IES UTILITIES INC.

John F. Franz, Jr.
Vice President, Nuclear

September 9, 1994
NG-94-3152

Mr. William T. Russell, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Attn.: Document Control Desk
Mail Station P1-137
Washington, DC 20555

Subject: Duane Arnold Energy Center (DAEC)
Docket No: 50-331
Op. License No: DPR-49
IES Utilities' Response to NRC Generic Letter 94-02, Long-Term Solutions and Upgrade of Interim Operating Recommendations for Thermal-Hydraulic Instabilities in Boiling Water Reactors.

References: 1) Amendment #119 to Op. License No DPR-49, dated May 28, 1985.
2) Mineck (IE) to Murley (NRC), "Response to NRC Bulletin 88-07, Supp. 1, 'Power Oscillations in Boiling Water Reactors'," NG-89-0555, March 6, 1989.
3) NEDO-31960, "BWR Owners' Group Long-Term Stability Solutions Licensing Methodology," June 1991.
4) Rothert (IE) to Murley (NRC), "Response to NRC Bulletin 88-07, 'Power Oscillations in Boiling Water Reactors'," NG-88-3187, September 19, 1988.

File: A-101b, C-51

Dear Mr. Russell:

Attached to this letter you will find our response to the specific requests for information contained in the subject Generic Letter. The DAEC has long had a conservative operating philosophy for addressing the concern over the potential for thermal-hydraulic instability events in certain operating regimes. We were one of the first Boiling Water Reactors (BWRs) to adopt the "detect and suppress" Technical Specifications (Reference 1) recommended by General Electric (GE) in Service Information Letter (SIL) # 380, Rev. 1 and our actions in response to NRC Bulletin 88-07, Supp. 1, as described in Reference 2, went beyond those recommended in that Bulletin. In addition, we have been active participants in the BWR Owners' Group (BWROG) committee for formulating long-term solutions to the thermal-hydraulic instability concerns. Both our proposed

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formulating long-term solutions to the thermal-hydraulic instability concerns. Both our proposed interim and long-term actions for addressing thermal-hydraulic instability, described in this submittal, continue to reflect that conservative operating philosophy.

Based upon unique features of the DAEC, which has a small reactor core with tight inlet flow orifices, we have chosen Option I-D, as described in Reference 3, as our long-term solution for addressing thermal-hydraulic instability concerns. Upon implementation of Option I-D, including the appropriate power shape controls, the DAEC will comply with NRC General Design Criteria 10 and 12 without continued reliance upon the existing BWROG Interim Corrective Actions (ICAs).

However, in keeping with our conservative operating philosophy, we feel that it is prudent to enhance the overall robustness of Option I-D by including a Stability Predictor as part of our long-term solution. This Predictor will provide additional defense-in-depth to the prevention of thermal-hydraulic instabilities afforded by the Exclusion Region, by serving as the power shape controls which are important to maintaining plant operation within the assumptions of the Reference 3 analysis. When coupled with the automatic instability detection and suppression capability of the flow-biased Average Power Range Monitor (APRM) SCRAM, the Predictor will also add defense-in-depth by serving as an operator aid in recognizing and taking manual action to suppress any sign of instability before challenging the automatic SCRAM.

The following new commitments are being made in this letter:

1) Complete Operator Training on Generic Letter 94-02 by October 28, 1994.

2) Submit plant-specific Licensing Topical Report (LTR) in support of Option I-D as the long-term solution option for the DAEC by December 31, 1995.

3) Submit the Technical Specification changes necessary to implement Option I-D by December 31, 1995.

4) Submit the technical description of the Stability Predictor, including any related administrative controls, by December 31, 1995.

5) The Stability Predictor will be installed and operational within 90 days following Startup from Refuel Outage - Cycle 15 (RFO14), currently scheduled for Fall 1996.

The above commitments supersede those previously made in response to Bulletin 88-07 (Reference 4) and Bulletin 88-07, Supp. 1 (Reference 2).

This letter is true and accurate to the best of my knowledge and belief.

IES UTILITIES INC.

By John F. Franz
John F. Franz
Vice President, Nuclear

State of Iowa
(County) of Linn

Signed and sworn to before me on this 8th day of September, 1994,

by John F. Franz.

