REACTOR COOLANT SYSTEM

3/4.4.9 PRESSURE/TEMPERATURE LIMITS

REACTOR COOLANT SYSTEM

LIMITING CONDITION FOR OPERATION

3.4.9.1 The Reactor Coolant System (except the pressurizer) temperature and pressure shall be limited in accordance with the limit lines shown on Figures 3.4-2 and 3.4-3 during heatup, cooldown, criticality, and inservice leak and hydrostatic testing with:

a. A maximum heatup of 100°F in any one hour period,

b. A maximum cooldown of 100°F in any one hour period, and

c. A maximum temperature change of less than or equal to 10°F in any one hour period during inservice hydrostatic and leak testing operations above the heatup and cooldown limit curves.

APPLICABILITY: At all times.

ACTION:

With any of the above limits exceeded, restore the temperature and/or pressure to within the limit within 30 minutes; perform an engineering evaluation to determine the effects of the out-of-limit condition on the fracture toughness properties of the Reactor Coolant System; determine that the Reactor Coolant System remains acceptable for continued operation or be in at least HOT STANDBY within the next 6 hours and reduce the RCS T_{avg} and pressure to less than 200°F and 500 psig, respectively, within the following 30 hours.

SURVEILLANCE REQUIREMENTS

4.4.9.1.1 The Reactor Coolant System temperature and pressure shall be determined to be within the limits at least once per 30 minutes during system heatup, cooldown, and inservice leak and hydrostatic testing operations.

4.4.9.1.2 The reactor vessel material irradiation surveillance specimens shall be removed and examined, to determine changes in material properties, at the intervals required by 10 CFR 50, Appendix H in accordance with the schedule in Table 4.4-5. The results of these examinations shall be used to update Figures 3.4-2 and 3.4-3

8602140118 860207
PDR ADOCK 05000395
P PDR

TABLE 4.4-5

REACTOR VESSEL MATERIAL SURVEILLANCE PROGRAM - WITHDRAWAL SCHEDULE

CAPSULE IDENTIFICATION	VESSEL LOCATION	LEAD FACTOR	WITHDRAWAL TIME ~~EFPY~~
U	343°	3.7	1st Refueling
~~W~~ V	~~110°~~ 107°	3.1	~~6~~ 3rd Refueling
~~Y~~ X	~~290°~~ 257°	3.1	~~10~~ 5th Refueling
~~Z~~ W	~~340°~~ 110°	~~3.1~~ 2.7	~~15~~ 10th Refueling
~~V~~ Y	~~107°~~ 290°	~~3.7~~ 2.7	~~STANDBY~~ 17th Refueling
~~X~~ Z	~~287°~~ 340°	~~3.7~~ 2.7	STANDBY

