to 120% of the original rating.

It is expected that NRC review and approval of the specific areas provided in the Appendices to this document will provide acceptable generic licensing criteria, methodology, test requirements and a defined scope of analytical and equipment review required for a power uprate.

3.0 LICENSING APPROACH

The licensing evaluations and reviews for uprating a BWR plant will be conducted in accordance with the specific criteria listed in Appendix B to this document.

Plant Technical Specifications will be affected in several areas, including those containing numerical references to rated power or parameters which are a function of power. Examples range from the definition of RATED THERMAL POWER to specifications covering OLMCPR (Operating Limit Minimum Critical Power Ratio). Other specifications which may potentially be affected are those which involve instrument setpoints. In most cases, plant-specific evaluations will define necessary changes, which will be reported in the plant-specific application. Recalibration of the power range monitors will be done so that the uprated power indicates 100% and the setpoints of high power alarms and trips relative to licensed thermal power are not expected to change. Appendix F discusses specific aspects of setpoint adjustment.

Plants seeking a power uprate are expected to request an amendment to their license consistent with the considerations which govern their current license. That is, there is no change in the licensing basis for the plant. No significant increases in the amount of effluents or radiation emitted from the facility are anticipated because of power uprate. Consideration of potential significant hazards will establish that operation of the facility in accordance with the proposed amendment would not:

(1) Involve a significant increase in the probability or consequences of an accident previously evaluated; or

(2) Create the possibility of a new or different kind of accident from any accident previously evaluated; or

(3) Involve a significant reduction in a margin of safety.

In general, the anticipated effect of power uprate on the bounding licensing criteria is as shown in Table 3-1. These estimates are based on typical plant configurations and latest analytical methods; the results for specific plant analyses may differ.

Table 3-1

ANTICIPATED EFFECT OF POWER UPRATE ON BOUNDING LICENSING CRITERIA

Key Licensing Criteria	Effect of 20% Thermal Power Increase	Explanation of Effect
LOCA challenges to fuel (10CFR50 & Appendix K)	<GE proprietary information removed>, no MAPLHGR change required	Vessel pressure increased, but application of same MAPHLGR results in minimal change in PCT
Change of Operating Limit MCPR	<GE proprietary information removed>	Increases due to flatter radial power distribution, increased safety limit
Challenges to RPV overpressure	<GE proprietary information removed>	Increased vessel volumetric power density
Primary containment pressure during a LOCA	<GE proprietary information removed>	Higher dome pressure
Pool temperature during a LOCA	<GE proprietary information removed>	Higher decay heat
Offsite Radiation Release, design basis accidents	~20% increase, must stay within 10CFR100.	Due to higher inventory radionuclides in fuel/clad gap
Onsite Radiation Dose, normal operation	~20% increase, must stay within 10CFR20.	Due to higher inventory radionuclides in fuel/clad gap
Heat discharge to environment	~4°F temperature increase	20% power increase
Equipment Qualification	<GE proprietary information removed>	Minimal change in operating conditions
Fracture Toughness, 10CFR50 Appendix G	<GE proprietary information removed>	~20% increase in neutron fluence
Stability	No effect	No increase in maximum rod line.
Anticipated Transient Without Scram (ATWS) peak vessel pressure	<GE proprietary information removed>, must stay within existing ASME Code "Emergency" category stress limit.	Increased power relative to SRV capacity

Vessel and NSSS equipment design pressure	No change	Comply with existing ASME Code stress limits of all categories

4.0 POWER UPRATING PROCESS

The power uprate effort usually begins with an initial feasibility study, followed by the major phase that culminates in engineering evaluations and licensing reports. Approval of this generic guideline and the process contained in its Appendices is vital to the planning and performance of these efforts so that acceptable scope and documentation are defined for straightforward utility preparation and NRC review of the license application.

A brief description of these two uprating phases and the final "Implementation" phase is provided in the following paragraphs.

4.1 FEASIBILITY STUDY

The feasibility study allows a utility to evaluate the overall cost of an uprate against the gain in electrical output. Preliminary decisions concerning uprated operating conditions are made. Major analyses and equipment reviews are deferred to the next uprate phase; however, sufficient evaluation is done to define required hardware modifications. This information is vital for the utility decisions necessary to pursue power uprate to implementation. For power increases of 5% or less, this phase is not usually extensive, since most plants (from BWR/4 and onward) were designed and analyzed in anticipation of that amount of uprate. For power increases of more than 5%, this phase will determine modifications (if needed) and costs involved in uprating to various capacities and the optimum increase for a specific plant and utility. Licensing considerations are also taken into account in determining the final uprated power level. Actual plant operation and test data, the current plant configuration, including deviations from the original design bases, and the configuration planned for each uprate implementation phase are examined to confirm that appropriate design, operating, and safety criteria can be met with the uprate. This data is then applied in the engineering evaluations.

4.2 ENGINEERING EVALUATIONS AND LICENSING REPORTS

In this phase, plant-specific engineering and safety evaluations are completed and documented at the power level determined in the feasibility study.

The engineering and safety evaluation covers a detailed analysis and assessment of affected aspects of the plant at the selected power level. Plant operation is evaluated from a representative fuel cycle viewpoint, similar to the original SAR analyses. The evaluation effort identifies hardware modifications required to achieve the uprated power.

A Licensing Report, which contains the summary and conclusions of the engineering evaluations, is generated, using the generic outline given in Appendix A, to address safety aspects of operating at the uprated power conditions and planned operating strategy selected from the feasibility phase. The report will identify deviations from these generic guidelines which may be required and will provide justification of the plant-unique approach. The Licensing Report will also include the "no significant hazards" assessment and will address and disposition key relevant licensing issues such as Regulatory Guides and General Design Criteria.

The Licensing Report accompanies the Licensee's application for an increase in the authorized power level, along with any revisions to the Technical Specifications. In its final form, this set of documents will target a specific fuel cycle in which uprated operation is planned. Cycle-specific operating limits and evaluations of limiting events will usually be provided separately, similar to current reload analysis and documentation practice. Cycle-specific information will be maintained at the pre-uprate conditions until the uprate steps are approved. The uprate application will address those modifications which are essential to unit safety functions.

4.3 IMPLEMENTATION

In this phase, the utility implements procedural, software configuration management, calibration and hardware changes to achieve the increased power level. Plant modifications will be done during this phase of the uprate process. Most of this work is expected to be accomplished during the refueling outage(s) preceding the first uprated cycle operation. Actual uprated power operation and tests (see Section 5.11.9) will be initiated after NRC approval of the uprate license amendment.

Figure 4-1 shows a typical strategy for a phased power uprate implementation approach. The ultimate power level approved by the NRC in their review of the Licensing Report is achieved over a period of several cycles, as plant modifications are implemented. The interim power levels will be determined on a plant-specific basis.

<GE proprietary information removed>

Figure 4-1. Power Uprate Implementation

5.0 SCOPE

An uprate licensing effort encompasses a broad scope of analyses and evaluations to support and justify safe operation at the higher thermal power level and the resulting higher electrical output. In general, this effort covers a detailed review of plant design and operation with respect to regulatory requirements applicable to the plant at the time of the uprate. It covers equipment performance, actual versus projected operating conditions, and transient and accident evaluations. To the extent that it is applicable, this generic guideline and additional generic BWR uprate analyses will be referenced by the plant-specific submittal without further evaluations.

The primary focus of the licensing evaluation is on bounding events and operating conditions that establish plant and core operating limits. The evaluation also covers other associated issues such as environmental considerations at the increased power level.

Appendix A provides the format for a typical plant-specific power uprate Licensing Report. This outline reflects the scope of the plant-specific power uprate Licensing Report. It is anticipated that all plant-specific Licensing Reports will follow this format with little or no exception.

The uprate effort covers NSSS and BOP systems and components. The systems that are not power related or affected by an increase in the power level are also identified in this review process. A generic list of these systems is identified in Tables J-1 and J-2 of Appendix J and <GE proprietary information removed>.

The remainder of this section provides a generic description of the major tasks to be reported in a licensing application for power uprate. The associated Appendices list the specific bases to be generically approved for application to all uprate plants.

5.1 REACTOR OPERATING CONDITIONS

One of the first tasks of an uprate effort is to establish thermal-hydraulic parameters for BWRs at the uprated thermal power level (Table 5-1.) These parameters are generated by evaluating turbine-generator capability and then performing coordinated reactor heat balances which relate the reactor thermal-hydraulic parameters to the increased plant feedwater and steam flow conditions. Input from actual plant operation is considered (e.g., steam line pressure drop) to match expected uprated conditions. The thermal-hydraulic parameters define the conditions for operation of the plant at uprated power, including feedwater temperature and dome pressure (important links to uprated turbine-generator operation), as well as specific power and flow conditions. These conditions are used to establish the range of operating conditions to be considered in subsequent analyses and will be presented in the plant-specific uprate application with comparison to the conditions previously analyzed and licensed. Appendix C presents generic assumptions and bases to be used to establish power uprate operating conditions that relate to the licensing evaluations.

5.2 POWER/FLOW MAP

Previous analyses for nearly all plants have established flexible power/flow operating maps which allow full power to be achieved and maintained over a significant range of core flow, as a result of incorporation of the operational options included in licensed performance improvement packages. Fuel cycle economy and operational flexibility are improved by allowing rated power operation over a wider range of core flow. The example of Figure 5-1 illustrates the Maximum Extended Operating Domain (MEOD) power versus flow operating map for power uprate. Application of these generic guidelines assumes that the plant implements the MELLLA rod line to provide a flow control line which extends to 120% of the original licensed rating. The MELLLA rod line will allow attainment of 120% of the original licensed thermal power at the original rated flow. For power uprate, it is only necessary to extend (raise) the licensed power portion of the operating map to a higher power. At 120% of the original rated power, the full power portion of the operating map will be either a reduced flow range (relative to the pre-uprate range), if operation above rated core (ICF) is licensed, or essentially a singular point, if ICF operation is not licensed. Separate submittals would be required to extend operation above the MELLLA line to allow achievement of 120% of original licensed thermal power at less than the original rated flow. Some plants have a partially expanded operating range, Extended Load Line Limit Analysis (ELLLA), which allows operation at original licensed thermal power at 87% of rated core flow. Extending power upward allow the ELLLA rod line produces less than 109% power at rated core flow, therefor, the generic uprate of 20% requires that MELLLA be implemented. A revised power/flow map will be provided in the uprate application to clearly define the proposed new operating range for the plant. The performance of the jet pumps and recirculation system is considered in generating the power/flow map for uprated operation.