MARY MICHELE O'NEAL
MY COMMISSION EXPIRES
6-8-95

Mary Michele O'Neal
Notary Public in and for the State of Iowa

June 8, 1995
Commission Expires

JFF/RAB/rab~

Attachments: 1) IES Utilities Response to the Requested Actions in Generic Letter 94-02
2) Figure 1, DAEC Power/Flow Map Depicting Typical Startup Path
3) Figure 2, DAEC Power/Flow Map Depicting Option I-D Exclusion Region

cc: R. Browning
L. Liu
L. Root
R. Pulsifer (NRC-NRR)
J. Martin (Region III)
NRC Resident Office
DOCU

IES Utilities Response to the Requested Actions in Generic Letter 94-02

NRC Request #1:

1. All licensees of BWRs, except Big Rock Point ..., are requested to review their current procedures and training programs and modify them as appropriate to strengthen the administrative provisions intended to avoid power oscillations or to detect and suppress them if they occur prior to implementation of the long-term solutions. The experience gained at WNP-2 should be a primary guide in this review. ...

IES Response:

Prior to the stability event at WNP-2, procedures and operator training had been established at the DAEC in response to the LaSalle stability event (Ref. NRC Bulletin (BN) 88-07 and Supplement 1). Operating instructions were established for avoiding the region of the power/flow operating map which was known to be the most susceptible to unstable conditions, *i.e.*, the high reactor power and low core flow region of the power/flow operating map. Guidance for detection and suppression of thermal-hydraulic instability, which was more conservative than the existing Technical Specification (TS) requirements based upon General Electric's earlier recommendations (Ref. Service Information Letter (SIL) #380, Rev. 1), was incorporated into operating procedures. Operator training was enhanced by the inclusion of a thermal-hydraulic instability model on the DAEC plant simulator and training scenarios which simulate the plant becoming unstable were developed and are used during on-going requalification training, thereby maintaining operator awareness of thermal-hydraulic instability concerns.

Subsequently, changes were made in our operating practices to incorporate the lessons-learned from the WNP-2 event, as described in various regulatory and industry documents (*e.g.*, NRC IN 92-74, GE RICSIL-006, Supp. 3 and INPO SER 19-92). Specifically, the operating procedures used to control plant startup were modified to provide a power ascension sequence which avoids, to the maximum extent practicable, the BN 88-07, Supp. 1 "exclusion region," which we refer to as the "Forbidden Zone" (see Figure 1, attached). This operating strategy steers a wide berth around the Forbidden Zone (as typified by Points A thru D on Fig. 1) during startups and shutdowns and thus creates a de-facto "buffer" around the Forbidden Zone. The use of this buffer is intended to account for any deviations in plant operating parameters from the values which were assumed in the analysis which defined the Forbidden Zone boundary. We understand that reliance upon analytically-defined zones, without accounting for variations in actual operating parameters, was the primary root cause of the WNP-2 event.

In addition, reactor engineering instructions for developing and monitoring rod withdrawal sequences have been modified to address concerns about axial and radial power shapes during startup, especially during low Xenon conditions. These instructions are used in pre-planning all major power maneuvers, such as startups, shutdowns and control rod sequence exchanges. The Reactor Engineers thoroughly review these plans with the Operators as part of the pre-job briefing before the power maneuver is executed.

Also, the administrative procedure for evaluating new fuel designs includes specific instructions to evaluate the thermal-hydraulic stability of the new fuel and addresses the "mixed core" issue identified as a contributory cause at WNP-2.

Our current Reactor Engineering staff has been thoroughly briefed on these issues and training for new Reactor Engineers includes review of both the LaSalle and WNP-2 events.

Based upon the above information, the DAEC has procedures and training currently in place for avoiding thermal-hydraulic instabilities and for detecting and suppressing them in the unlikely event that they do occur.

