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Calvert Cliffs
Nuclear Power Plant

A Member of the
Constellation Energy Group

September 14, 2000

U. S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Document Control Desk

SUBJECT: Calvert Cliffs Nuclear Power Plant
Unit Nos. 1 & 2; Docket Nos. 50-317 & 50-318
License Amendment Request: Revision to Technical Specification P-T Curves

REFERENCES:

(a) Letter from Mr. D. G. McDonald (NRC) to Mr. R. E. Denton (BGE), dated March 15, 1994, Issuance of Amendment for Calvert Cliffs Nuclear Power Plant, Unit No. 1 (TAC No. M87690)

(b) Letter from Mr. D. G. McDonald (NRC) to Mr. R. E. Denton (BGE), dated November 1, 1994, Issuance of Amendment for Calvert Cliffs Nuclear Power Plant, Unit No. 2 (TAC No. M89588)

(c) Letter from Mr. A. W. Dromerick (NRC) to C. H. Cruse (BGE), dated March 20, 2000, Calvert Cliffs Nuclear Power Plant, Unit No. 1 – Amendment Re: Pressure-Temperature Limits Evaluation (TAC No. MA7220)

(d) Letter from Mr. C. H. Cruse (CCNPP) to NRC Document Control Desk, dated September 14, 2000, Exemption Request from the Requirements of 10 CFR 50, Appendix G

Pursuant to 10 CFR 50.90, Calvert Cliffs Nuclear Power Plant, Inc. (CCNPP) hereby requests an amendment to Renewed Operating License Nos. DPR-53 and DPR-69 to incorporate the changes described below into the Technical Specifications for Calvert Cliffs Units 1 and 2.

DESCRIPTION

The proposed amendment revises the Unit 1 and Unit 2 heatup curves (Technical Specification Figures 3.4.3-1) and Unit 1 and Unit 2 cooldown curves (Technical Specification Figures 3.4.3-2) to increase the allowable heatup and cooldown rates. Use of stress intensity factor K_{IC}, permitted by American Society of Mechanical Engineers (ASME) Code Case N-640, made it possible to increase the heatup and cooldown rates without changing the existing pressure-temperature (P-T) limits. The existing P-T limits were approved by References (a), (b), and (c). Application of Code Case N-640 to generate

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P-T curves is not currently permitted by the regulations. Therefore, pursuant to 10 CFR 50.12, a separate request for an exemption to use Code Case N-640 is made by Reference (d).

BACKGROUND

Appendix G to 10 CFR Part 50 requires the establishment of pressure/temperature (P-T) limits for material fracture toughness requirements of the reactor coolant pressure boundary (RCPB) materials. It requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the methods of analysis and the required margins of safety of the applicable section of the ASME Code.

Accordingly, the Calvert Cliffs P-T limits for material fracture toughness requirements of RCPB materials were developed using the methods of linear elastic fracture mechanics and the guidance found in ASME Boiler and Pressure Vessel Code, Section III, Appendix G. The Calvert Cliffs P-T limits are based on fluence level. The fluence levels are determined in the same manner as the pressurized thermal shock (PTS) screening criteria defined in 10 CFR 50.61 for the critical elements. Methods described in the Nuclear Regulatory Commission Regulatory Guide 1.99, Revision 2, are used to predict the embrittlement effect of neutron irradiation on reactor vessel materials. Regulatory Guide 1.99 defines embrittlement effect in terms of adjusted reference temperatures, which depends on the material property of the PTS critical element.

Calvert Cliffs Technical Specification Figures 3.4.3-1 and 3.4.3-2 contain P-T limit curves for heatup, cooldown, and inservice leak and hydrostatic testing, and data for the maximum rate of change of reactor coolant temperature. Each P-T limit curve defines an acceptable region for normal operation. The low temperature overpressure protection (LTOP) system controls reactor coolant system (RCS) pressure at low temperatures so the integrity of the RCPB is not compromised by violating the P-T limits. Technical Specification 3.4.3 provides allowable operational P-T combinations during cooldown, shutdown, and heatup to keep from violating the 10 CFR Part 50, Appendix G, requirements.

The reactor vessel material is less tough at low temperatures than at normal operating temperatures. As the vessel neutron exposure accumulates, the material toughness decreases at any particular temperature and the material becomes less resistant to fracture due to pressure stress. Reactor coolant system pressure, therefore, is maintained low at low temperatures, and is increased only as temperature is increased, so that the crack driving force due to pressure is below the limit of material resistance to crack initiation (K_{IC}) or propagation (K_{IA}).