Not practical to attain >108% with ELLA, so MEOD will be necessary for Extended Power Uprate

The primary approach to achieving a higher thermal power level is to increase core flow along previously established rod lines. This is illustrated by point B in Figure 5-1 as uprated operation above the currently licensed operating point A. A plant license change to "widen" the core flow operating range may be done before power uprate and will be consistent with the power/flow range previously licensed for the applicable product line. This strategy allows the plant to continue to use all or most of the existing available core flow operational flexibility. The strategy selected will be consistent with applicable guidelines for assuring that adequate reactor stability is maintained (see Section 5.3.3). No increase in the maximum core flow limit is generically associated with power uprate, and that is the basis of the approval sought for this generic uprate guideline (see Appendix C to this document).

However, a plant-unique strategy could include both changes (power and maximum core flow). It would then be required to provide justification for the maximum flow increase in the plant-specific license submittal.

Analyses are performed to demonstrate safety in all operating portions of the uprated power/flow map. At the end of a cycle, full power is maintained by increasing core flow (toward point C in Figure 5-1). For plants utilizing Pellet Clad Interaction-Intergranular Stress Corrosion Cracking (PCI-IGSCC) resistant fuel, full power is maintained anywhere in the core flow range by a combination of rod withdrawals and minimal flow control changes.

When the all-rods-out condition is reached, end-of-cycle coastdown may be used to extend the power generation period. On the power/flow map, this is along the right side of the core flow range from points C toward D (final power before shutdown for refueling). Some plants augment the power level during this period by reducing the temperature of the feedwater flow (Final Feedwater Temperature Reduction, FFWTR). If previously licensed, the plant-specific uprate application will include consideration of FFWTR. If not previously licensed for the plant, it will not be included with the uprate application. It is not a required part of the generic power uprate guideline.

5.3 ACCIDENTS AND TRANSIENTS

As part of an uprate review process, the applicable plant Safety Analysis Report (SAR) analyses are evaluated. Results of the evaluation will also be included explicitly or by reference in the Licensing Report to be submitted as part of the plant-specific uprate application. Subsequently, they will be part of an SAR update. Where necessary, analyses of all limiting accidents and transients are performed at the uprated conditions to show continued compliance with applicable regulatory requirements. The analyses will be performed using NRC approved codes. The assumptions and scope of the analysis will be consistent with the plant's current licensing bases. For example, previously licensed operating options such as Single recirculation Loop Operation (SLO) will be included. See the Appendices for specific assumptions, methodology and scope to be provided in each area of evaluation.

5.3.1 ECCS-LOCA Performance Analyses

ECCS-LOCA performance analyses will be performed to demonstrate that the 10CFR50.46 requirements continue to be met consistent with the uprate conditions (power and pressure). The analyses, which include an evaluation at 102% of the uprated power conditions, re-establish the limiting single-failure combination and the limiting break size. A representative break spectrum will be analyzed, or <GE proprietary information removed>. LOCA analyses will be performed with the SAFER/GESTR-LOCA methodology as documented in Reference 2, or an alternate NRC approved methodology for LOCA 10CFR50.46 analysis will be used. A separate LOCA analysis report may be prepared and submitted before or with the uprate application. Emergency Core Cooling System (ECCS) performance will be based on existing Technical Specifications or revisions proposed at the time of the uprate application. Evaluation is expected to include consideration of previously licensed Technical Specification operational options (selected by the utility) for equipment out of service (e.g., an Automatic Depressurization (ADS) valve) and/or SLO. Operating limits will be confirmed or readjusted as necessary for all fuel types applicable at the time of the uprate. Appendix D lists the generic bases to be approved for ECCS-LOCA analysis and evaluation.

Containment and radiological evaluation of the LOCA will also be done for the uprated conditions, including consideration of Regulatory Guide 1.49 (Reference 1). See Sections 5.4 and 5.10 for further discussion of these areas and Appendices G and H for generic bases to be applied.

5.3.2 Transient Analyses

A review of the plant SAR and reload transients is conducted at the uprated conditions. Where necessary, analyses are performed to demonstrate compliance with the fuel thermal margin requirements and other applicable transient criteria. As in the LOCA evaluation, consideration of operational options (e.g., SLO) and/or equipment out-of-service options (selected from previously licensed options by the utility) will be included in the transient analysis (e.g., an inoperable Safety/Relief Valve (SRV)). The following description shows how transient analysis methods will be used. In some cases, alternate methodology (approved by NRC for fuel cycle-specific transient analysis) will be used. Appendix E lists the specific aspects of plant transient evaluation that are included in the generic uprate basis.

<GE proprietary information removed>

Analysis of these most limiting events for uprated power at the most limiting conditions on the operating power/flow map (Figure 5-1) will assure that fuel operating limits are met.

The safety analysis section of the SAR includes a broad set of transient events that is usually subdivided in accordance with these categories:

(1) Decrease in Core Coolant Temperature

(2) Increase in Reactor Pressure

(3) Decrease in Reactor Core Coolant Flow Rate

(4) Increase in Core Flow Rate

(5) Increase in Reactor Coolant Inventory

(6) Decrease in Reactor Coolant Inventory

(7) Increase in Reactivity

(8) Increase in Core Coolant Temperature

Table E-1 lists the limiting SAR events to be evaluated for power uprate. For all plants, all other (non-limiting) SAR cases have already been documented with operating conditions above rated steam flow. <GE proprietary information removed>.

The transients associated with Category 1 (Decrease in Core Coolant Temperature) are <GE proprietary information removed>. A decrease in coolant temperature causes an increase in reactor power. The events included in the power uprate basis are the limiting cases for this type of disturbance as documented in GESTAR.

Category 2 (Increases in Reactor Pressure) <GE proprietary information removed>. For BWR/6 plants, the SAR and reload evaluations also include the downscale failure of both turbine pressure regulators. These events are included primarily to ensure that the power increase caused by an abrupt pressure rise does not violate the required fuel operating limits. <GE proprietary information removed>. The bounding analysis for the ASME evaluation is also to be included in the power uprate evaluation as shown in Table E-1 and discussed in Section 5.5.1.

Category 3 (Decreases in Reactor Core Coolant Flow Rate) <GE proprietary information removed>, because they are not limiting, even after a 20% uprate.

Category 4 (Increases in Core Flow Rate) is <GE proprietary information removed>.

Category 5 (Increase in Reactor Coolant Inventory) is <GE proprietary information removed>.

Category 6 (Decrease in Reactor Coolant Inventory) is <GE proprietary information removed>

Category 7 (Increase in Reactivity) is <GE proprietary information removed>

<GE proprietary information removed> Category 8 (Increase in Core Coolant Temperature).

The bounding transients are documented in GESTAR for previously licensed operation. Table E-1 includes those events, plus a few additional cases intended to reconfirm the limiting events on a plant specific basis. Application of the setpoint methodology referenced in Appendix F ensures that the frequency of unplanned transients is not significantly increased as a result of decreased margin to safety system setpoints after power uprate.

5.3.3 Thermal-Hydraulic Stability

Evaluations are conducted for each fuel type/configuration as described in Section S.4 of GESTAR - US Supplement (Reference 14) to show continued compliance with the plant's stability criteria. The NRC's Safety Evaluation report on "BWR Owners Group Long-Term Stability Solutions Licensing Methodology" (Reference 19) describes additional measures to ensure stable operation of BWRs. Power uprates defined by these generic guidelines are consistent with both References 14 and 19. Constraints on possible expansion of the high-power/low-core-flow portion of the operating range are considered in the power uprate analysis and in defining the plant startup procedures.

Operation will not be expanded beyond the region previously licensed for the applicable product line. Appendix C defines the specific guidelines to be followed so that power uprate plants remain within the previously licensed range of core flow at the current rated power for each GE BWR product line. Power uprate applications will not introduce any flow control rod lines which are above the currently licensed ranges. Expansion of the flow range beyond these guidelines for any plant may be licensed separately, but it is not a required generic part of these uprate guidelines. Figure 5-1 demonstrates a power uprate operating range that does not introduce any higher rod pattern, which is characteristic of uprating a plant that has already expanded its operating map to the licensed range for its product line.

These guidelines will be used for selecting the operating range for power uprate. The specific ranges previously licensed for each product line will be maintained so that the power uprate will have no detrimental effect with regard to stability. Each uprate application will utilize the latest information available at the time of the submittal. In this way, the uprate will maintain stability protection at the same level as agreed upon for non-uprated operation of the applicable product line (see Appendix C for the specific requirements of this generic guideline constraint.) Since the exclusion region boundaries are redefined such that the absolute powers and core flows are the same as the current boundaries, power uprate will not affect stability.

5.3.4 Anticipated Transient Without Scram (ATWS)

Evaluation is performed to show continued compliance with the NRC's rule on ATWS. ATWS rule compliance primarily involves alternate shutdown equipment which has been previously installed at each unit. The equipment will remain and its performance at any changed conditions (due to uprate) will be evaluated (e.g., higher operating pressure). Where applicable, a bounding case will be reanalyzed at the uprated power to confirm that adequate overpressure protection and suppression pool cooling are maintained for limiting cases in each BWR product line. This analysis would also include evaluation of any changes in pressure setpoints of the safety/relief valves and/or high pressure recirculation pump trip. In some cases these setpoints, as well as the allowable number of relief valves out of service may be re-optimized to improve the ATWS response. Appendix L describes the generic guidelines related to evaluation of this special situation. Power uprate operation does not significantly affect the long-term ATWS response because it does not involve a uniquely higher rod line, and, therefore, there is no increase in the power level following the ATWS recirculation pump trip.

5.4 RADIOLOGICAL CONSEQUENCES

Radiological consequences, as stated in the SAR, will be evaluated or analyzed to show that the NRC regulations are met for uprated power conditions. This evaluation/analysis will be based on the methodology, assumptions, and analytical techniques described in the Regulatory Guides (RGs), the Standard Review Plan (where applicable), and in previous Safety Evaluations (SEs). The evaluation of radiological consequences includes the effect of a higher power level on:

- Source terms
- Offsite doses
- Control room, and Emergency Response Facility habitability
- Accidents as described in the SAR (LOCA, control rod drop, fuel handling, main steam line break, instrument line break, offgas system, radwaste tank failure and cask drop)

In general, the radiation sources inside the fuel rods, creation of activation products outside of the fuel rods, and concentration of coolant activation activities are directly proportional to the thermal power. Therefore, the original radiation inventories, expressed in terms of curies per megawatt of thermal power, will bound the uprated condition, provided that the core design, fuel loading, and mean exposure are not changed significantly. If significant changes to the fuel loading or design parameters are made to optimize for uprated conditions, the uprate application will re-perform the radiological evaluation to account for changes to the isotopic concentrations in the fuel. Issues relating to burnup and enrichment also need to be addressed if the uprated burnup and enrichment are to exceed any of the conditions in 10CFR51.52(a).