<u>NRC Request #1a:</u>

[In reviewing its current procedures and training programs] each licensee ... should:

a. [i] Ensure that procedural requirements exist for initiation of a manual scram under all operating conditions when all recirculation pumps trip (or there are no pumps operating) with the reactor in the RUN mode, and [ii] ensure that operators are aware of the potential for very large power oscillations and the potential for exceeding core thermal safety limits before automatic protection systems function following the trip of all recirculation pumps (the procedural manual scram is not necessary after long-term solutions are approved and implemented for individual plants);

<u>IES Response:</u>

a. [i] The DAEC TSs prohibit Power Operation above 1% Rated Thermal Power in Natural Circulation (ref. TS 3.3.F). TS 3.3.F is not explicit on this point but has historically been interpreted to require an immediate reactor SCRAM. This TS provision has been in place since 1977 and was adopted because of concerns over thermal-hydraulic instabilities. This interpretation of the TS, given its longevity, has been thoroughly integrated into plant procedures and operator training and more importantly, into our operating culture. However, we will state this requirement for the reactor SCRAM more explicitly in the long-term TS changes described in Item 2 [iii] below.

a. [ii] As discussed above, initial and requalification training for operators addresses both the LaSalle and WNP-2 events and includes pertinent scenarios on the plant simulator. However, to provide the operators with the latest information on this subject, we plan to include discussion of this Generic Letter in the next cycle of operator requalification training. This training will be completed by October 28, 1994.

<u>NRC Request #1b:</u>

[In reviewing its current procedures and training programs] each licensee ... should:

b. [i] Ensure that factors important to core stability characteristics (e.g., radial and axial peaking, Feedwater temperature, and thermal hydraulic compatibility of mixed fuel types) are controlled within appropriate limits consistent with the core design, power/flow exclusion boundaries, and core monitoring capabilities of the reactor in question, and that these factors are controlled through procedures governing changes in reactor power, including startup and shutdown, particularly at low-flow operating conditions. [ii] Each

licensee should review its procedures and determine if instability can be avoided by these procedures and [iii] if the procedures can be carried out using existing instrument information. [iv] If it is concluded that a near-term upgrade of core monitoring capability is called for to ease the burden on operators, determine the need to incorporate on-line stability monitoring or monitors for stability sensitive parameters and inform the NRC of the schedule and technical evaluation for such upgrades found to be necessary. (These procedural operation controls will no longer be necessary for licensees which implement fully automatic long-term solutions, such as Options III or IIIa of Reference 2. [v] Licensees should propose for plant-specific review the administrative controls to be retained in conjunction with other long-term solutions.)

IES Response:

b. [i] As stated earlier, our operating practice has been modified to maintain as much "buffer" around the Forbidden Zone (see Fig. 1) as practicable. The intent behind this operating strategy is to utilize this buffer to account for any deviations in plant operating parameters from the values which were assumed in the analysis which defined the Forbidden Zone boundary. This operating strategy is controlled by procedures used during both plant startup and shutdown evolutions.

In addition, reactor engineering instructions for developing and monitoring rod withdrawal sequences have been modified to address concerns about axial and radial power shapes during startup, especially during low Xenon conditions. Also, the administrative procedure for evaluating new fuel designs includes specific instructions to evaluate the thermal-hydraulic stability of the new designs and addresses the "mixed core" issue identified as a contributory cause at WNP-2.

b. [ii] We have reviewed our current operating practices for consistency with the latest BWR Owners' Group (BWROG) Interim Corrective Actions (ICAs)[1] and concluded that our practices are consistent. As permitted by the ICAs, we have taken some specific deviations based upon plant-specific evaluations.

First, we have combined the three ICA regions on the power/flow map into a single "Forbidden Zone" (See Figure 2, attached). This is consistent with our implementation of the required actions for BN 88-07, Supplement 1[2]. Intentional operation in this Forbidden Zone is not permitted, except to protect plant equipment or fuel clad integrity, and any entry requires immediate exit by either increasing core flow or inserting control rods. Combining the three BWROG regions was done for simplicity both in writing plant procedures and conducting operator training. This is considered to be conservative when coupled with the DAEC TS prohibition on Power Operation in natural circulation conditions (see response to item 1a. [i] above).