The potential for vessel overpressurization is most acute when the RCS is water solid during shutdown, since a pressure fluctuation can occur more quickly than an operator can react to relieve the condition. Exceeding the RCS P-T limits by a significant amount could cause brittle cracking of the reactor vessel. Technical Specification 3.4.3 requires administrative control of RCS P-T during heatup and cooldown to prevent exceeding the P-T limits. Technical Specification 3.4.12 provides RCS overpressure protection by limiting coolant input capability and ensuring adequate pressure relief capacity. One power-operated relief valve has adequate relieving capability to prevent overpressurization for the maximum coolant input capability. The fracture mechanics analyses show that the vessel is protected when the power-operated relief valves are set to open at or below the curves in Technical Specification Figure 3.4.12-1.

REQUESTED CHANGES

Revise Technical Specification Figures 3.4.3-1 (Unit 1), 3.4.3-1 (Unit 2), 3.4.3-2 (Unit 1), and 3.4.3-2 (Unit 2) as shown in the marked-up Technical Specification pages in Attachment (1).

SAFETY ANALYSIS

The resistance to brittle fracture is determined by analyzing the stress (and stress intensity factors) applied to the vessel, and comparing them to the maximum stress intensity factors that can be applied to the material without inducing fracture. The maximum stress intensity factor that the vessel material can withstand without failing is known as the material reference toughness, and is a function of temperature. At low temperatures, fracture resistance is low; while at high temperatures, fracture resistance is higher. The relationship between toughness and temperature can be plotted and can also be described mathematically. The ASME Code provides two descriptions of the relationship between vessel fracture resistance and temperature. These two descriptions are for different types of fracture resistance, and are called K_{IC} and K_{IA}. The equations for each are provided in ASME Section XI, Article A-4000:

$$K_{IC} = 33.2 + 20.734 \exp(0.02 (T - RT_{NDT}))$$

And

$$K_{IA} = 26.8 + 12.445 \exp(0.0145 (T - RT_{NDT})).*$$

* K_{IA} appears in an alternative, equivalent format in ASME Section XI, Appendix G:

$$K_{IA} = 26.78 + 1.223 \exp(0.0145 (T - RT_{NDT} + 160)).$$

K_{IC} is the maximum stress intensity factor that may be applied to a material that will not cause an existing crack to propagate. This fracture toughness parameter was determined by drawing a lower bound to static crack initiation toughness data. If applied loads are limited so that they do not create stress intensity factors that exceed K_{IC}, then cracks will not initiate.

K_{IA} is the minimum stress intensity factor that must be applied to make a growing crack continue growing. This fracture toughness parameter was determined by drawing a lower bound to static, dynamic and crack arrest data. If applied loads are limited so that they do not create stress intensity factors that exceed K_{IA}, then growing cracks will stop propagating.

It takes more energy to initiate a crack than it takes to continue propagating an already growing crack. Since it takes more energy to create a new crack, the applied stress intensity factors necessary to initiate a crack are higher than those needed to continue propagating a crack. As a result, material resistance to crack initiation is higher than material resistance to propagation, so K_{IC} is higher than K_{IA}.

The existing LTOP limits are based on the use of K_{IA} with the maximum pressure limit at 100% of ASME Section XI, Appendix G, P-T limits. With the justification provided in Reference (d) to use Code Case N-640, K_{IC} can be used in lieu of K_{IA} for determining P-T limits. When Code Case N-640 is used, LTOP systems must also limit the maximum pressure in the vessel to 100% of the pressure allowed by the ASME P-T limit curves.

Pressure-temperature curves are calculated using ASME Section XI, Appendix G guidance. The governing equation is:

$2K_{IM} + K_{IT} < K_{IA}$.

Where: K_{IM} = Allowable pressure stress intensity factor, ksi√in;

K_{IT} = Allowable thermal stress intensity factor, ksi√in;

K_{IA} = Reference critical stress intensity factor for the material, ksi√in.

K_{IM} and K_{IT} are calculated according to ASME Section XI, Appendix G, G-2214, with K_{IM} derived principally from membrane stress due to vessel internal pressure, and K_{IT} derived from thermal stress due to vessel temperature transients.