During normal operation, the radiation levels in the plant are the result of radiation streaming from the reactor vessel or from radioisotopes carried in the reactor water, steam, or radwaste process. In all cases, these quantities are approximately proportional to core thermal power. Increases in normal radiological releases from routine operation should be considered in the power uprate amendment requests to demonstrate continued compliance with the design objectives of 10CFR50 Appendix I and the requirements of 10CFR20. Each power uprate application should also demonstrate that the onsite radiation dose due to the uprated conditions will continue to meet the requirements of 10CFR20.

The magnitude of the potential radiological consequences of a design basis accident (DBA) is proportional to the quantity of fission products released to the environment. This quantity is a product of the activity released from the core and the transport mechanisms between the core and the effluent release point. For a steam line break or instrument line break accident, the radiological consequences will be, at most, <GE proprietary information removed>. For the remaining DBAs, the radiological releases are expected to increase, at most, by <GE proprietary information removed>. In some cases, the magnitude of the uprate may be limited, to maintain the radiological consequences below regulatory guidelines.

The uprate application will provide justification that current radiological consequences are still bounding and within applicable criteria, or provide re-analysis of any areas adversely affected by power uprate. Appendix H describes the generic bases to be used in the generic radiological evaluations or in re-analysis of any areas adversely affected by power uprate.

5.5 NSSS COMPONENTS

A comprehensive review of the NSSS components and systems will be performed at the uprated power conditions. This review is designed to evaluate the effect of higher power and the associated increase in temperatures, pressure, and flow rates. Safety aspects of equipment performance, as well as operational capability, will also be assessed.

5.5.1 Reactor Vessel and Internals

The reactor pressure vessel and internal components such as the jet pump assemblies, jet pump sensing lines, lower plenum components, FW spargers, fuel bundles, steam separators, and the steam dryers are evaluated at the limiting conditions of uprated power operation.

5.5.1.1 Reactor Core Coolant Hydraulics and Internal Pressure Differences

Analyses are performed to determine the core flow split among the fuel bundles and the core bypass region, steam conditions, core average void fraction, core pressure drop distribution and total core pressure drop. The outputs from these evaluations are used for various equipment evaluations (e.g., reactor internal pressure drop analysis), as well as for analysis of plant transients and accidents. <GE proprietary information removed>

5.5.1.2 Structural Assessment

A review is conducted to assess the effect of increased power and pressure conditions on the reactor vessel, internals and nozzles. Various analyses are performed to show continued compliance with the existing criteria and standards at the uprated conditions. The results of each of these system evaluations will be presented in the uprate application. Appendix I presents the specific methods to be applied in this area. In cases where the modifications or repairs have been made to the internals, the assessment will be made against the current configuration of the reactor. No change in the present conservatively established surveillance intervals is necessary given the change in vessel conditions caused by a 20% uprate.

5.5.1.3 Reactor Vessel Internals Vibration Assessment

Analyses are performed to ensure that the reactor vessel internals design continues to comply with the existing structural requirements. Components such as the jet pump assemblies, jet pump sensing lines, lower plenum components, FW spargers, fuel bundles, steam separators, and the steam dryer are evaluated at the uprate power, maximum core flow point from the viewpoint of vibration data available from the specific unit and/or from another unit of the same or similar design. The evaluation process involves evaluation of plant startup data, dynamic structural analysis, and, if necessary, fatigue usage factor determination.

5.5.1.4 Reactor Vessel Overpressure Protection

Evaluations and analyses are performed to demonstrate that the reactor vessel continues to conform to ASME Boiler and Pressure Vessel Code requirements, as applicable, for the uprated power and pressure conditions. Increases in protection setpoints (e.g., Safety/Relief Valve setpoints) and any applicable valve out-of-service options are also considered in this analysis. <GE proprietary information removed>. This model has been shown to be conservative for overpressure evaluations (References 4 and 5). In some cases, alternate methodology (approved by NRC for ASME overpressure protection analysis) will be used.

The worst transient event with failure of the first scram signal is evaluated (usually the <GE proprietary information removed>. Credit is only taken for ASME-qualified safety/relief valves. Appendix E provides the generic guidelines for this evaluation.

5.5.1.5 Reactor Vessel Fracture Toughness

Reactor pressure vessel embrittlement is caused by neutron exposure of the wall adjacent to the core (the "beltline" region). Power uprate will result in a higher operating neutron flux at the RPV wall, which will increase the integrated fluence over time. Thus, the effect of power uprate on reactor vessel fluence is estimated, then this fluence is used to evaluate the effect on vessel fracture toughness. <GE proprietary information removed> Actual evaluations are based on the results of in-vessel surveillance sample flux wires. <GE proprietary information removed>. The actual fluences may still be less than the SAR design basis values when <GE proprietary information removed>. The estimated uprated fluences are used to evaluate the effect on vessel fracture toughness. Detailed calculations of the reactor fluence based on anticipated fuel loading will be performed during the power uprate program. The fracture toughness requirement of 10CFR50 Appendix G states that the beltline materials adjusted reference temperature (ART) should remain below 200^{o}F. Changes in the nil-ductility transition temperature (RT_{NDT}) due to fluence are predicted according to Regulatory Guide 1.99, Revision 2.

The increased fluence for power uprate may cause an increase in the 32 effective full power year (EFPY) shift and, consequently, a change in the adjusted reference temperature, which is the initial RT_{NDT} plus the shift. The power uprate effect on the shift is estimated to be <GE proprietary information removed> New vessel pressure temperature curves may also be required due to the change in the 32 EFPY shift. The required system hydro test (with fuel) temperatures are estimated to undergo a <GE proprietary information removed> increase <GE proprietary information removed>. The non-nuclear heatup, cooldown, and the nuclear (critical) limits may also <GE proprietary information removed> change due to the power uprate. Plant-specific results will be included in the uprate application.

5.5.1.6 Steam Dryer/Separators

Evaluations are performed to determine the effect of the higher steam flow rate through the dryers and separators to ensure that the quality of exit steam continues to meet the existing operational criteria. Steam dryer and separator loads will also be evaluated and documented in the uprate application to show that they remain acceptable. Appendix I includes generic aspects of the methodology for this evaluation. The effect of higher steam flow and steam dryer pressure drop on the water level in the dryer skirt, and transient water level response will be considered using the applicable setpoint methodology.

5.5.2 NSSS Piping

Evaluations and analyses are performed to determine the potential effect of higher flow rates, temperatures and pressures for the recirculation and main steam piping for thermal expansion, dynamic loads, and (as applicable to the plants current licensing basis) vibration effects. Operational data and design basis information will be utilized to the extent that applicable information is available on the specific unit or a representative unit for the unit size and design. As applicable, licensed non-standard operating modes (e.g., one MSIV closed) will also be evaluated. Appendix K defines the specific methods and assumptions to be used generically in this evaluation.

<GE proprietary information removed>

5.6 NSSS SYSTEMS

Analyses and/or evaluations of various affected NSSS systems are performed to verify their continued operational capability to meet the existing design and safety requirements. Specific generic aspects of system evaluation are presented for approval in Appendix J to this document. These evaluations include the systems listed in the following sections.

5.6.1 Neutron Monitoring System

The APRMs will be re-calibrated to read the new uprated power level. The APRM high flux scram and the upper limit of the rod block setpoints, expressed in units of percent of licensed power, will not be changed. The flow-biased APRM trips, expressed in units of absolute thermal power (i.e. MW), will remain the same. <GE proprietary information removed>. Appendix F addresses setpoint methodology to be applied to power uprate adjustments.

IRMs will be adjusted (if necessary) so that overlap with the SRMs and APRMs is adequate. <GE proprietary information removed>.

It is expected that the neutronic life of the LPRM detectors and radiation level of the TIP may be affected due to the higher power level. The application will provide an estimate of this effect and any change in planned replacements of the detectors.

5.6.2 Recirculation System

The planned approach to achieve an increase in rated power requires no increase in the maximum core flow. Operation will primarily be on extensions of existing rod lines, as discussed in Section 5.2, and will require that the Recirculation System overcome a slight increase in the two-phase flow resistance due to an increase in the core average void fraction. <GE proprietary information removed> A review of plant-specific operating data will be performed to confirm that the Recirculation System will accommodate the expected insignificant increase in the flow resistance at the uprated power condition when operating at maximum core flow. Potential increases in system vibration will be evaluated from plant data (noted in Section 5.5.3).

5.6.3 Control Rod Drive (CRD) and CRD Hydraulic Systems

The Control Rod Drive and CRD Hydraulic Systems will be evaluated to determine the effect of an increase in reactor operating pressure in on its performance, specifically the effect on scram time. <GE proprietary information removed> The increased power level will have an effect on control blade lifetime. This factor will be included in plant-specific evaluations of the blades.

5.6.4 Residual Heat Removal System

The ECCS performance of the Residual Heat Removal (RHR) System (LPCI mode) during a LOCA will be evaluated for the uprated power condition (part of the Safety Analysis discussed in Section 5.3.1 and Appendix D). Acceptable compliance with all required criteria is expected using the approved SAFER/GESTR-LOCA methodology (Reference 2).

The sizing basis of the RHR heat exchanger is different for the various BWR product lines. <GE proprietary information removed>. A proposed increase in core thermal power translates to a proportionally higher decay heat level. An evaluation will be performed to determine the performance of the shutdown cooling subsystem for the uprated condition. It is expected that, after uprate, the time to achieve emergency shutdown will remain acceptable. The RHR heat exchanger is expected to have enough excess capacity to achieve a cold shutdown condition within the design objectives for operation at uprated power. No hardware or operational effect on the RHR shutdown cooling subsystem resulting from operation at the uprated power level is anticipated. Appendix J describes generic guidelines for RHR evaluation.

5.6.5 Standby Liquid Control System

The potential effect of power uprate on Standby Liquid Control System (SLCS) shutdown capability and injection capability will be evaluated. Power uprate may require a slight increase in shutdown concentration or boron enrichment requirements, due to higher fuel batch fractions or enrichments. Any required changes to the concentration design criterion can be accomplished by implementing a new acceptable storage-volume concentration.

Evaluations will also be performed to assure that the SLCS has high enough operating pressure to inject adequate boron solution at the higher reactor pressure. <GE proprietary information removed>. It is expected that the SLCS will have adequate pressure to deliver the boron solution to the reactor at the higher operating pressure associated with power uprate, <GE proprietary information removed>.