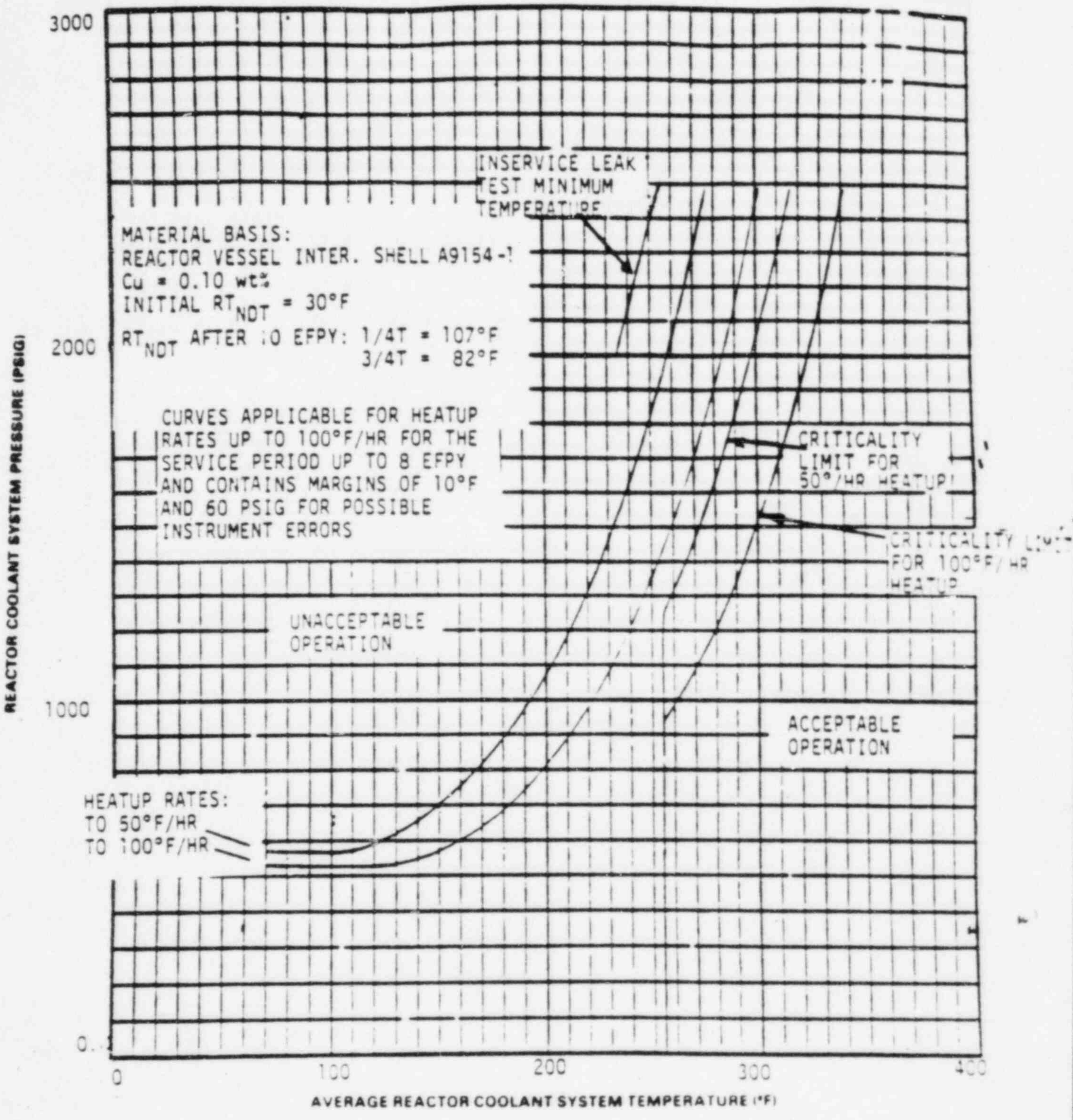

Figure 3.4-2 Reactor Coolant System Pressure - Temperature Limits Versus 100°F/Hour and 50°F/Hour Heatup Rate - Criticality Limit and Inservice Leak Test Limit