The second exception taken to the BWROG ICAs is the definition of the lower boundary of the "Controlled Entry Region" in the ICAs, which corresponds to the lower boundary of the

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[1] BWROG-94078, "BWR Owners' Group Guidelines for Stability Interim Corrective Actions," June 6,1994.

[2] D. Mineck (IE) to Dr. T. Murley (NRC), NG-89-0555, "Response to NRC Bulletin 88-07, Supplement 1," March 6, 1989.

DAEC Forbidden Zone. The ICAs use the 70% loadline for this lower boundary, whereas the DAEC lower boundary is the 75% loadline. Use of a higher loadline is justified based upon a plant-specific analysis done for the DAEC using the NRC-approved BWROG methods[3]. The results of that analysis, which were reported in Appendix A to NEDO-31960, are reproduced in Figure 2 of this letter. (Note: that analysis used data for DAEC Cycle 10 core loading. We have confirmed that those results are applicable to the current operating cycle - Cycle 13.) A major conclusion of that analysis is that the calculated "Exclusion Region," *i.e.*, the region of the power/flow map where instabilities are most-likely to occur (represented by a calculated Decay Ratio of ≥ 0.8), for the DAEC is significantly smaller than the "generic" Exclusion Region used to derive the ICA regions. Consequently, when the DAEC-specific Exclusion Region is overlaid onto the current Forbidden Zone of the power/flow map (see Figure 2), it is evident that there is significant margin to that calculated Exclusion Region. In fact, the margin to the DAEC-specific Exclusion Region represented by the 75% loadline is equivalent to a margin in Decay Ratio of at least 0.2 (Decay Ratio ≈ 0.6). This additional margin in Decay Ratio will compensate for any potential deviations in core power shape, Xenon concentration, Feedwater temperature, etc., from those values used in the analysis. Thus, sufficient margin to the predicted instability region exists using the 75% loadline as the lower boundary of our Forbidden Zone.

Lastly, we define the onset of core thermal-hydraulic instability as an oscillatory Average Power Range Monitor (APRM) signal with an amplitude of 10% peak-to-peak, with an increasing trend. The ICA definition is: "A sustained increase in APRM and/or LPRM peak-to-peak signal noise level, reaching two or more times its initial level at reduced core flow conditions (for plants with very low inherent noise, a threshold noise level of approximately 5% is appropriate.)" The inherent process noise at the DAEC is not low. Typical APRM noise levels of 4 - 8% peak-to-peak are common during normal operation. Consequently, our use of the 10% noise criterion is consistent with the intent of the ICAs to use two or more times the normal signal level. Because DAEC operators are directed by procedures to insert a manual SCRAM whenever they observe *any* APRM signal which meets the above criteria for instability; in order to avoid unnecessary manual SCRAMS, we use the "and increasing trend" criterion to accommodate spurious spikes in the APRM signal of greater than 10% in peak amplitude. This is consistent with the "sustained increase" language in the ICA definition.

Based upon the above information, we have concluded that our existing procedures are effective both for preventing thermal-hydraulic instabilities and for detecting and suppressing them in the unlikely event that they do occur.

1b. [iii]&[iv] We have reviewed our existing core monitoring capabilities and concluded that they are adequate for implementing the above procedures. Therefore, no near-term upgrades are being proposed.

1b. [v] As described in our response to Request #2 below, we plan to install a Stability Predictor as part of our long-term solution. Because we do not yet know the technical details for the Predictor, we have not identified any specific administrative controls which will be needed to support the long-term solution. If, once we have the technical details for the Predictor, we

[3] NEDO-31960, Supplement 1, "BWR Owners' Group Long-Term Stability Solutions Licensing Methodology," March, 1992

identify a need for such administrative controls, we will submit them for plant-specific review as part of the technical description of the Predictor.

NRC Request #2:

2. [i] All licensees of BWRs, except Big Rock Point, are requested to develop and submit to the NRC a plan for long-term stability corrective actions, including design specifications for any hardware modifications or additions to facilitate manual or automatic protective response needed to ensure that the plant is in compliance with General Design Criteria [GDC] 10 and 12. An acceptable plan could provide for implementing one of the long-term stability solution options proposed by the BWROG and approved by the NRC in Reference 3 or in subsequent documentation. [ii] The plan should include a description of the action proposed and a schedule of any submittal requiring plant-specific design review and approval by the NRC and an installation schedule (if applicable). [iii] The plan should also address the need for near-term and long-term technical specification modifications. Generic BWROG documents or planned submittal may be referenced in the plan.