To develop the P-T limits a heatup or cooldown rate is evaluated to determine the value of K_{IT} versus time. At each time during the heatup or cooldown transient, the applied K_{IT} is subtracted from K_{IA} to determine the maximum permissible K_{IM} according to the following re-arrangement of the governing equation:

$K_{IM} < 1/2(K_{IA} - K_{IT})$

Knowing the maximum K_{IM} permits calculation of maximum allowable pressure.

As described in Code Case N-640, K_{IC} may be used in lieu of K_{IA}, so the governing equation becomes:

$2\,K_{IM} + K_{IT} < K_{IC}$.

Since K_{IC} is greater than K_{IA}, the sum $2\,K_{IM} + K_{IT}$ is also greater. Theoretically, it is permissible to increase the permissible K_{IM}, or K_{IT}, or a combination of both. Code Case N-640 requires the LTOP setpoints be established to ensure the maximum pressure in the vessel does not exceed 100% of the pressure allowed by the ASME P-T curves. In order to use Code Case N-640 to change P-T limits while maintaining current LTOP setpoints, it is necessary to define the new maximum K_{IM} such that the pressure necessary to create the maximum K_{IM} is equal to or greater than maximum allowable pressure for the existing LTOP limits. It is important to note that the new P-T limits will not permit operation at higher pressures (K_{IM}) than permitted previously. Instead, pressure will be limited in the new curves to the same value it was limited to in the old curves.

As heatup and cooldown rates are increased, the value of K_{IT} increases. Rates are selected so that the calculated K_{IT} satisfies:

$K_{IT} < K_{IC} - 2\,K_{IM}$.

By constraining K_{IM} as described above, K_{IT} (and the heatup and cooldown rates) can be increased while maintaining the existing P-T limits. However, it is important to note that none of the heatup or cooldown rates are greater than 100°F/hr. Thus, there are no changes to the cooldown rates above 300°F, and to the cooldown rates assumed in the Chapter 14 Safety Analyses of the Updated Final Safety Analysis Report.

LTOP Enable Temperature

The LTOP enable temperature defines at what point the LTOP system must be operable during startup and shutdown conditions. The current CCNPP LTOP enable temperature is based on Branch Technical Position RSB 5-2, which defines the enable temperature as the water temperature corresponding to a metal temperature of at least RT_{NDT} + 90°F at the beltline location (1/4t or 3/4t) that is controlling in the Appendix G limit calculation. To bound the existing LTOP enable temperatures, we are proposing use of LTOP enable temperature defined by ASME Section XI Code Case 514, which is listed in Regulatory Guide 1.147 as acceptable to the NRC. Code Case 514 states that LTOP systems shall be effective at coolant temperatures less than 200°F or at coolant temperatures corresponding to a reactor vessel metal temperature less than RT_{NDT} + 50°F, whichever is greater. Use of the Code Case 514 enable temperature criterion permits the higher heatup rates calculated using K_{IC} without requiring a change to the LTOP enable temperature. Therefore, there will be minimum impact on plant procedures, equipment, and software.

The proposed changes to the heatup and cooldown rates are necessary to address operator difficulties and safety challenges encountered when entering and exiting plant outage periods. The existing restrictive heatup and cooldown rates in low temperature regions impact the integrity of plant components due to corrosion, plant work-arounds, and critical path time.

During startup from an outage, operation of two reactor coolant pumps (RCPs) to heatup the RCS challenges the existing allowed heatup rate. Two RCPs in low temperature region generate a heatup rate that can exceed the existing maximum allowed heatup rate limit. Single RCP operation is prohibited at CCNPP. Prior to planned heatup, operators allow temperature of the RCS to drift up. The steam generators (SGs) act as a large heat sink limiting the maximum temperature achievable in the RCS with decay heat. Therefore, the SGs frequently require heating with sparged condensate to meet the RCP start criteria. Sparging the condenser and reducing vacuum to raise the temperature of the SG feedwater raises the saturation temperature of the water and increases the oxygen concentration to a level that creates a corrosion environment on the outside of the SG tubes. In addition, the temperature differential between the SGs and the RCS is restricted to prevent exceeding the existing cooldown rates. This restriction imposes a limit to the maximum RCS temperature for an RCP start. Needless transitions to and from shutdown cooling can occur due to these restrictions, which can result in a significant dose to personnel. This places an unnecessary burden on the plant and the operators.

The proposed changes would alleviate the problems described above by allowing a better controlled plant evolution during startup and shutdown.