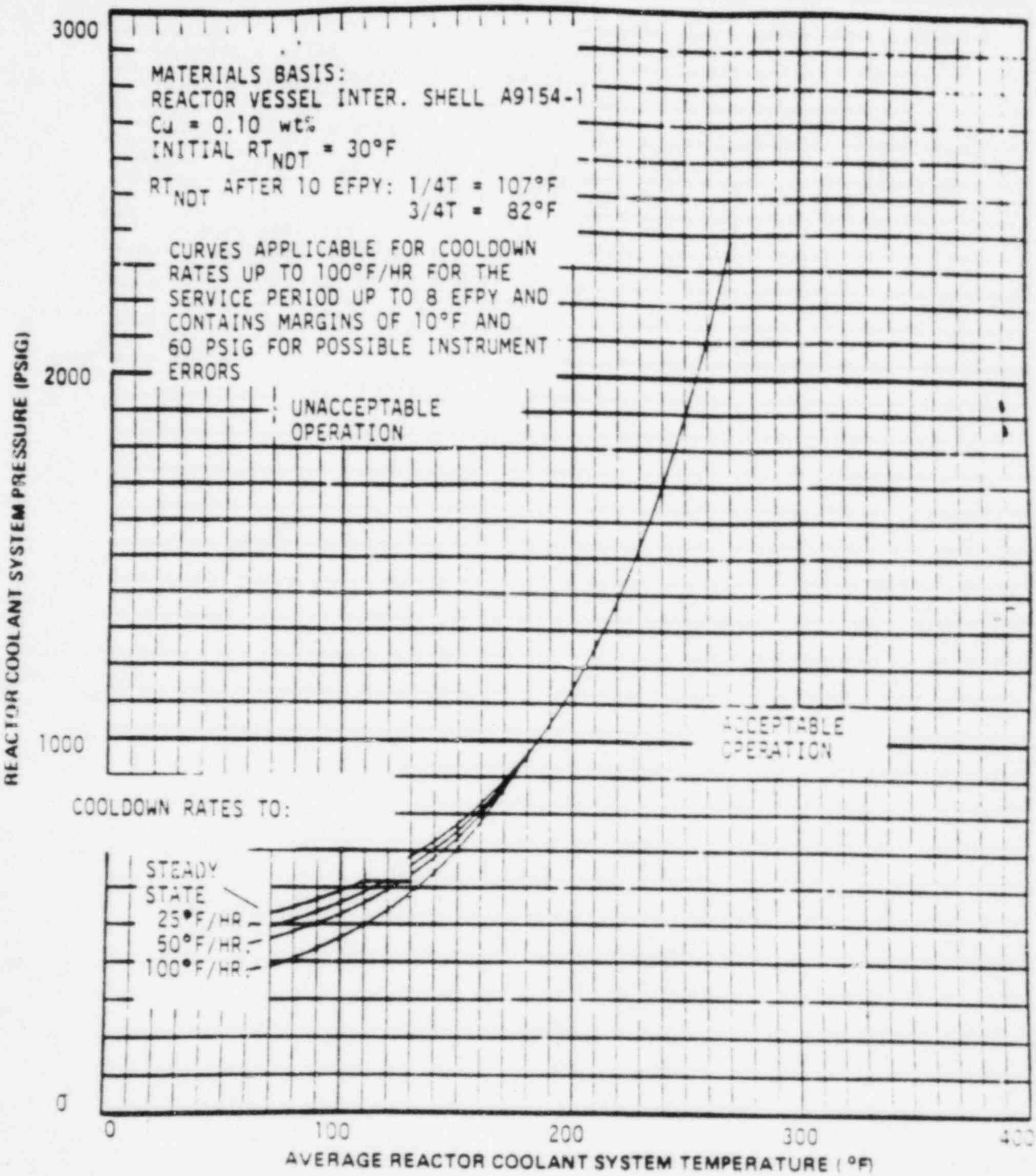

Figure 3.4-3
Reactor Coolant System Pressure - Temperature Limits
Versus Cooldown Rates

SPECIFIC ACTIVITY (Continued)

The ACTION statement permitting POWER OPERATION to continue for limited time periods with the primary coolant's specific activity greater than 1.0 microcuries/gram DOSE EQUIVALENT I-131, but within the allowable limit shown on Figure 3.4-1, accommodates possible iodine spiking phenomenon which may occur following changes in THERMAL POWER. Operation with specific activity levels exceeding 1.0 microcuries/gram DOSE EQUIVALENT I-131 but within the limits shown on Figure 3.4-1 must be restricted to no more than 800 hours per year (approximately 10 percent of the unit's yearly operating time) since the activity levels allowed by Figure 3.4-1 increase the 2 hour thyroid dose at the site boundary by a factor of up to 20 following a postulated steam generator tube rupture. The reporting of cumulative operating time over 500 hours in any 6 month consecutive period with greater than 1.0 microcuries/gram DOSE EQUIVALENT I-131 will allow sufficient time for Commission evaluation of the circumstances prior to reaching the 800 hour limit.

Reducing T_{avg} to less than 500°F prevents the release of activity should a steam generator tube rupture since the saturation pressure of the primary coolant is below the lift pressure of the atmospheric steam relief valves. The surveillance requirements provide adequate assurance that excessive specific activity levels in the primary coolant will be detected in sufficient time to take corrective action. Information obtained on iodine spiking will be used to assess the parameters associated with spiking phenomena. A reduction in frequency of isotopic analyses following power changes may be permissible if justified by the data obtained.

3/4.4.9 PRESSURE/TEMPERATURE LIMITS

The temperature and pressure changes during heatup and cooldown are limited to be consistent with the requirements given in the ASME Boiler and Pressure Vessel Code, Section III, Appendix G.

1) The reactor coolant temperature and pressure and system heatup and cooldown rates (with the exception of the pressurizer) shall be limited in accordance with Figures 3.4-2 and 3.4-3. ~~for the first full-power service period~~.

    a) Allowable combinations of pressure and temperature for specific temperature change rates are below and to the right of the limit lines shown. Limit lines for cooldown rates between those presented may be obtained by interpolation.

PRESSURE/TEMPERATURE LIMITS (Continued)

b) Figures 3.4-2 and 3.4-3 define limits to assure prevention of non-ductile failure only. For normal operation, other inherent plant characteristics, e.g., pump heat addition and pressurizer heater capacity, may limit the heatup and cooldown rates that can be achieved over certain pressure-temperature ranges.