IES Response:

2. [i] The proposed long-term solution for the DAEC is Option I-D as described in the BWROG Licensing Topical Report (LTR) NEDO-31960, which has been approved by the NRC[4]. In summary, Option I-D uses both administratively-controlled prevention and automatic detection and suppression to assure compliance with GDC 10 and 12. It is applicable to plants like the DAEC which have small reactor cores with tight fuel inlet flow orifices. With this design, the predicted dominant mode of instability is core-wide oscillations, not regional-mode oscillations. Option I-D takes advantage of the existing flow-biased APRM neutron flux SCRAM system to ensure automatic detection and suppression of core oscillations (compliance with GDC 12) before the fuel Minimum Critical Power Ratio Safety Limit is challenged (compliance with GDC 10). During planned operations, potential instabilities are avoided by administratively avoiding the region of the power/flow map where instabilities are predicted to occur, *i.e.*, the Exclusion Region in Figure 2.

   Based upon the lessons learned from the WNP-2 event relative to use of analytically-derived instability regions, we recognize that "power shape controls," which ensure that the plant is operated consistently with the assumptions in the analysis that define the exclusion region, are an essential part of the implementation of the Option I-D solution. Consequently, as part of our long-term solution, we propose to use an on-line "Stability Predictor" as our primary means of power shape control. This Stability Predictor will allow us to determine our operating margin from unstable conditions, both core-wide and regional, based upon actual core conditions. By monitoring this margin during plant maneuvers such as startup and shutdown, we can take compensatory measures to restore any loss of margin prior to onset of instability.

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[4] A. Thadani (NRC) to L. England (BWROG), "Acceptance for Referencing of Topical Reports NEDO-31960 and NEDO-31960, Supplement 1, 'BWR Owners' Group Long-Term Stability Solutions Licensing Methodology'," dated July, 1993.

2. [ii] Because we have only recently concluded that the Stability Predictor is our preferred method of power shape controls, we plan to implement this portion of our long-term solution on a schedule which is consistent with our normal design cycle for plant modifications. In order to allow sufficient time to prepare the design specifications, solicit potential vendors and procure the Predictor, we plan to submit to the NRC the technical details for the Predictor no later than December 31, 1995. This design schedule will allow us to have the Predictor installed and operational no later than 90 days following startup from the Cycle 15 refuel outage (i.e., RFO14), currently planned for Fall 1996. Because we do not yet know the installation details for the Predictor, this schedule will permit an installation plan which may require a refuel outage, with adequate time for testing upon resumption of power operation following that outage.

Again, after careful evaluation, we have chosen the use of an on-line Stability Predictor as the most practical power shape control for the DAEC. This approach was chosen over other power shape controls proposed by the BWROG, such as boiling boundary. Consequently, submittal of the DAEC-specific LTR using the BWROG methodology, which supports the application of Option I-D to our plant, will be made on a schedule which supports installation of the Predictor. Therefore, we plan to submit the DAEC LTR by December 31, 1995. This schedule allows us to submit the LTR at the earliest practical date while incorporating the actual core design conditions for Cycle 15, the operating cycle during which we plan to implement the long-term solution.

2. [iii] In order to fully implement the administratively-controlled Exclusion Region of Option I-D, revisions to the existing DAEC Technical Specifications (TS) will be required. Specifically, the existing "detect & suppress" TSs in Section 3.3.F must be replaced with the necessary controls for the Exclusion Region. It should be noted that the power/flow map showing the actual Exclusion Region will be included in the Core Operating Limits Report (COLR), because the Exclusion Region has the potential to be cycle-specific. Consequently, TS Section 6.11.2 regarding the COLR will be revised to include the power/flow map with the specified stability Exclusion Region.

In addition, we propose to clarify the existing TS requirement to state more specifically that a manual SCRAM is required when the Reactor is in RUN mode with no recirculation pumps running.