DETERMINATION OF SIGNIFICANT HAZARDS

The proposed change has been evaluated against the standards in 10 CFR 50.92 and has been determined to not involve a significant hazards consideration, in that operation of the facility in accordance with the proposed amendments:

1. *Would not involve a significant increase in the probability or consequences of an accident previously evaluated.*

   In accordance with 10 CFR Part 50, Appendix G, the Calvert Cliffs pressure/temperature (P-T) limits for material fracture toughness requirements of the reactor coolant pressure boundary materials were developed using the methods of linear elastic fracture mechanics and the guidance

found in the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, Appendix G. The Calvert Cliffs P-T limits are based on fluence level. The fluence levels are determined in the same manner as the pressurized thermal shock (PTS) screening criteria defined in 10 CFR 50.61 for the critical elements. Methods described in the Nuclear Regulatory Commission Regulatory Guide 1.99, Revision 2, are used to predict the embrittlement effect of neutron irradiation on reactor vessel materials. Regulatory Guide 1.99 defines embrittlement effect in terms of adjusted reference temperatures, which depends on the material property of the PTS critical element.

The proposed higher heatup and cooldown rates for the Technical Specification P-T limits were made possible by the ASME Code Case N-640 which permits use of reference stress intensity factor K_{IC} in place of K_{IA}. Use of K_{IC}, for the maximum stress intensity factor that will not lead to failure, is the correct value to use. Although conservative in terms of developing P-T limits, use of K_{IA} results in a very restrictive heatup and cooldown rate that challenges plant safety. To bound the existing LTOP enable temperatures, while increasing the heatup and cooldown rates, the criteria described in ASME Section XI Code Case 514 is used. Code Case 514 is listed in Regulatory Guide 1.147 as acceptable to the Nuclear Regulatory Commission (NRC) for this application. With the new higher heatup and cooldown rates, the underlying intent of the 10 CFR Part 50, Appendix G, requirement for adequate margin to prevent brittle failure of the reactor coolant pressure boundary materials is maintained. Additionally, since the cooldown rates are not changed above 300°F, the safety analyses and dose consequences in the Updated Final Safety Analysis Report are not affected.

Therefore the proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. *Would not create the possibility of a new or different type of accident from any accident previously evaluated.*

   The implementation of the proposed revision has no significant effect on either the configuration of the plant, or the manner in which it is operated.

   Therefore, this proposed change does not create the possibility of a new or different kind of accident from any previously evaluated.

3. *Would not involve a significant reduction in a margin of safety.*

   As discussed above, although conservative in terms of developing P-T limits, use of K_{IA} results in a very restrictive heatup and cooldown rate that challenges plant safety. The insignificant margin reduction in P-T limits is more than compensated by the safety benefits that are realized in terms of plant component integrity as a result of the higher heatup and cooldown rates. With the proposed change, the underlying intent of the 10 CFR Part 50, Appendix G, requirement for adequate margin to prevent brittle failure of the reactor coolant pressure boundary materials is maintained, and there is a net gain in overall plant safety margin.

   Therefore, this proposed change does not significantly reduce the margin of safety.

ENVIRONMENTAL ASSESSMENT

We have determined that operation with the proposed amendment will not result in any significant change in the types or significant increases in the amounts of any effluents that may be released offsite, and no significant increases in individual or cumulative occupational radiation exposure. Therefore, the proposed amendment is eligible for categorical exclusion as set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment is needed in connection with the approval of the proposed amendment.

SAFETY COMMITTEE REVIEW

The Plant Operations and Safety Review Committee and the Offsite Safety Review Committee have reviewed this proposed amendment and concur that operation with the proposed amendment will not result in an undue risk to the health and safety of the public.

SCHEDULE

We plan to make use of the proposed heatup and cooldown rates for the upcoming spring 2001 Unit 2 refueling outage. In order to allow time to make the necessary preparation to use the new heatup and cooldown rates, we request that the Nuclear Regulatory Commission review and approve the proposed amendment on or before February 28, 2001.

Should you have questions regarding this matter, we will be pleased to discuss them with you.