2) These limit lines shall be calculated periodically using methods provided below.

3) The secondary side of the steam generator must not be pressurized above 200 psig if the temperature of the steam generator is below 70°F.

4) The pressurizer heatup and cooldown rates shall not exceed 100°F/hr and 200°F/hr respectively. The spray shall not be used if the temperature difference between the pressurizer and the spray fluid is greater than 625°F.

5) System in-service leak and hydrotests shall be performed at pressures in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section XI.

The fracture toughness properties of the ferritic materials in the reactor vessel are determined in accordance with the 1972 Summer Addenda to Section III of the ASME Boiler and Pressure Vessel Code.

Heatup and cooldown limit curves are calculated using the most limiting value of RT_{NDT} (reference nil-ductility temperature). The most limiting RT_{NDT} of the material in the core region of the reactor vessel is determined by using the preservice reactor vessel material properties and estimating the radiation-induced ΔRT_{NDT}. RT_{NDT} is designated as the higher of either the drop weight nil-ductility transition temperature (NDTT) or the temperature at which the material exhibits at least 50 ft lb of impact energy and 35-mil lateral expansion (normal to the major working direction) minus 60°F.

RT_{NDT} increases as the material is exposed to fast-neutron radiation. Thus, to find the most limiting RT_{NDT} at any time period in the reactor's life, ΔRT_{NDT} due to the radiation exposure associated with that time period must be added to the original unirradiated RT_{NDT}. The extent of the shift in RT_{NDT} is enhanced by certain chemical elements (such as copper) present in reactor vessel steels. Design curves which show the effect of fluence and copper content on ΔRT_{NDT} for reactor vessel steels are shown in Figure B 3/4 4-2.

PRESSURE/TEMPERATURE LIMITS (Continued)

Given the copper content of the most limiting material, the radiation-induced ΔRT_{NDT} can be estimated from Figure B3/4.4.2. Fast neutron fluence (E > 1 Mev) at the vessel inner surface, the 1/4 T (wall thickness), and 3/4 T (wall thickness) vessel locations are given as a function of full-power service life in Figure B3/4.4.1. The data for all other ferritic materials in the reactor coolant pressure boundary are examined to insure that no other component will be limiting with respect to RT_{NDT}.

The preirradiation fracture-toughness properties of the V. C. Summer Unit 1 reactor vessel materials are presented in Table B3/4.4-1. The fracture-toughness properties of the ferritic material in the reactor coolant pressure boundary are determined in accordance with the NRC Regulatory Standard Review Plan.[1] The postirradiation fracture-toughness properties of the reactor vessel beltline material were obtained directly from the V. C. Summer Unit 1 Vessel Material Surveillance Program.

The ASME approach for calculating the allowable limit curves for various heatup and cooldown rates specifies that the total stress intensity factor, K_I, for the combined thermal and pressure stresses at any time during heatup or cooldown cannot be greater than the reference stress intensity factor, K_{IR}, for the metal temperature at that time. K_{IR} is obtained from the reference fracture toughness curve, defined in Appendix G of the ASME Code.[2] The K_{IR} curve is given by the equation:

$$K_{IR} = 26.78 + 1.223 \exp [0.0145 (T-RT_{NDT} + 160)] \quad \text{Equation (1)}$$

---

1. "Fracture Toughness Requirements," Branch Technical Position MTEB 5-2, Chapter 5.3.2 in Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition, NUREG-0800, 1981.

2. ASME Boiler and Pressure Vessel Code, Section III, Division 1 - Appendices, "Rules for Construction of Nuclear Vessels," Appendix G, "Protection Against Nonductile Failure," pp. 559-564, 1983 Edition, American Society of Mechanical Engineers, New York, 1983.