5.6.6 Reactor Water Cleanup System

<GE proprietary information removed>. However, operation at uprated power can affect the quantity of fission products, corrosion products, and other soluble and insoluble impurities in the reactor water. Reactor water chemistry is typically well within

fuel warranty and Technical Specification limits on effluent conductivity and particulate concentration and no changes will be made in water quality requirements. Reactor water chemistry excursions usually coincide with power changes, not steady-state operation at a particular power level. Therefore, it is concluded that the RWCU System will have sufficient capacity for reactor operation at the uprated power level and no modifications are expected. The application will confirm the applicability of this conclusion to the specific plant.

5.6.7 HPCI(S)/RCIC Systems

The capability of the HPCI(S) and RCIC Systems to meet their design requirements at the new uprated power level will be evaluated. It is expected that both the HPCI(S) and RCIC Systems will have the capability to deliver the required flow at the slightly higher reactor pressures. HPCS evaluations will include the applicable effect of reactor pressure on its head/flow performance.

The capability of the turbine-driven systems (HPCI and RCIC) to successfully develop the horsepower and speed required by the pumps to meet the new pressure requirements will be evaluated. <GE proprietary information removed>. The HPCI(S) System evaluation includes LOCA effect from uprated power. The RCIC or HPCS System evaluation includes analysis of RCIC-only or HPCS only inventory supply during loss of all feedwater flow transients.

5.6.8 Nuclear System Pressure Relief and Automatic Depressurization System

In cases of up to 20% uprate, the capacity of the existing set of safety/relief valves (SRVs) is expected to be sufficient. Opening pressure setpoints are expected to be raised about the same as the vessel dome pressure increase to preserve adequate simmer margin during uprated operation. Overpressure transients, including cases with initial scram failed, will be analyzed to confirm that the required ASME criteria continue to be satisfied at the new uprated conditions. If the unit has any SRV out-of-service options in the Technical Specifications, they will also be reevaluated. Since most units have ample SRV capacity for overpressure protection, uprate performance is expected to be acceptable. The uprate application will confirm this conclusion for each plant. Appendix E includes generic guidelines for the overpressure protection evaluation.

The performance of the existing Automatic Depressurization System (ADS) valves will also be evaluated in the LOCA analysis for uprated power. <GE proprietary information removed>. With the SAFER/GESTR-LOCA methods (Reference 2), acceptable performance is expected for the ADS. Generic guidelines for this evaluation are presented in Appendix D to this document.

5.6.9 Containment Isolation System

The ability of containment isolation valves and operators to perform their required functions under the uprated flows, pressure differences, and environmental conditions will be evaluated and hardware or setpoint changes implemented if necessary.

5.7 REACTOR CORE DESIGN AND FUEL

The reactor core and fuel performance characteristics during uprated power operation will be assessed as part of the fuel reload analysis. In addition to the higher core thermal power that affects the core and the fuel performance, power uprate operation also results in <GE proprietary information removed> increased steam void content. The power distribution in the core may be changing to allow increasing overall core power while limiting the absolute power in any individual fuel bundle. Evaluations of core performance will be provided with the reload submittal that implements power uprate (at once or in steps) for a specific cycle.

5.7.1 Shutdown Margin And Hot Excess Reactivity

All minimum shutdown margin requirements apply to cold shutdown (212°F) conditions and will be maintained without change. Checks of cold shutdown margin based on Standby Liquid Control System boron injection capability and shutdown using control rods with the most reactive control rod stuck out will be made.

Through the fuel cycle redesign, sufficient excess reactivity can be obtained to match the desired cycle length. The increase in hot reactivity may result in less hot-to-cold reactivity difference and, therefore, smaller cold shutdown margins. However, this loss in margin can be accommodated through core design. If needed, a bundle design with improved shutdown margin characteristics can be used to preserve the flexibility between hot and cold reactivity requirements for future cycles.

Reload fuel cycle analysis and core design for operation in the uprate power level will optimize the energy requirement and power distribution so that the core and fuel performance characteristics can be met through fuel loading strategy and control rod patterns.

New fuel designs are not needed for power uprate to assure adequate safety. However, new fuel enrichments or higher batch fractions may be used to provide additional operating flexibility and maintain fuel cycle length. All fuel and core design limits will continue to be met by control rod pattern adjustments.

5.7.2 Thermal Limits

The power distributions used in the safety analyses will be compared to the actual cores' distribution to ensure they are appropriately limiting. The thermal limits include allowances for the combined effects of the gross and local power density distributions, control rod pattern, and reactor power level adjustments during plant operation on the fuel heat flux and temperature. Thermal-hydraulic design and operating limits assure an acceptably low probability of boiling transition-induced fuel cladding failure occurring in the core at any time, even for the most severe postulated operational transients.

Limits are also placed on the peak bundle heat generation rates in order to meet peak fuel cladding temperature limits for the Loss-of-Coolant Accident (LOCA) and fuel mechanical design bases.

The subsequent reload core designs for operation at the uprated power level will take into account the above limits to assure acceptable differences between the licensing limits and their corresponding operating values. The cores' average power density is increased proportionally by power uprate, which, in turn, will affect operating flexibility, reactivity characteristics, and energy requirements.

Operating limits are established to assure that regulatory and safety limits are not exceeded for a range of postulated events (e.g., transients, LOCA, etc.). Cycle-specific core configurations will be evaluated for each reload to confirm the power uprate capability and to establish or confirm cycle-specific limits. Reload submittal analyses include limiting transient evaluations to determine MCPR and MAPLHGR operating limits for all fuel types, included in a specific cycle. Evaluations are also made to confirm that the core operating states are within the fuel mechanical design basis (e.g. channel wall pressure difference.)

The following steady-state operating thermal limits will be examined to ensure compliance throughout the uprated power/flow operating range:

- Minimum Critical Power Ratio (MCPR)
- Maximum Linear Heat Generation Rate (MLHGR)
- Maximum Average Planar Linear Heat Generation Rate (MAPLHGR)

5.7.2.1 Minimum Critical Power Ratio Performance

In general, power uprate will be expected to result in some decrease in steady-state Operating MCPR if no change in fuel design or core design is made and similar rod pattern are used. It is expected that core designs can be developed which will provide adequate operating CPR margin will exist at uprated power; core operations will not be unduly restricted.

Calculation of the SLMCPR is based on <GE proprietary information removed>.

A flatter core power distribution may enable more fuel bundles to operate on or near thermal limits, which could increase the SLMCPR. Any required change in SLMCPR will be determined for the core and fuel designs applied in uprated operation.

5.7.2.2 Maximum Average Planar Linear Heat Generation Rate Performance

Similar to the steady-state operating MCPR performance, it is expected that a power uprate would result in approximately the same amount of decrease in steady-state operating Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) if there are no changes in fuel design and similar rod pattern. For MAPLHGR performance, an optimized rod pattern can help to enhance the available margin.

The fuel thermal-mechanical limits at power uprate conditions will be confirmed to be within the fuel design criteria as part of the core reload analysis. The uprated operating range will be evaluated to derive power- and flow-dependent $MCPR_f$ and

MAPLHGR limits ($MCPR_f$ $MCPR_p$ $MAPLHGR_f$ and $MAPLHGR_p$) using the analysis procedure applied in the ARTS performance improvement program.

5.7.2.3 Maximum Linear Heat Generation Rate

<GE proprietary information removed>.

5.8 CONTROL AND INSTRUMENTATION

The control and instrumentation signal ranges and setpoints are reviewed and evaluated in order to make any necessary modifications due to changes in power, system pressure, neutron flux, and steam and feedwater flow. Appendix F provides additional discussion of instrument setpoints.

The GE generic setpoint methodology (Reference 16) or an equivalent plant-unique alternative is still applicable for uprate. An analysis is performed to determine the setpoint changes (if required) for various systems, including:

<GE proprietary information removed>

5.9 ENVIRONMENTAL IMPACT EVALUATION

Evaluations will be performed to show that the higher power level does not result in a significant adverse environmental impact on land, water, air or natural resources. The primary change will be a small increase in the amount of heat discharged from the condenser circulating water system. Where coolant is returned to a river, lake or ocean, the change is estimated to be an increase of approximately 4°F. The integrated effect (T x flow) of cooling tower units will be less. The unique site conditions will be evaluated and documented in the application. Any changes necessary in the Environmental Protection Plan and environmental permits will be submitted and approved prior to operation at the uprated condition.

5.10 BALANCE-OF-PLANT SYSTEMS

Detailed reviews and analyses will be performed to determine the capability of various BOP systems and components to ensure that they are capable of delivering the increased power output. The results will be documented in each application. The systems that receive the major review are described in the following sections.

5.10.1 Turbine-Generator

Thermodynamic and mechanical review and/or analysis is performed to assure that the turbines can pass the higher steam flow rates with adequate design and pressure control. System operating pressures are chosen using the observed steamline pressure drop in order to preserve <GE proprietary information removed>.

Review and/or analysis is conducted to evaluate the performance of the moisture-separator or moisture separator reheater systems under higher operating conditions. Similarly, a review is performed to ensure that the main generator and its auxiliaries are capable of producing higher electrical output while still meeting design requirements.

Various operational impacts will be evaluated (e.g., the effect of the increased generator loads on the TBCCW System will be evaluated).

5.10.2 Primary Containment System

The application will show acceptability of the effect of the uprated power on containment capability. These evaluations will include:

- Containment pressures and temperatures
- LOCA containment dynamic loads
- SRV containment dynamic loads
- Subcompartment pressurization

In general, the approach <GE proprietary information removed>. Longer-term effects (e.g., suppression pool temperature) will be analyzed and shown to be acceptable. Appendix G presents the generic approach for this evaluation.

5.10.3 Feedwater and Condensate System

Review and/or analysis is performed to ensure that the feedwater heaters, heater drains, condensate demineralizers, and the pumps (feedwater and condensate) are capable of providing higher flow rates. The review also includes evaluation of the performance of the feedwater control valves and/or feedwater turbine controls to maintain adequate water level control at the uprated conditions.

<GE proprietary information removed>

5.10.4 Condenser and Plant Cooling Water Systems

Analysis is performed to predict condenser performance at the uprated steam flow rate. <GE proprietary information removed>. Either increased discharge temperatures or degraded condenser vacuum conditions may limit plant power level during hot weather. No changes will be made to the present plant heat sink maximum temperature limits.

Review is performed to determine the effect of uprate on various plant cooling systems. In most areas, no change is expected, since plant operating temperatures are nearly unchanged. The normal and emergency service water systems, RHR service water, and the turbine building closed cooling water system will be evaluated for their increased duty.

5.10.5 Circulating Water System and/or Cooling Tower

Review and/or analysis is performed to evaluate the performance of the circulating water system and/or cooling tower under the uprated thermal loads. Similar to the main condenser, these systems may operationally limit the power level during hot weather, but no safety effect exists as long as the plant is operated within the applicable Technical Specifications. The results from these reviews are also used in performing the Environmental Evaluation for the plant.