Very truly yours,

STATE OF MARYLAND :
: **TO WIT:**
COUNTY OF CALVERT :

I, Charles H. Cruse, being duly sworn, state that I am Vice President, Nuclear Energy, Calvert Cliffs Nuclear Power Plant, Inc. (CCNPP), and that I am duly authorized to execute and file this License Amendment Request on behalf of CCNPP. To the best of my knowledge and belief, the statements contained in this document are true and correct. To the extent that these statements are not based on my personal knowledge, they are based upon information provided by other CCNPP employees and/or consultants. Such information has been reviewed in accordance with company practice and I believe it to be reliable.

Subscribed and sworn before me, a Notary Public in and for the State of Maryland and County of CALVERT, this 14th day of SEPTEMBER, 2000.

WITNESS my Hand and Notarial Seal:

Lynn M. Taylor
Notary Public

My Commission Expires: 2/1/02
Date

CHC/GT/bjd

Attachment: (1) Technical Specification Marked-up Pages

cc: R. S. Fleishman, Esquire
J. E. Silberg, Esquire
Director, Project Directorate I-1, NRC
A. W. Dromerick, NRC
H. J. Miller, NRC
Resident Inspector, NRC
R. I. McLean, DNR

ATTACHMENT (1)

TECHNICAL SPECIFICATION MARKED-UP PAGES

3.4.3-3

3.4.3-4

3.4.3-5

3.4.3-6

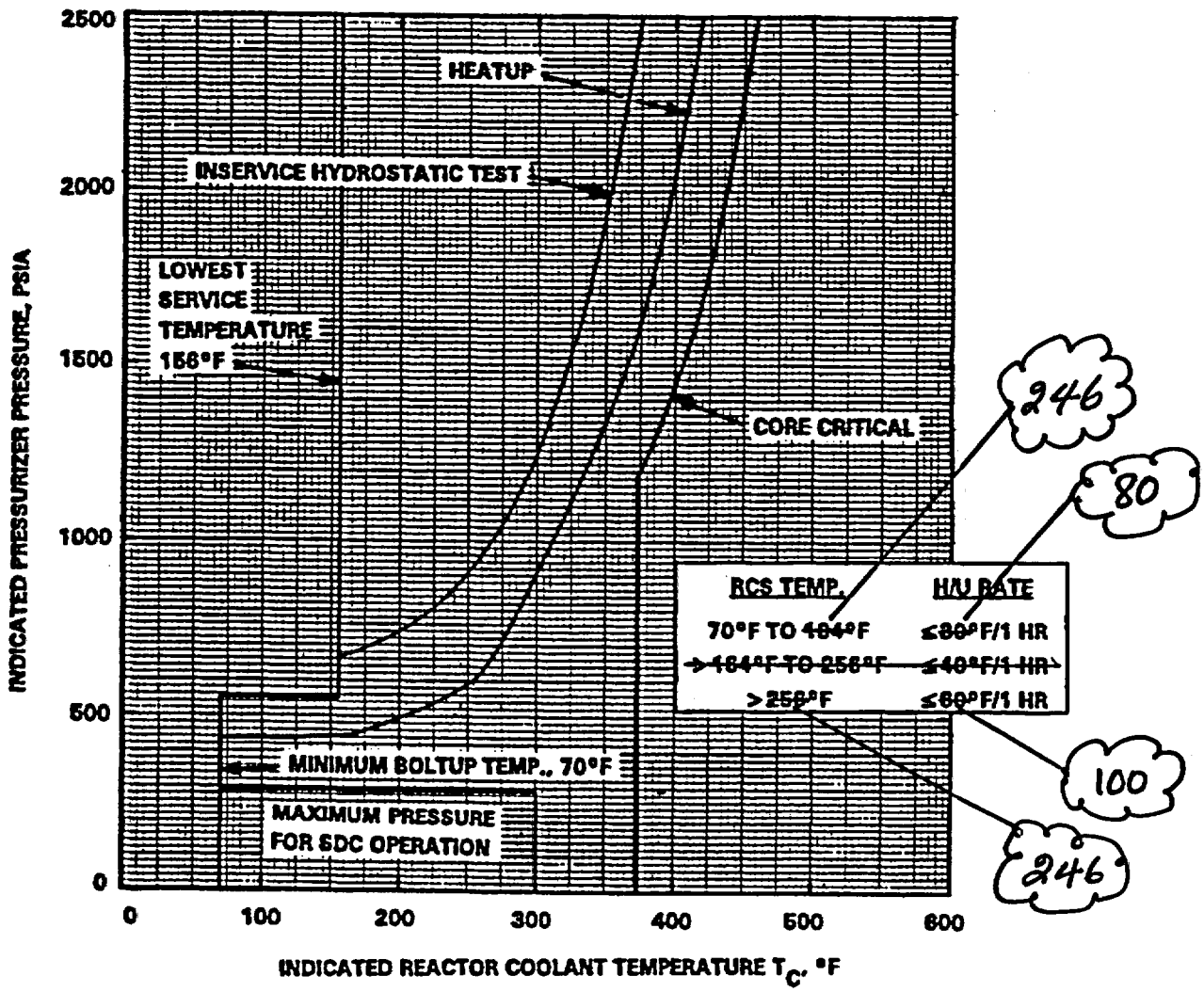

Figure 3.4.3-1
Calvert Cliffs Unit 1 Heatup Curve, for Fluence ≤ 4.49×10^{19} n/cm^2
Reactor Coolant System Pressure Temperature Limits

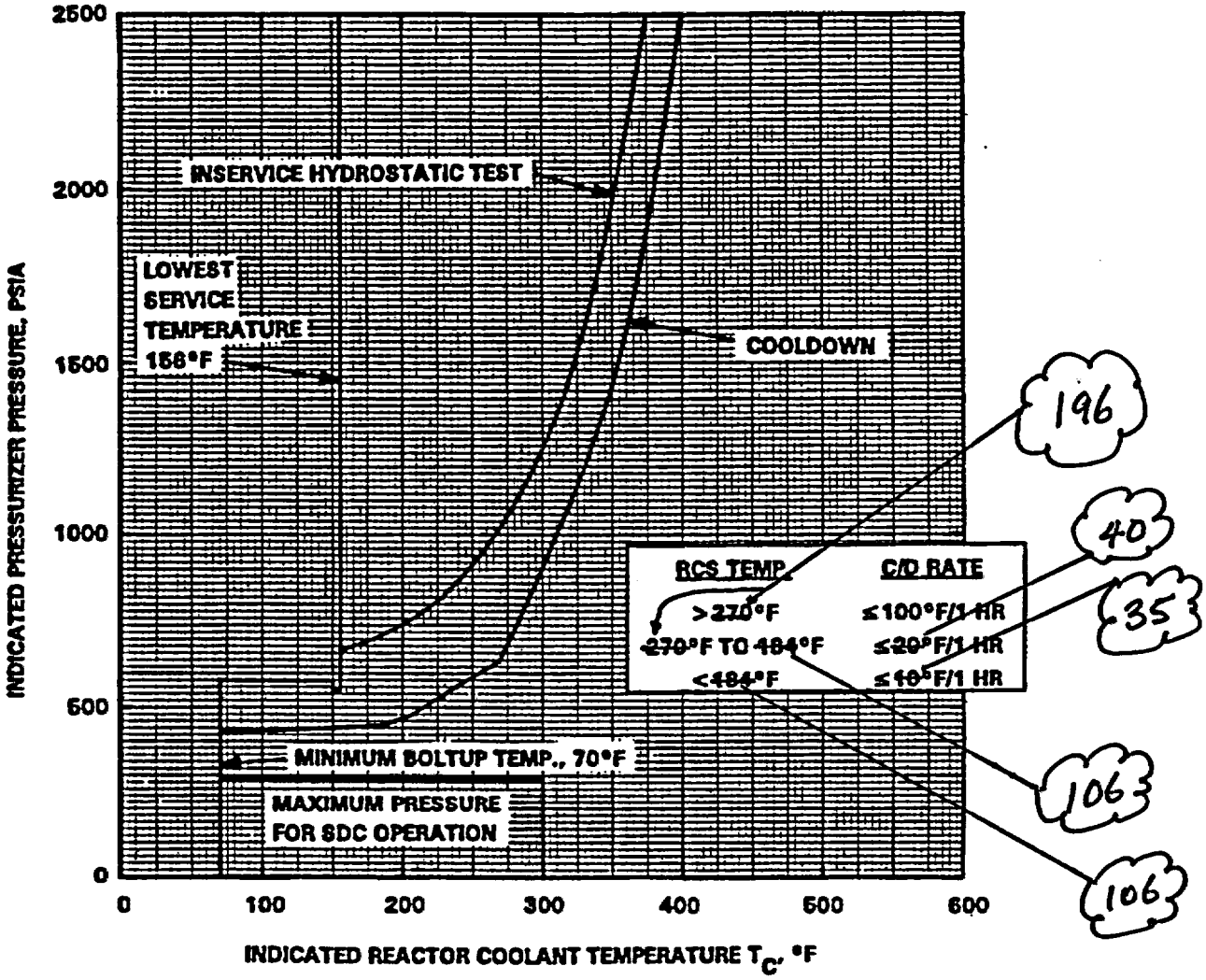

Figure 3.4.3-2
Calvert Cliffs Unit 1 Cooldown Curve, for Fluence ≤ 4.49×10^{19} n/cm^2
Reactor Coolant System Pressure Temperature Limits