TABLE B 3/4.4-1

REACTOR VESSEL TOUGHNESS

COMPONENT	MATERIAL TYPE	Cu %	P %	NDTT (°F)	MIN. 50 FT-LB 35 MIL TEMP. (°F)	RT_{NDT} (°F)	AVG. UPPER SHELF (FT-LB)
Closure Head	A533-B-Class 1			-20	40	-20	106
Head Flange	SA508 Class 2			10	<60	10	129
Vessel Flange	SA508 Class 2			0	<60	0	172
Inlet Nozzle	SA508 Class 2			-20	<40	-20	130
Inlet Nozzle	SA508 Class 2			0	<60	0	114.5
Inlet Nozzle	SA508 Class 2			-20	<40	-20	135
Outlet Nozzle	SA508 Class 2			-10	<50	-10	146
Outlet Nozzle	SA508 Class 2			-10	<50	-10	165
Outlet Nozzle	SA508 Class 2			0	<50	0	150
Nozzle Shell	A533-B-Class 1	.13	.010	-20	78	18	100.5
Nozzle Shell	A533-B-Class 1	.12	.009	-30	86	26	91
Inter. Shell	A533-B-Class 1	.10	.009	-20	90	30	80.5
Inter. Shell	A533-B-Class 1	.09	.006	-20	40	-20	106.5
Lower Shell	A533-B-Class 1	.08	.005	-10	70	10	91.5
Lower Shell	A533-B-Class 1	.08	.005	-30	70	10	106
Trans. Ring	A533-B-Class 1			-40	23	-37	107
Bottom Head	A533-B-Class 1			-10	42	-10	134
Core Region Weld		.06	.013	-50	16	-44	84
Weld HAZ				-70	-37	-70	130