Because we cannot implement the long-term solution without these proposed TS changes, the schedule for these TS changes needs to be coordinated with the planned issuance of the NRC Staff's SER on our LTR and Predictor installation. Consequently, we plan to submit the TS change request on a schedule consistent with submittal of our LTR, so that the Staff can conduct parallel reviews. Therefore, our TS change request will be submitted by December 31, 1995. This schedule allows the Staff's normal review period required for TS change requests to support refuel outages.

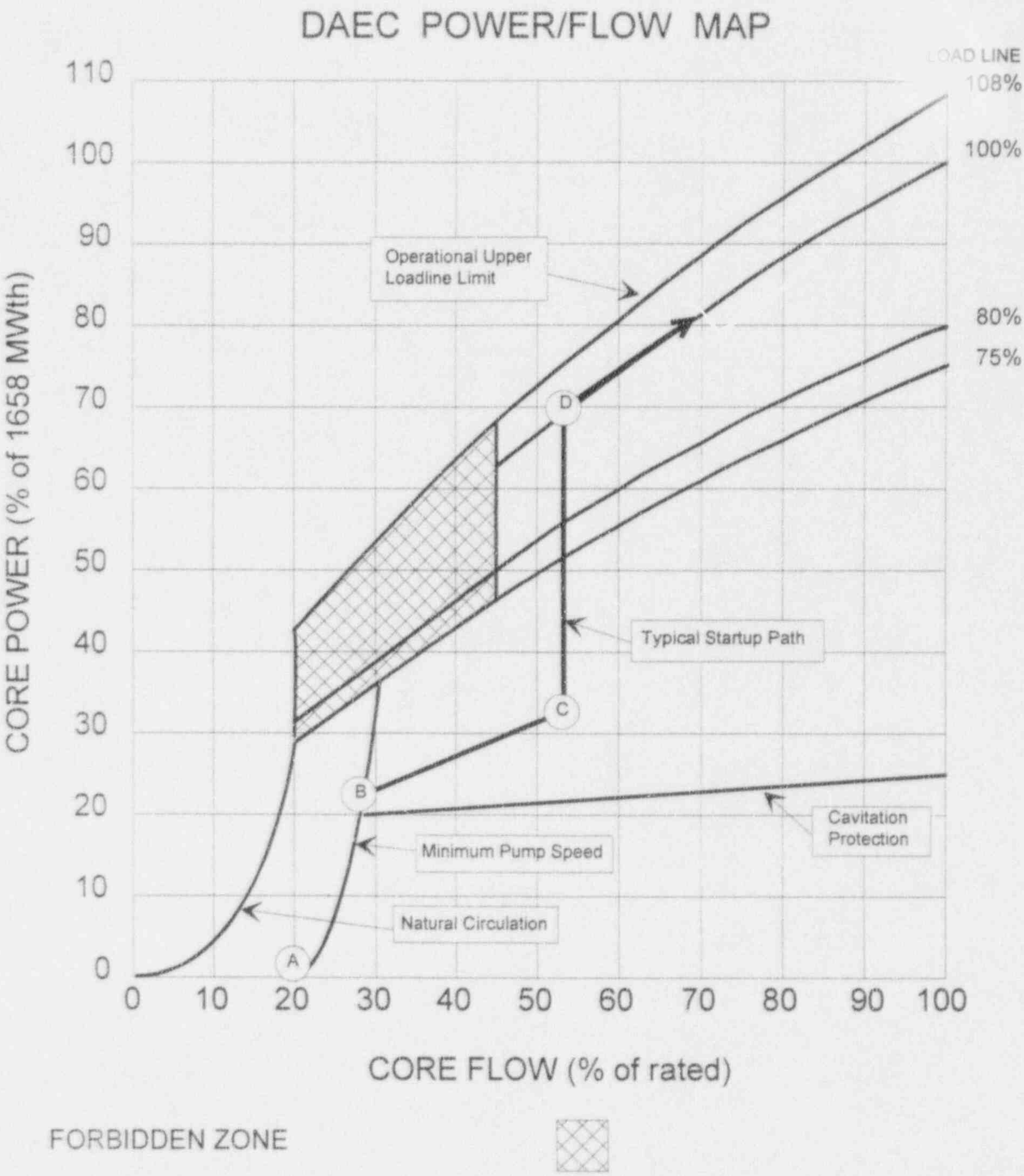

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Figure 1

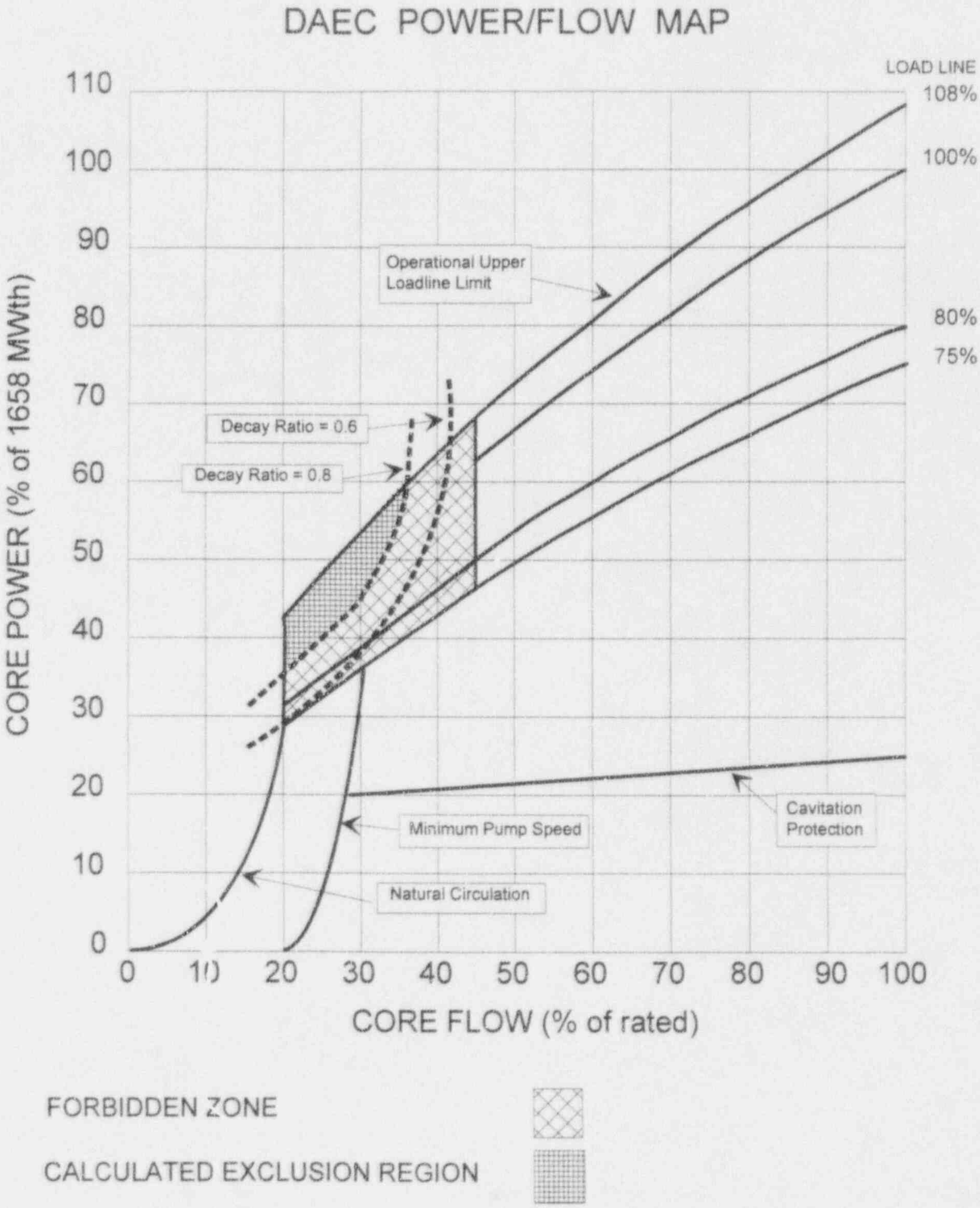

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Figure 2