5.10.6 Electrical Systems

Evaluations are performed to demonstrate that the electrical systems and components (including transformers) are capable of operating under increased electrical output and increased plant load conditions.

5.10.7 Emergency Diesels, M-G Sets and Batteries

Review is performed to determine the effect of higher power level on the diesels, M-G sets and emergency batteries. In general, no load increase is expected, since the existing ratings and requirements are maintained for the safety equipment.

5.10.8 Spent Fuel Pool System

Evaluation of the modified spent fuel pool conditions (shutdown margin and heat removal) will be provided.

5.10.9 Radwaste System

Evaluation is performed to review any effect of higher power level on the Radwaste System. <GE proprietary information removed>.

5.10.10 BOP Piping

Similar to NSSS piping, evaluations and analyses are also to be performed to determine the potential effect of power uprate on BOP piping. Consideration will include higher flow rates, temperatures, and pressures (as applicable) in order to assess the potential effect on erossion/corrosion and code design adequacy due to uprated conditions, including thermal expansion and (as applicable to the plants current licensing basis) vibration effects.

5.11 ADDITIONAL ASPECTS OF UPRATE

5.11.1 10CFR50 Appendix R

The Appendix R requirements are reviewed to ensure that these requirements continue to be met at the uprated power level.

5.11.2 Environmental Qualification (EQ) Criteria

Review of compliance from the viewpoint of EQ criteria is to be performed for safety-related equipment to show that equipment can perform its required functions under the uprated power condition. <GE proprietary information removed>.

5.11.3 Emergency Operating Procedures

The Emergency Operating Procedures will be evaluated to identify the effect (if any) of operating under uprated power conditions. <GE proprietary information removed>.

5.11.4 Requirements for Shutdown and Refueling

The shutdown and refueling requirements are reviewed to identify modifications (if any) required to accommodate the uprated power configuration.

5.11.5 Operator Training

Operating training requirements will be reviewed. Additional training required to operate the plant in an uprated condition is expected to be minimal.

5.11.6 Plant Life

The plant nuclear steam supply system (reactor pressure vessel, reactor internals and primary coolant pressure boundary) will be evaluated against criteria regarding the effect of power uprate on age-related degradation. Equipment which is routinely replaced such as the fuel and the control rod drive mechanisms will not be included in this evaluation.

The longevity of most equipment will not be affected by power uprate. Those few components which might be affected already have effective plant programs in place to detect and mitigate age-related degradation. In some cases, additional maintenance, inspection, testing or surveillance procedures may have to be put in place for equipment like the main transformer which will operate under higher loads at uprated conditions.

5.11.7 Station Blackout (SBO)

<GE proprietary information removed>. The licensing application will include evaluation of SBO.

5.11.8 High Energy Line Break (HELB)

Evaluation of the effect (if any) of power uprate conditions on environmental qualification will be provided.

5.11.9 Power Uprate Testing

A testing plan will be included in the uprate licensing application. It will include pre-operational tests for systems or components which have revised performance requirements. Guidelines for the power uprate ascension plan are given in Appendix L.

<GE proprietary information removed>

5.11.10 Power-Dependent Data Banks

Data banks for the process computer, safety parameter display and control room operational indications/logs will be revised to correspond to the new rating just ahead of the actual cycle in which uprate is to be implemented.

5.11.11 Probabilistic Safety Assessment (PSA)

The impact of power uprate on plant risk will be assessed by reviewing the Individual Plant Examinations (IPE). Each nuclear plant has completed an IPE in response to Generic Letter 88-20. Most utilities completed their IPE by performing a PSA. Level 1 PSA models the events that lead to core damage and calculates the core damage frequency. Level 2 PSA models the core melt progression and containment failure and calculates the frequency and magnitude of radioactive release.

The assessment of the effect of power uprate on the plant IPE will consider the effect of power uprate on IPE inputs and assumptions such as:

<GE proprietary information removed>

5.12 SYSTEMS NOT AFFECTED BY POWER UPRATE

Appendix J discusses the systems and components that are not dependent or are not significantly dependent upon power level, and are therefore not included in plant-specific applications.

Table 5-1

REACTOR THERMAL-HYDRAULIC PARAMETERS (TYPICAL BWR)

Parameter	Original Licensed Condition	5% Thermal Power Uprate	20% Thermal Power Uprate
Thermal Power (MWth)	2436	2558	2924
(Percent of Current Rated)	100	105	120
Steam Flow (million lb/hr)	10.5	11.1	13.0
(Percent of Current Rated)	100	106	124
Dome Pressure (psia)	1020	1035	1095
Dome Temperature (°F)	547	549	556
Feedwater flow (million lb/hr)	10.5	11.1	13.0
Feedwater Temperature (°F)	420	425	439
Full Power Core Flow (million lb/hr)	58 to 85	62.6 to 85	76.5 to 85
(Percent of current rated)	75 to 110	81 to 110	99 to 110
Core Inlet Enthalpy (Btu/lb at rated core flow)	527	528	535
Core Inlet Subcooling at core pressure (Btu/lb)	20.9	21.6	24.1
Core bypass fraction (percent)	12.5	12.7	13.0
Core pressure drop (psi)	<GE proprietary information removed>		
Core average void fraction (percent)	<GE proprietary information removed>		
Dominant Channel exit quality (percent)	15.2	16.1	18.9

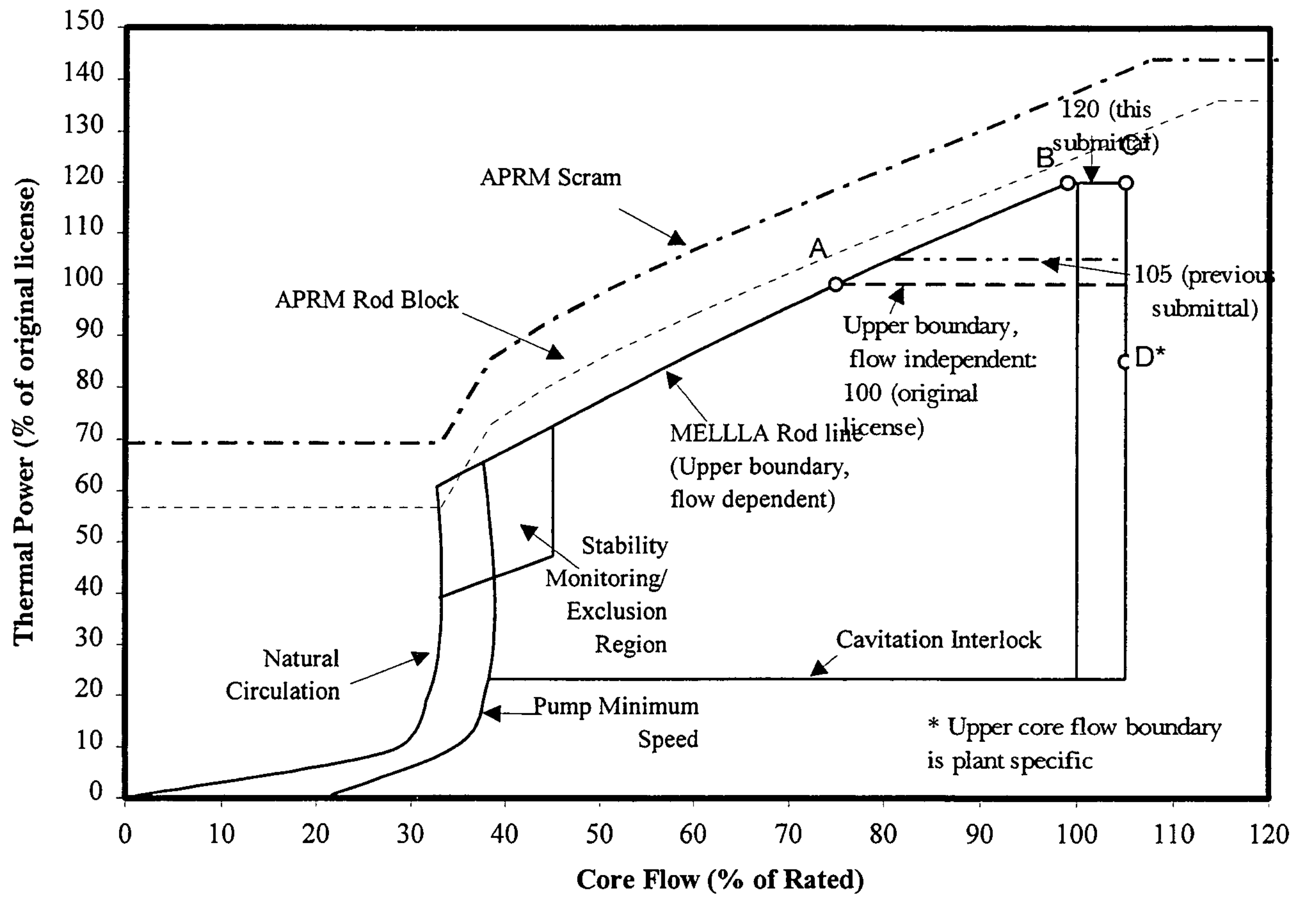

Figure 5-1. Typical Power Uprate (+20 % Thermal Power) Annotated Power/Flow Map

6.0 CONCLUSION

This document provides GE's recommended scope of evaluation for power uprate of a BWR to 120% of original licensed thermal power. This document outlines an uprate evaluation and analysis plan that is comprehensive, rigorous and realistic. Specific generic methods, assumptions, and scope of evaluation are presented in the Appendices to this report.

NRC approval of the guidelines described in this document is requested to promote consistency in upcoming plant submittals and to reduce uncertainties in regulatory requirements associated with power uprate assessments. NRC review and approval for this generic approach should standardize the individual plant uprate applications to the maximum extent possible and significantly reduce NRC resources required to address the applications anticipated in the next few years.