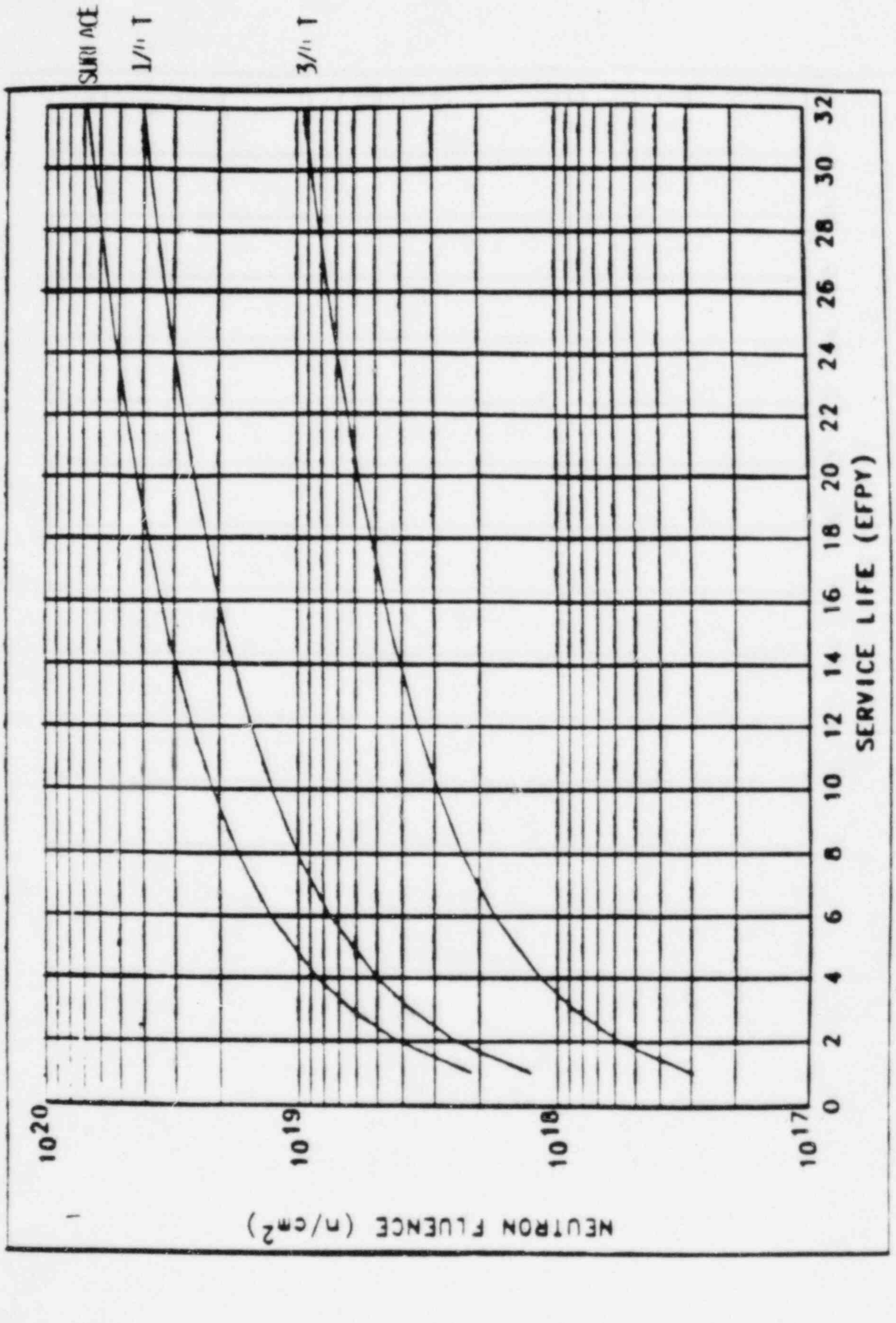

FIGURE B 3/4.4-1 FAST NEUTRON FLUENCE (E>1 MeV) AS A FUNCTION OF FULL POWER SERVICE LIFE (EFPY)