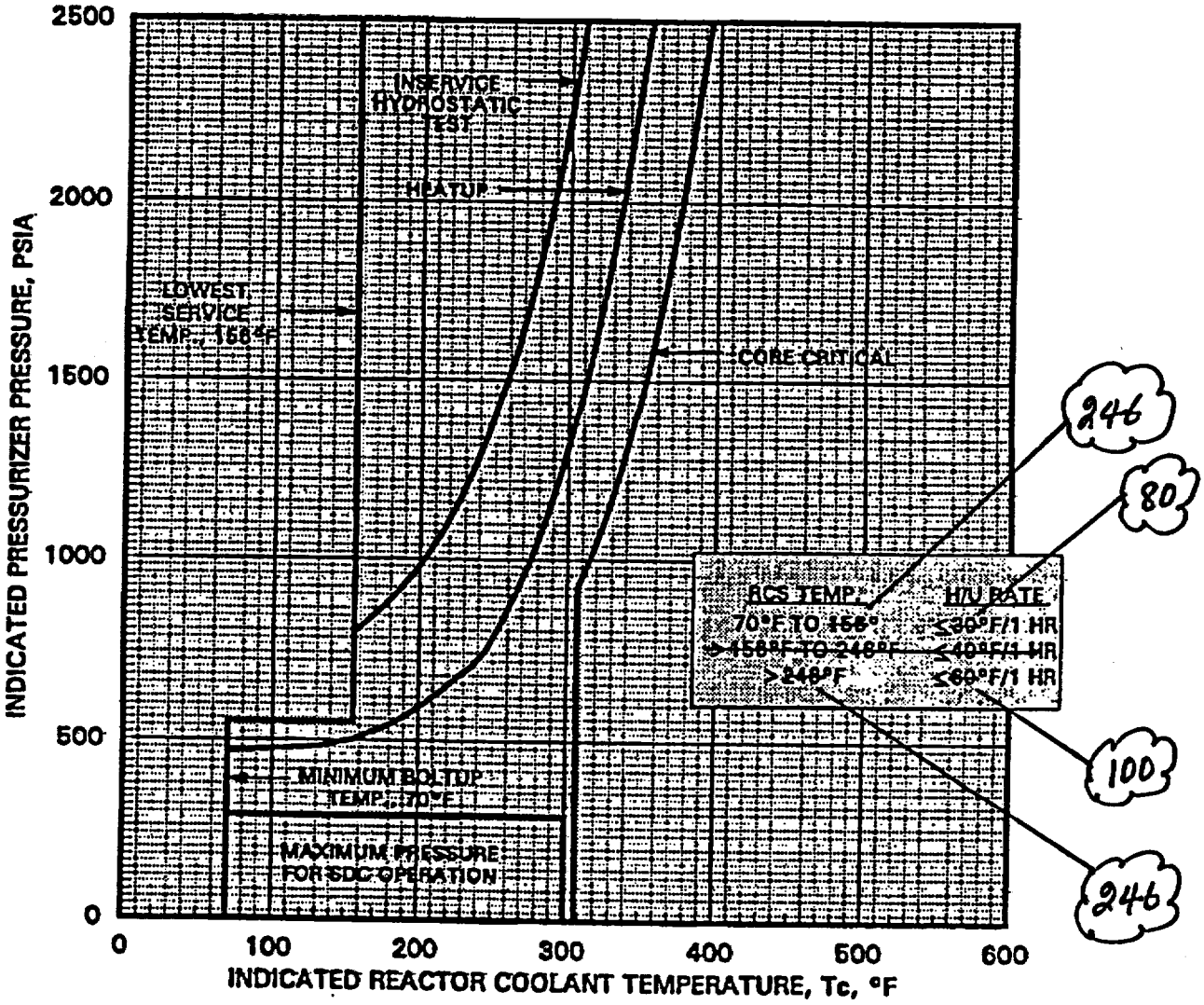

Figure 3.4.3-1
Calvert Cliffs Unit 2 Heatup Curve, for Fluence ≤ 4.0×10^{19} n/cm^2
Reactor Coolant System Pressure Temperature Limits