7.0 REFERENCES

1. NRC Regulatory Guide 1.49, "Power Levels of Water-Cooled Nuclear Power Plants", May 1973.
2. "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident", NEDE-23785-1-PA, June 1984.
3. "General Electric Standard Application for Reactor Fuel, (GESTAR)", NEDE-24011-P-A-10, February 1991.
4. "Qualification of the One-Dimensional Core Transient Model for BWR's", NEDO-24154, Vol. 1 and 2; October 1978.
5. "Qualification of the One-Dimensional Core Transient Model for BWR's", NEDE-24154-P, Vol. 3; October 1978.
6. Letter from J.S. Charnley (GE) to C.O. Thomas (NRC), "Amendment 11 to GE LTR NEDE-24011-P-A", February 27, 1985.
7. Letter from J.S. Charnley (GE) to C.O. Thomas (NRC), "Supplementary Information Regarding Amendment 11 to GE Licensing Topical Report NEDE-24011-P-A", October 9, 1985.
8. R.B. Linford, "Analytical Methods of Plant Transient Evaluations for the General Electric Boiling Water Reactor", NEDO-10802, February 1973.
9. R.B. Linford, "Analytical Methods of Plant Transient Evaluations for the GE BWR Amendment No. 1", NEDO-10802-01, June 1975.
10. R.B. Linford, "Analytical Methods of Plant Transient Evaluations for the GE BWR Amendment No. 2", NEDO-10802-02, June 1975.
11. J.A. Woolley, "Three-Dimensional BWR Core Simulator", NEDO-20953A, January 1977.
12. "Steady-State Nuclear Methods", NEDE-30130-P-A and NEDO-30130-A, April 1985.
13. Letter from K.W. Cook (GE) to F. Schroeder and D.G. Eisenhut (NRC), "Implementation of a Revised Procedure for Calculating Hot Channel Transient CPR", July 20, 1979.
14. "General Electric Standard Application for Reactor Fuel (GESTAR)", U.S. Supplement, NEDE-24011-P-A-10-US, March 1991.
15. J. Duncan and P.W. Marriott, "General Electric Company Analytical Model for Loss-of-Coolant Analysis in Accordance with 10CFR50 Appendix K", NEDE-20566-P-A, September 1986.
16. Wooley, Leong, Smith, Wolf, "General Electric Instrument Setpoint Methodology", NEDE-31336, October 1986.
17. "The General Electric Mark III Pressure Suppression Containment System Analytical Model", NEDO-20533, June 1974.

18. "Decay Heat Power in Light Water Reactors", ANSI/ANS 5.1-1979, Approved by American National Standards Institute, August 29, 1979.

19. "BWR Owners Group Long-Term Stability Solutions Licensing Methodology", NEDO-31960 and Supplement 1.

20. E. C. Eckert and K. K. Berry, "Generic Guidelines For General Electric Boiling Water Reactor Power Uprate", NEDE-31897P-A, June 1991.

21. "Generic Evaluations of General Electric Boiling Water Reactor Power Uprate", NEDE-31984P, July 1991.

22. "Licensing Topical Report, TRACG Model Description," NEDE-32176P, February 1993.

23. Federal Register, Vol. 49 No. 124 (10CFR62, ATWS Rule), June 26 1984.

24. "Assessment of BWR Mitigation of ATWS", NEDE-24222, December 1979.

25. "Engineering Evaluation of Average Power Range Monitor, Rod Block Monitor, Technical Specifications (ARTS) Improvement Program", NEDE-30908P, April 1983.

APPENDIX A: PROPOSED SPECIFIC POWER UPRATE LICENSING REPORT

This appendix presents an example table of contents for a plant specific power uprate Licensing Report. Per section 3., the items in the plant specific Licensing Report will include those in the current licensing basis.

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APPENDIX B: LICENSING APPROACH AND CRITERIA FOR POWER UPRATE

B.1 LICENSING APPROACH

Plant-specific uprate Licensing Reports will reference two GE generic licensing topical reports (LTRs) in order to focus the plant reviews on those issues that are either plant unique or cannot practically be addressed in a BWR bounding manner. The scope/content of the generic LTRs will be analogous to LTR1 and LTR2 (References 20 & 21) approved by the NRC for reference in the 5% power uprate programs and is described in the following paragraphs.

The purpose of this report (ELTR1) is to establish an agreed-upon scope and depth for plant-specific uprate reports currently targeted for submittal to the NRC starting in the first quarter of 1996. Additionally, this report defines the methodology, analysis assumptions and acceptance criteria to be utilized in plant reports.

A follow-on report (ELTR2), analogous to Reference 21, is anticipated, which will provide generic evaluations which can be referenced, to reduce the content of plant-specific Licensing Reports. It will provide generic bounding results for BWR plant licensing issues, analytical studies and equipment evaluations. Licensing issues studies will include NRC Generic Letters, IE Bulletins, GE SILs, TMI items, Regulatory Guides, Part 21 evaluations, etc. ELTR2 will update the disposition and issue resolution initially provided in LTR2 (Reference 21). If it is not possible to resolve one of the previous licensing items generically, a resolution basis will be included, to be confirmed on a plant-unique basis in the plant-specific Licensing Report or possibly on a generic basis in a subsequent supplement to ELTR2.

B.2 LICENSING CRITERIA

The licensing evaluations and reviews for uprating a BWR plant will be conducted in accordance with the following criteria:

1) All safety aspects of a plant that are affected by an increase in the thermal power level will be evaluated, including the Nuclear Steam Supply System (NSSS) and Balance-of-Plant (BOP) systems.
2) Evaluations and reviews will be based on licensing criteria, codes and standards applicable to the plant at the time of the power uprate submittal; there is no change in the previously established licensing basis for the plant.
3) Evaluations and/or analyses will be performed using NRC-approved analysis methods for the Safety Analysis Report (SAR) accidents and transients affected by power uprate.
4) Evaluations and reviews of the NSSS systems and components, containment structures, and BOP systems and components will show continued compliance to the codes and standards applicable to the current plant licensing basis (i.e., no change to comply with more recent codes and standards will be proposed due to power uprate).

5) NSSS components and systems will be reviewed to confirm that they continue to comply with the functional and regulatory requirements specified in the SAR and/or applicable reload license.

6) While major NSSS hardware changes are not expected, any required plant modifications will be designed to applicable safety requirements and implemented in accordance with 10CFR50.59.

7) All plant systems and components affected by an uprate will be reviewed to ensure no significant increase in challenges to the safety systems.

8) A review will be performed to assure that increased thermal power level continues to comply with the existing plant environmental regulations.

9) A review, as defined in 10CFR50.92(c), will be performed to establish that no significant hazards exist as a result of operation at the increased power level and submitted.

10) The individual plant license amendment submittal will request an increase in core thermal power level equal to (or less than) 120% of the original licensed thermal power. <GE proprietary information removed>.

11) Changes made to systems since a plant's original operating license have been evaluated in accordance with 10CFR50.59 or are the result of requested Operating License or Technical Specification changes. The effect of these changes on the SAR are required by 10CFR50.71(e) to be incorporated into the SAR on an annual basis. The SAR is required to be current for changes implemented six months or more prior to its latest revision. Review of the latest SAR and of design changes/safety evaluations implemented, but not yet shown in the SAR ensures adequate evaluation of the licensing basis for the effect of power uprate through the date of that evaluation. Additionally, safety evaluations for changes not yet implemented will be reviewed for the effects of uprated power.

B.3 DETERMINATION OF NO SIGNIFICANT HAZARDS

Plants seeking a power uprate are expected to request an amendment to their license consistent with the considerations which govern their current license; that is, there is no change in the licensing basis for the plant. No significant increases in the amount of effluents or radiation emitted from the facility are anticipated because of power uprate. Consideration of potential significant hazards will establish that operation of the facility in accordance with the proposed amendment would not:

(1) Involve a significant increase in the probability or consequences of an accident previously evaluated; or

(2) Create the possibility of a new or different kind of accident from any accident previously evaluated; or

(3) Involve a significant reduction in a margin of safety.

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The probability of occurrence and consequences of an accident previously evaluated will be demonstrated as being minimal. As shown in Table 3-1, the increase in offsite radiation release is commensurate with the increase in power level and will remain well below the 10CFR100 criteria.

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Plant-specific Licensing Reports will provide detailed, quantitative evaluations demonstrating that operation at the uprated power level will not involve a significant hazard.

APPENDIX C: SPECIFIC ASSUMPTIONS AND BASES FOR POWER UPRATE OPERATING CONDITIONS

C.1 SCOPE

This appendix defines the guidelines that will be used generically for the selection of the steady-state operating conditions for power uprate of up to 120% or the original licensed thermal power. It includes documentation of the bases and assumptions for each guideline. Also included are the guidelines associated with the selection of the power/flow map operating range for the unit after power uprate. Plants that make selections that differ from these bases (such as special operational features) will provide separate explanations and justifications in the plant unique licensing submittal.

C.2 GUIDELINES FOR POWER UPRATE OPERATING CONDITIONS

The generic guidelines to be applied during establishment of uprated operating conditions are listed with the pertinent bases, methods, and assumptions that apply to each one.

C.2.1 Uprated Core Thermal Power

The uprated core thermal power level (MWt) to be proposed shall be equal to (or less than) 120% of original licensed thermal power.

Current operational heat balance methods will be used for definition of the uprated operating conditions. A reactor heat balance shall be prepared and issued (by GE) for the uprated condition. It shall be included within the uprate submittal. The specific value of the uprated thermal power level (MWt) shall be calculated using the full, standard configuration of feedwater heaters in service.

End-of-cycle operation with Feedwater Temperature Reduction (FWTR) remains as a special option. If previously applicable to the unit (and still desired), it will be reanalyzed up to the uprated thermal power as part of the plant-specific uprate submittal. If not previously licensed, FWTR will be treated as a new feature, separate from power uprate. Similarly, other Equipment-Out-of Service options (e.g. SRV's, Feedwater heaters, Recirculation pump) will be reassessed for applicability to uprated operation.

Justification of Uprated Core Thermal Power

(1) The original design basis for all GE BWR/4, 5, and 6 Product Lines had anticipated operation at a steam flow operating condition of at least 105%.

Operation at 120% of original licensed thermal power is achievable on the previously licensed MELLLA rod line. This minimizes the effect of uprating on ATWS and stability response. The 20% uprate has minimal effect on other operational and safety performance characteristics of the Nuclear Steam Supply. Its economic feasibility will be evaluated on a plant-specific basis to determine the optimum uprate under this program.

(2) In general, operating experience at the plants has shown that the operating and safety margins included in the design have been confirmed. Although plant unique conditions will be factored into each submittal, uprate to the design steam flow condition is considered to be generically achievable without significant modification of NSSS or BOP systems.

(3) The use of current operational heat balance methods to define the uprated operating conditions is consistent with current SAR and reload practice. A reactor heat balance shall be prepared and issued (by GE) for the uprated condition. It shall be included within the uprate submittal.

(4) Use of the full, standard configuration of feedwater heaters in service to establish the specific value of the uprated thermal power level (MWt) is also consistent within current SAR and reload practice. An increase of less than 20 ° F in final feedwater temperature is expected. The uprated design basis value for the feedwater temperature will be established through coordinated heat balances for the reactor and the turbine systems.