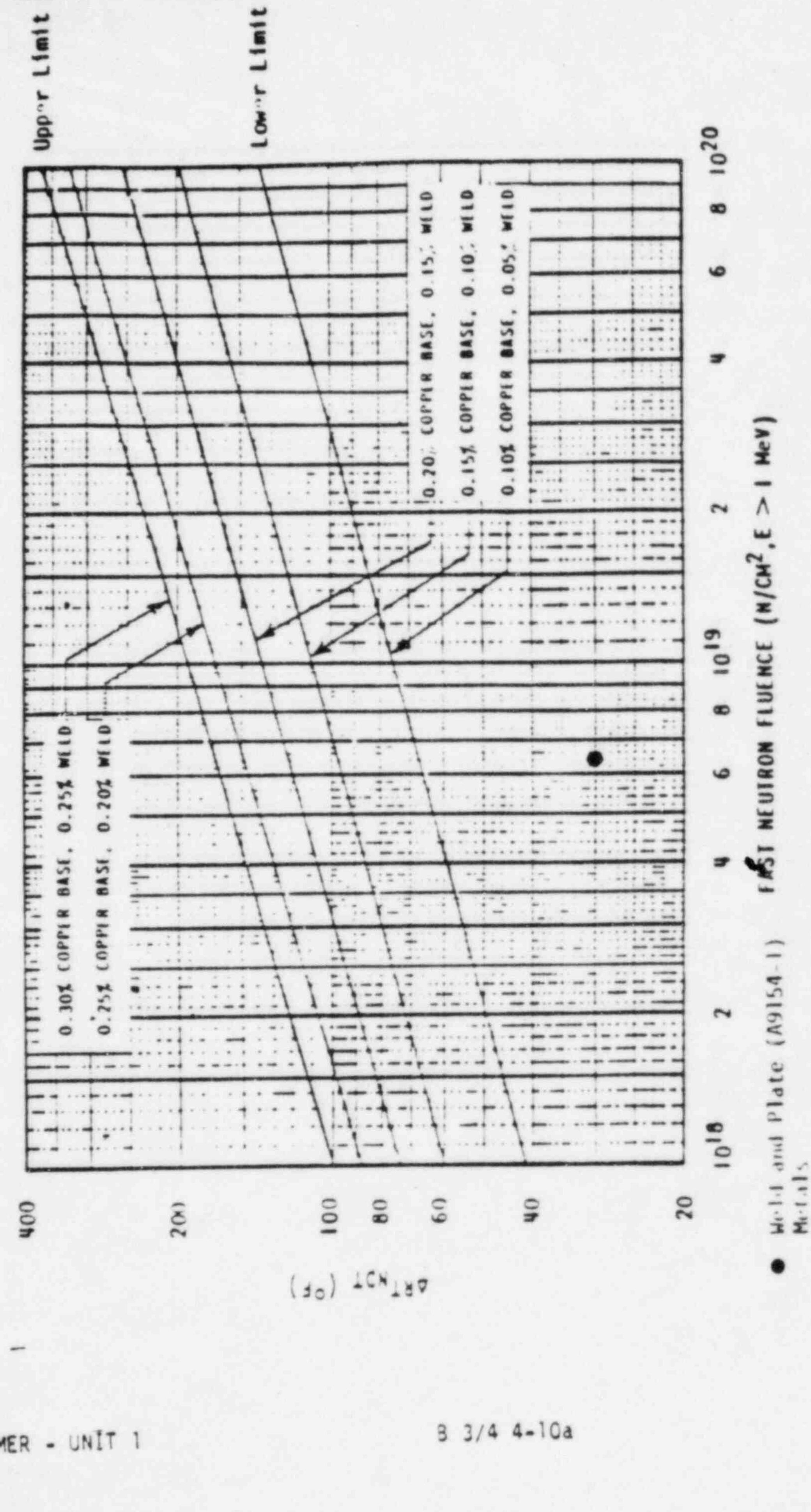

FIGURE B 3/4.4-2 Effect of Fluence and Copper on Shift of RT_{NDT} for Reactor Vessel Steels Exposed to Irradiation at 550°F where K_{IR} is the reference stress intensity factor as a function of the metal temperature T and the metal reference nil-ductility temperature RT_{NDT}. Thus, the governing equation for the heatup-cooldown analysis is defined in Appendix G of the ASME Code as follows:

$$C\,K_{IM} + K_{It} \leq K_{IR} \qquad \text{Equation (2)}$$

where

K_{IM} is the stress intensity factor caused by membrane (pressure) stress

K_{It} is the stress intensity factor caused by the thermal gradients

C = 2.0 for Level A and Level B service limits

C = 1.5 for hydrostatic and leak test conditions during which the reactor core is not critical

At any time during the heatup or cooldown transient, K_{IR} is determined by the metal temperature at the tip of the postulated flaw, the appropriate value for RT_{NDT}, and the reference fracture toughness curve. The thermal stresses resulting from temperature gradients through the vessel wall are calculated and then the corresponding (thermal) stress intensity factors, K_{It}, for the reference flaw are computed. From Equation 2 , the pressure stress intensity factors are obtained and, from these, the allowable pressures are calculated.

COOLDOWN

For the calculation of the allowable pressure-versus-coolant temperature during cooldown, the Code reference flaw is assumed to exist at the inside of the vessel wall. During cooldown, the controlling location of the flaw is always at the inside of the wall because the thermal gradients produce tensile stresses at the inside, which increase with increasing cooldown rates. Allowable pressure-temperature relations are generated for both steady-state and finite cooldown rate situations. From these relations, composite limit curves are constructed for each cooldown rate of interest.

The use of the composite curve in the cooldown analysis is necessary because control of the cooldown procedure is based on measurement of reactor coolant temperature, whereas the limiting pressure is actually dependent on the material temperature at the tip of the assumed flaw.

During cooldown, the 1/4 T vessel location is at a higher temperature than the fluid adjacent to the vessel ID. This condition, of course, is not true for the steady-state situation. It follows that, at any given reactor coolant temperature, the ΔT developed during cooldown results in a higher value of K_{IR} at the 1/4 T location for finite cooldown rates than for steady-state operation. Furthermore, if conditions exist such that the increase in K_{IR} exceeds K_{It}, the calculated allowable pressure during cooldown will be greater than the steady-state value.

The above procedures are needed because there is no direct control on temperature at the 1/4 T location and, therefore, allowable pressures may unknowingly be violated if the rate of cooling is decreased at various intervals along a cooldown ramp. The use of the composite curve eliminates this problem and insures conservative operation of the system for the entire cooldown period.

Three separate calculations are required to determine the limit curves for finite heatup rates. As is done in the cooldown analysis, allowable pressure-temperature relationships are developed for steady-state conditions as well as finite heatup rate conditions assuming the presence of a 1/4 T defect at the inside of the vessel wall. The thermal gradients during heatup produce compressive stresses at the inside of the wall that alleviate the tensile stresses produced by internal pressure. The metal temperature at the crack tip lags the coolant temperature; therefore, the K_{IR} for the 1/4 T crack during heatup is lower than the K_{IR} for the 1/4 T crack during steady-state conditions at the same coolant temperature. During heatup, especially at the end of the transient, conditions may exist such that the effects of compressive thermal stresses and lower K_{IR}'s do not offset each other, and the pressure-temperature curve based on steady-state conditions no longer represents a lower bound of all similar curves for finite heatup rates when the 1/4 T flaw is considered. Therefore, both cases have to be analyzed in order to insure that at any coolant temperature the lower value of the allowable pressure calculated for steady-state and finite heatup rates is obtained.

The second portion of the heatup analysis concerns the calculation of pressure-temperature limitations for the case in which a 1/4 T deep outside surface flaw is assumed. Unlike the situation at the vessel inside surface, the thermal gradients established at the outside surface during heatup produce stresses which are tensile in nature and thus tend to reinforce any pressure stresses present. These thermal stresses are dependent on both the rate of heatup and the time (or coolant temperature) along the heatup ramp. Since the thermal stresses at the outside are tensile and increase with increasing heatup rates, each heatup rate must be analyzed on an individual basis.