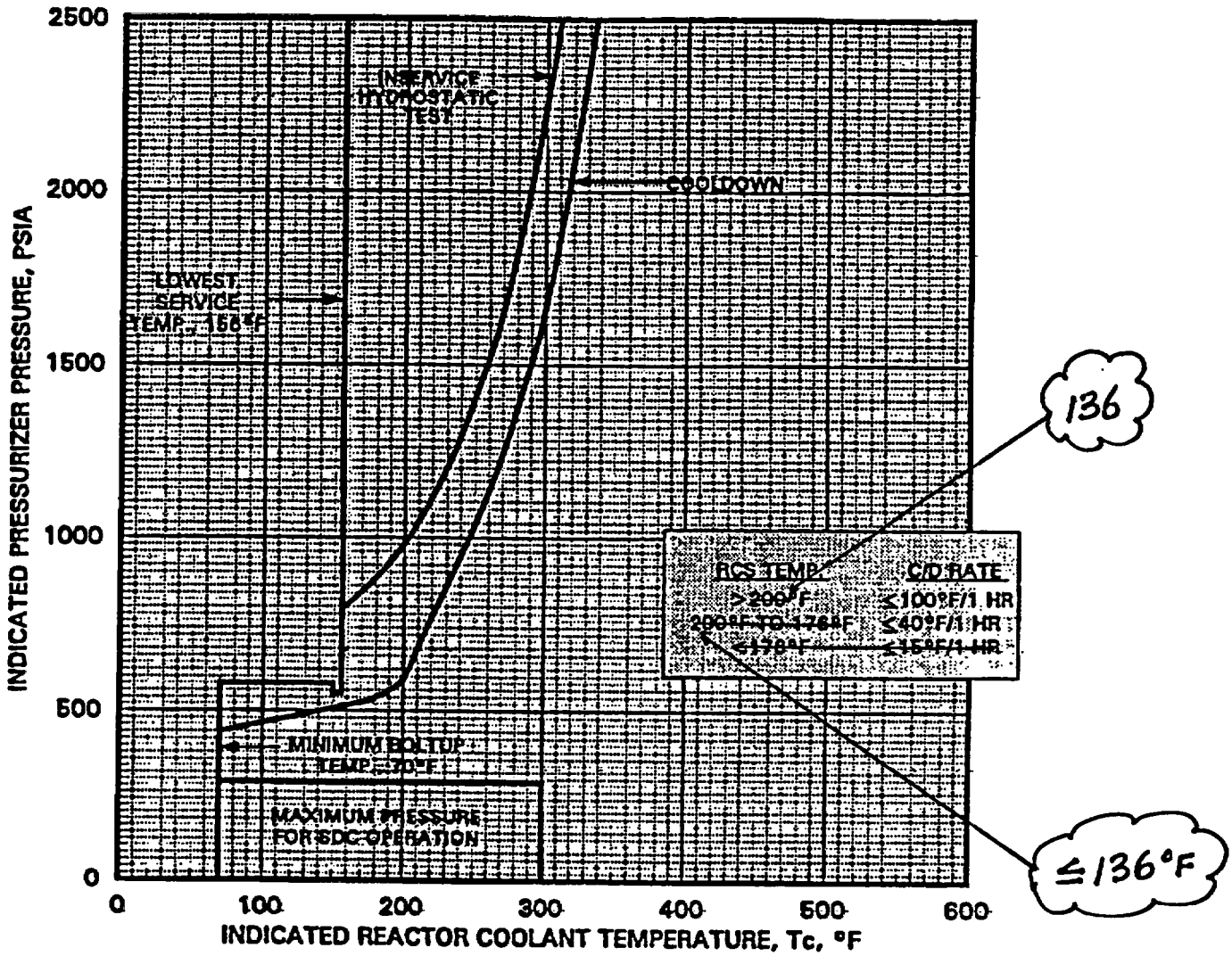

Figure 3.4.3-2
Calvert Cliffs Unit 2 Cooldown Curve, for Fluence ≤ 4.0×10^{19} n/cm^2
Reactor Coolant System Pressure Temperature Limits