(5) The uprated power level (as well as related steam and feedwater flow rates and electrical power level) shall be indicated in the main control room similar to current practice. That means that the uprated operating parameters will be indicated as 100% of the new licensed conditions wherever applicable (e.g., the indicated average power range monitor output signals). Similarly, licensing analysis documentation (e.g., reload licensing documents) will shift to the new licensed rating when it is approved.

C.2.2 Operating Pressure

The operating pressure for the uprated power condition may be increased to assure that satisfactory reactor pressure control capability is maintained, while still providing adequate margin to safety limits and vessel stress limits. The selection of this uprate parameter is primarily operational, but it is a basic input to many of the safety evaluations. The adequacy of pressure control shall primarily be assured by use of data available from operation at the current power level and must be demonstrated as uprated power conditions are achieved.

Justification

(1) The operating pressure shall be established on the basis of steam line pressure drop characteristics and the excess steam flow capability of the turbine observed during plant operation up to the current rated power level.

(2) Satisfactory reactor pressure control (by the turbine pressure regulator and the turbine control valves) requires the design to provide adequate flow margin between the uprated operating condition and the steam flow capability of the turbine control valves at their maximum stroke. An increase in the turbine inlet pressure may be necessary to increase this flow margin, thereby establishing the operating pressures for the whole system.

(3) The adequacy of the pressure control flow margin chosen for this operational aspect of power uprate is to be demonstrated at the uprated conditions by performing controller testing equivalent to the testing done during the original startup of the unit. Analytical confirmation of the adequacy of the controls will be done using appropriate simulation techniques, but the demonstration test requirement provides the final assurance.

C.2.3 Power/Flow Operating Map

Figure 5-1 illustrates a typical BWR operating power/flow map. The power/flow map applicable for operation after power uprate shall be constrained by the following limits:

(1) The upper boundary shall be limited to the uprated power level (identical to current practice, but for the higher rating). Note that power will be indicated as 100% of the new rating.

(2) The right side of the operating range shall be the same core flow limit as currently licensed. After uprate, the currently licensed upper limit on core flow range remains unchanged.

(3) The left (lower core flow) side of the operating map defines the acceptable flow control/rod line for plant operation. The following sections discuss these examples in more detail.

(4) The plant has previously implemented the maximum expansion of the power/flow map licensed for its product line. This has been called the maximum extended operating domain (MEOD) option for BWRs. For purposes of this guideline, it is characterized by the lowest value of core flow at which currently rated power is approved (point A in Figure 5-1). Values of this characteristic flow point are listed in Table 5-1 for all pertinent BWR product lines.

The power uprate will be limited to the existing absolute power versus core flow rod line. The flow range available for operation at the new power level is bounded on the lower side by point B in Figure 5-1. Table C-1 gives the new lower limits for these plants.

(5) The boundaries on the lower part of the map are set to avoid cavitation in various parts of the recirculation system. They are based on the absolute values of flows and temperatures. Therefore, these lower boundaries will be moved "downward" slightly as the re-scaled power/flow map is prepared <GE proprietary information removed>

Justification of Power/Flow Operating Range

(1) Compliance with the uprated maximum power limit (the top of the operating map) is unchanged from current Technical Specification practice. Analytical evaluations (described in other Appendices to this document) account for uncertainty in the actual power level.

(2) By not changing the previously approved high core flow limit, power uprate operation does not introduce any significant changes in the evaluations associated with core flow. The effect of changes in pressure drops, recirculation flow rates, the potential for recirculation flow-induced vibration effects, and the high flow dependency of some transient events are all constrained to be essentially equal to the previously analyzed conditions.

(3) By constraining the plants that have previously introduced MEOD to the same absolute upper flow control/rod line, this guideline avoids introduction of potential operation beyond the range already analyzed and experienced at the plant. The primary issue related to the upper rod line is core neutronic hydraulic stability. Power uprate according to this guideline will not challenge the operating range previously approved and utilized at the plant.

(4) The cavitation interlocks/boundaries that appear on the operating map are based on the absolute values of flows and temperatures. Therefore, they can be maintained at the same absolute limit as before. In the re-scaled power/flow map, they will appear to be lower, but in reality they will be providing their cavitation function at the same operating point as before.

These generic guidelines will be used to consistently establish uprated power operating conditions. Further levels of detail (and any exceptions) will be included in the plant-specific submittals as required.

Table C-1

LOWER LIMITS OF CORE FLOW RANGE AT RATED POWER*

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APPENDIX D: SPECIFIC ASSUMPTIONS AND BASES FOR ECCS-LOCA EVALUATIONS

D.1 SCOPE

This appendix defines the guidelines that will be used generically for the evaluation of Emergency Core Cooling System (ECCS) performance during analysis of postulated loss-of-coolant accidents (LOCAs) from uprated operating conditions. It includes documentation of generic bases, methods, and assumptions to be used with the guidelines. Plants that evaluate LOCAs in a manner that differs from these guidelines will provide separate explanations and justifications in the plant-unique licensing submittal.

D.2 GUIDELINES FOR ECCS-LOCA EVALUATIONS

The generic guidelines to be applied during evaluation of ECCS performance for LOCA events at uprated operating conditions are listed with the pertinent bases, methods, and assumptions.

D.2.1 Licensing Requirements For ECCS-LOCA Evaluation

ECCS-LOCA analysis is to be done for uprated power conditions to show compliance to 10CFR50.46 criteria. LOCA cases will be analyzed using methods and assumptions that have been accepted by the NRC with respect to the requirements of 10CFR50 Appendix K.

The results of the ECCS-LOCA evaluation (using either methodology defined in D.2.3 or an alternate methodology, approved by NRC for LOCA 10CFR50.46 analysis) may be documented as a separate report that is referenced by the plant-specific power uprate submittal. The plant-specific report will contain at least a summary of the most limiting ECCS-LOCA results to support the conclusion that operation at uprated power is acceptable from the viewpoint of ECCS-LOCA.

Justification

This evaluation guideline is completely consistent with current licensing requirements and practices.

D.2.2 Operating Conditions for ECCS-LOCA Analysis

ECCS-LOCA Appendix K analyses will be performed with average core power at least 102% of the uprated core thermal power level. The hot bundle(s) shall also be initialized with the peak linear heat generation rate (LHGR) at 102% of the LHGR limit applicable to the fuel type.

Basic analysis will be done at 100% core flow supported by generic evaluations to show that sensitivity to the initial core flow remains a small effect on peak cladding temperature (PCT) over the operating range.

The initial operating pressure, steam and feedwater flows, and feedwater temperature (factors which affect system inventory and energy) will be chosen to bound the normal operating heat balance at uprated conditions. Where applicable, the initial pressure will be the Technical Specification Limiting Condition for Operation

Justification

(1) The elements of this evaluation guideline are completely consistent with current licensing analysis practice. The required power level is in accordance with NRC Regulatory Guide 1.49.

(2) Sensitivity to changes in core flow across the full power operating core flow range continues to be very small (PCT changes of < 20°F), even at uprated conditions. The rated flow range is reduced relative to the pre-uprate MEOD flow range.

(3) Establishment of initial conditions by bounding the official heat balance conditions for uprated conditions matches current licensing analysis practice.

D.2.3 Computerized Methods for ECCS-LOCA Analyses

There are two sets of accepted GE methods for ECCS-LOCA analysis. From the viewpoint of generic methodology approval, either set of methods is considered to be acceptable.

(1) The methods expected to be used for most power uprate submittals are the newer set of codes: LAMB/SCAT/SAFER/GESTR/(CORECOOL). This set is usually identified simply as SAFER/GESTR.

(2) The other set of methods that could also be used is the former set of codes: LAMB/SCAT/SAFE/REFLOOD/CHASTE.

Usual practice is to reanalyze the LOCA-ECCS events with SAFER/GESTR (using uprated conditions) and to document the results in a separate licensing report for use ahead of or with power uprate. An alternate NRC approved methodology for LOCA 10CFR50.46 analysis may be used if the analysis if not provided by GE, or as future GE methods are approved. The alternate method must be NRC approved for power uprate application.

Justification for Computerized Methods

(1) The SAFER/GESTR methods have been documented by GE in Reference 2. Both of these reports have received NRC approval for application of the newer technology to LOCA evaluation. Some of the plants approaching power uprate have already shifted their LOCA licensing basis to this methodology.

(2) The SAFER/GESTR methodology (as accepted) requires compliance of the uprate analysis results to 10CFR50.46 Licensing Basis criteria for PCT and other pertinent limits using 10CFR50 Appendix K model assumptions and inputs. Compliance of a more nominal PCT calculation is also required to the upper bound PCT criteria that incorporates statistical uncertainty margins.

(3) The older set of methods (LAMB/SCAT/SAFE/REFLOOD/CHASTE) has also been documented by GE in Reference 15. The report and methodology has received NRC approval. This methodology (and its related predecessors) has been used as the basis for the original SAR and Cycle 1 license for most plants.

It is still the analysis of record for some of the plants that are approaching power uprate.

(4) Use of either methodology to show ECCS-LOCA compliance to the licensing requirements for power uprate is completely consistent with current licensing bases.

(5) Future GE methods which are approved for LOCA 10CFR50.46 analysis can form a good basis for power uprate transient analysis. Justification of future methods applicability to power uprate analysis will be provided at the time of their submittal for NRC review, for reference in plant unique power uprate applications.

D.2.4 Break Spectrum, Worst Single Failure, and Loss of Offsite Power

The ECCS-LOCA analysis for uprate conditions shall include consideration of the worst additional single-failure and potential loss of offsite power. <GE proprietary information removed>

Justification

This power uprate guideline is completely consistent with 10CFR50.46 and Appendix K. It completely follows current licensing practice. <GE proprietary information removed>

These generic guidelines will be used to consistently establish acceptance of ECCS-LOCA evaluations for BWR plants seeking approval for power uprate.

D.2.5 Plant Parameters for ECCS-LOCA Analysis

When SAFER/GESTR methodology is used for the LOCA-ECCS evaluation, different analytical values of selected plant system parameters may be chosen than used in the previous analysis. The values may be less stringent performance characteristics for equipment. Parameters used in the analysis will be documented in a manner consistent with the SAR.

Should more stringent Technical Specification requirements be needed for any equipment, they will be included with the uprate submittal. In general, however, Technical Specification changes associated with the revised analytical parameters for mitigating functions will not be submitted for NRC approval coincident with the power uprate submittal in order to minimize the uprate review effort.

Should plant equipment experience dictate the need for a specific requirement change, a Technical Specification change submittal will be made separately, if possible. Such a limited change request may, however, be made concurrent with power uprate if it has been discussed with the NRC staff and it has been concluded that joint review will be more efficient than separate review. It is recognized that additional justification information must be provided, and that the joint review may take longer than for a standard uprate submittal.

The setpoints for some functions will be different from previous analysis. The Technical Specifications will be revised at the time of power uprate for those setpoint changes needed to maintain trip avoidance margins that are similar to current plant operation. Setpoint methodologies acceptable to the NRC will be applied.

Justification

(1) The use of mitigation equipment parameters which are less stringent than the current (unchanged) Technical Specifications is conservative, since it produces more severe analytical results.

(2) The general guideline to avoid coincident submittal of any relaxed Technical Specifications will keep the power uprate review as simple as possible and minimize the time and resources required for approval.

(3) Any coincident change will only be made based on a specific plant experience need. It must be consistent with the supporting analysis. It will be clearly identified and additional information will be provided to independently evaluate the requirement change. This type of change, should it be needed, will be prearranged with the NRC staff when it is agreed that joint review will require less overall effort than separate review. A possible extension of the power uprate review schedule is recognized.

(4) Changes which are required by the power uprate will be submitted with the uprate package. Setpoint changes (utilizing approved methodologies) which maintain current trip avoidance margins are required to avoid increases in the number of outages and system challenges. Other sections of this report discuss most of these changes. They are considered to be an integral part of the standard power uprate scope. The safety analysis must show the acceptability of the revised setpoints.

APPENDIX E: SPECIFIC ASSUMPTIONS AND BASES FOR TRANSIENT EVALUATIONS

E.1 SCOPE

This appendix defines the guidelines that will be used generically for evaluation of transient events for uprated plants. It includes documentation of the bases and assumptions for each guideline. Also included are the transient analysis guidelines associated with the uprated power/flow map operating range selected as described in Appendix C to this document. Plants that make selections that differ from these bases will provide separate explanations and justifications in the plant unique licensing submittal.

E.2 GUIDELINES FOR TRANSIENT EVALUATIONS

The generic guidelines to be applied during analysis and evaluation of abnormal operational transients at uprated operating conditions are provided with pertinent generic bases, methods, and assumptions that apply to each one.

In some cases, the transient analysis may not be done by GE. For those plants, equivalent approved methodology will be used and documented in the plant-specific submittal. An alternate NRC approved methodology for transient analysis may be used as future GE methods are approved. The alternate method must be NRC approved for power uprate application.

E.2.1 GE Analytical Methods to be Used for Transient Evaluations

There are two sets of GE methods that are approved for the evaluation of GESTAR abnormal transients. The methods are identified as GENESIS and GEMINI in (Reference 3).

(1) GEMINI: The GE method to be used for most power uprate submittals is the newer transient evaluation approach identified as GEMINI in GESTAR. <GE proprietary information removed>

(2) GENESIS: <GE proprietary information removed> Analysis will be done at ≥102% uprated power using the Technical Specification scram time. The statistical adjustments are made to the results to include uncertainty allowances and the benefit of scram times if shown to be faster than the Technical Specifications.

(3) Future methods approved by the NRC for reload transient analysis will be applied to power uprate analysis.

Justification of GE Transient Methods

(1) Both proposed methodologies (GEMINI and GENESIS) are approved by the NRC for use in transient licensing analyses (approval of GESTAR and the related methodology references). Their use is consistent with current licensing practice.

(2) In most cases, the shift to the GEMINI methods (if it has not yet occurred) will be done at the time of a particular reload. Changing at the time of the uprate

submittal is also acceptable, since full approval for the method has been received.

(3) Future GE methods which are approved for fuel cycle reload transient analysis can form a good basis for power uprate transient analysis. Justification of future methods applicability to power uprate analysis will be provided at the time of their submittal for NRC review, for reference in plant unique power uprate applications.

E.2.2 Transients to be Analyzed

Analysis will be performed for the limiting transient events. This includes all events that establish the core thermal operating limits and the events that show bounding conformance to the other transient protection criteria (e.g., ASME overpressure limits). Table E-1 shows the minimum list of events to be included in the power uprate evaluation. The expanded (over GESTAR) list of transients provided in Table E-1 is intended to confirm that the existing set of reload analysis transients remains valid, and evaluate operational aspects of the power uprate.

Justification

<GE proprietary information removed>

E.2.3 GE Computer Models for Analysis of Each Event

The specific GE computer models to be used for each event (or previously approved optional models) are shown in Table E-1. For plants in which others supply the analysis, equivalent approved methods will be described in the plant-specific uprate submittal.

Justification

<GE proprietary information removed>

E.2.4 Power Level for Transient Analyses

The specific power levels for each of the limiting events are also shown in Table E-1. <GE proprietary information removed>

Justification

The power levels shown are completely consistent with current licensing requirements and <GE proprietary information removed>

The analysis defined for this set of limiting events will provide adequate assurance that all aspects of transient safety will be satisfied for uprated power operation. Selection of the set of events is also discussed in Section 5.3.2. Specific cycle confirmation will continue through the standard reload process, including a re-analysis ahead of the first cycle to experience uprated operation.

E.2.5 Safety Limit MCPR

The basis for the current SLMCPR will be examined, and, if necessary, a new SLMCPR will be provided for application to power uprate operation.

Justification

Changes core power distribution or the measurement accuracies in plant parameters may require reevaluation of the MCPR safety limit.

E.2.6 Plant Modifications

The transient analysis will consider plant modifications in order to simulate the post-uprate configuration. For example changes in the potential feedwater system run-out and feedwater heating loss will be included in the transient evaluation. If a phased implementation of power uprate is planned, the most limiting phase will be considered, or specific phases will be analyzed.

Justification

The transient analyses should reflect a current or bounding plant configuration.

Table E-1

TRANSIENT EVENTS ANALYZED FOR POWER UPRATE

<GE proprietary information removed>

APPENDIX F: SPECIFIC ASSUMPTIONS AND BASES FOR CONTROL, INSTRUMENTATION, AND SETPOINT EVALUATIONS

F.1 SCOPE

This appendix defines the generic guidelines for power uprate effects on controls, instrumentation, and setpoints. Many aspects of this area are operational and thus are not covered in depth here. Other aspects are discussed because they are coupled to the selection of uprated operating conditions in Appendix C. Other areas are clearly related to safety functions, especially the bases for setpoints. This appendix includes documentation of the bases and assumptions for each guideline. Plants that use different guidelines, bases, or assumptions must provide separate explanations and justifications in the plant unique licensing submittal.

F.2 GUIDELINES FOR CONTROLS

The generic guidelines applicable to plant control systems during evaluation of operation at uprated conditions are listed with the pertinent bases, methods, and assumptions that apply to each one. It is recognized that most of the control systems are operational functions, rather than safety-related, but some of those key items are also included here for consistency among the plants in areas that generate common questions.

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F.3 GUIDELINES FOR INSTRUMENTATION

The generic guidelines applicable to plant instrumentation during evaluation of operation at uprated conditions are listed with the pertinent bases, methods, and assumptions that apply. This section focuses on instrumentation that is related to the safe operation and shutdown of the plant, not the operational functions. Any plant unique deviations from these guidelines will be explained and justified in the plant-specific submittal.

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F.4 GUIDELINES FOR INSTRUMENT SETPOINTS

The generic guidelines applicable to instrument setpoints for operation at uprated conditions are listed with the pertinent bases, methods, and assumptions that apply. This section focuses on instruments that are related to the safe operation and shutdown of the plant, not the operational functions. Any plant unique deviations from these guidelines will be explained and justified in the plant-specific submittal.

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APPENDIX G: METHODS AND ASSUMPTIONS FOR CONTAINMENT EVALUATION

This appendix outlines the methods, approach and scope of plant-specific containment analyses which are planned to be done in support of Power Uprate. The results of these analyses will be reported in Sections 4.1.1 and 4.1.2 of the plant-specific Licensing Reports (Appendix A). In this appendix, key assumptions and methods to be used for the analyses are identified. In general, the scope of these evaluations is to examine the effect of power uprate on containment pressure and temperature response and dynamic loads due to LOCA and SRV actuation.

Containment Systems are described in the plant Safety Analysis Report (SAR) (RG1.70 SAR Section 6.2). The accident response analysis is also discussed in the plant SAR (RG1.70 SAR Subsection 6.2.1) wherein plant response to various large and small LOCAs is evaluated and the short and long-term containment pressure and temperature responses are presented.

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APPENDIX H: METHODS AND ASSUMPTIONS FOR RADIOLOGICAL EVALUATIONS

H.1 SCOPE

This appendix describes the methodology and assumptions for the evaluation of radiological effect for power uprate up to 120% thermal power. <GE proprietary information removed>

APPENDIX I: METHODS AND ASSUMPTIONS FOR VESSEL AND COMPONENTS EVALUATIONS

I.1 SCOPE

This appendix describes the methods and assumptions to be used for the vessel and components evaluations. <GE proprietary information removed>

APPENDIX J: METHODS AND ASSUMPTIONS FOR SYSTEM EQUIPMENT EVALUATION

J.1 SCOPE

This appendix defines the generic methods and assumptions to be used for system equipment evaluation. <GE proprietary information removed>

APPENDIX K: METHODS AND ASSUMPTIONS FOR PIPING EVALUATION

K.1 EVALUATION SCOPE

The piping power uprate evaluations for BWR/4, 5 and 6 product lines will be performed using the evaluation approach described below. For other BWR product lines, an analogous approach will be applied, which considers the current design and licensing bases of the specific plant being evaluated. These evaluations will address all plant piping that is impacted by power uprate.

K.2 EVALUATION METHOD

The evaluation method described below has been reviewed and accepted by the NRC for power uprate, initially by a presentation to the NRC and subsequently through the application of the method described to plants applying for uprated power approvals through the licensing staff (Reference 21, Supplement 2, Section 4.8).

<GE proprietary information removed>

APPENDIX L: SPECIFIC ASSUMPTIONS AND BASES FOR EVALUATIONS OF OTHER ASPECTS OF POWER UPRATE

L.1 SCOPE

This appendix defines the guidelines that will be used generically for aspects of power uprate not included in other appendices to this report, including documentation of the bases and assumptions for each guideline. Plants that make selections that differ from these bases must provide separate explanations and justifications in the plant-unique licensing submittal.

L.2 GUIDELINES FOR UPRATE TESTING

The generic guidelines to be applied during the approach to and demonstration of uprated operating conditions are listed with the pertinent bases, methods, and assumptions that apply. Each power uprate submittal will include a test plan that includes the following items:

<GE proprietary information removed>

L.3 GUIDELINES FOR EVALUATION OF ATWS

The generic guidelines to be applied for evaluation of a unit for potential Anticipated Transients Without Scram (ATWS) are listed with the pertinent bases, methods, and assumptions that apply. This evaluation is for confirmation of continued compliance to 10CFR 50.62 (Reference 23). <GE proprietary information removed>

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