Following the generation of pressure-temperature curves for both the steady-state and finite heatup rate situations, the final limit curves are produced by constructing a composite curve based on a point-by-point comparison of the steady-state and finite heatup rate data. At any given temperature, the allowable pressure is taken to be the lesser of the three values taken from the curves under consideration. The use of the composite curve is necessary to set conservative heatup limitations because it is possible for conditions to exist wherein, over the course of the heatup ramp, the controlling condition switches from the inside to the outside and the pressure limit must at all times be based on analysis of the most critical criterion.

Then the composite curves for the heatup rate data and the cooldown rate data are adjusted for possible errors in the pressure and temperature sensing instruments by the values indicated on the respective curves.

Finally, the new 10CFR50[3] rule which addresses the metal temperature of the closure head flange and vessel flange regions is considered. This 10CFR50 rule states that the metal temperature of the closure flange regions must exceed the material RT_{NDT} by at least 120°F for normal operation when the

3. Code of Federal Regulations, 10CFR50, Appendix G, "Fracture Toughness Requirements," U.S. Nuclear Regulatory Commission, Washington, D.C., Amended May 17, 1983 (48 Federal Register 24010).

pressure exceeds 20 percent of the preservice hydrostatic test pressure (621 psig for V. C. Summer Unit 1). Table B3/4.4-1 indicates that the limiting RT_{NDT} of 10°F occurs in the head flange of V. C. Summer Unit 1, and the minimum allowable temperature of this region is [illegible]0°F at pressures greater than 621 psig.

Limit curves for normal heatup and cooldown of the primary Reactor Coolant System have been calculated using the methods discussed [illegible] The derivation of the limit curves is presented in the NRC Regulatory Standard Review Plan.[4]

Transition temperature shifts occurring in the pressure vessel materials due to radiation exposure have been obtained directly from the reactor pressure vessel surveillance program. Charpy test specimens from Capsule U indicate that both the surveillance weld metal and core region intermediate shell plate code no. A9154-1 exhibited shifts in RT_{NDT} of 30°F at a fluence of 6.39×10^{18} n/cm^2. This shift is well within the appropriate design curve (Figure B3/4.4-1) prediction. Therefore, the heatup and cooldown curves in Figures 3.4-2 and 3.4-3 are based on the trend curve in Figure B3/4.4-2 and these curves are applicable up to 8 effective full power years (EFPY). The heatup curve in Figure 3.4-2 is not impacted by the new 10CFR50 rule. However, the cooldown curve in Figure 3.4-3 is impacted by this 10CFR50 rule.

Allowable combinations of temperature and pressure for specific temperature change rates are below and to the right of the limit lines shown on the heatup and cooldown curves. The reactor must not be made critical until pressure-temperature combinations are to the right of the criticality limit line shown in Figure 3.4-2. This is in addition to other criteria which must be met before the reactor is made critical.

The leak test limit curve shown in Figure 3.4-2 represents minimum temperature requirements at the leak test pressure specified by applicable codes. The leak test limit curve was determined by methods of References 2 and 4.

Figures 3.4-2 and 3.4-3 define limits for insuring prevention of nonductile failure.

4. "Pressure-Temperature Limits," Chapter 5.3.2 in Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition, NUREG-0800, 1981.

Although the pressurizer operates in temperature ranges above those for which there is reason for concern of non-ductile failure, operating limits are provided to assure compatibility of operation with the fatigue analysis performed in accordance with the ASME Code requirements.

The OPERABILITY of two RHRSRVs or an RCS vent opening of at least 2.7 square inches ensures that the RCS will be protected from pressure transients which could exceed the limits of Appendix G to 10 CFR part 50 when one or more of the RCS cold legs are less than or equal to 300°F. Either RHRSRV has adequate relieving capability to protect the RCS from overpressurization when the transient is limited to either (1) the start of an idle RCP with the secondary water temperature of the steam generator less than or equal to 50°F above the RCS cold leg temperatures or (2) the start of a HPSI pump and its injection into a water solid RCS.

ATTACHMENT B

No Significant Hazards Determination

The proposed changes to the Technical Specifications include revisions to section 3/4.4.9, "Pressure/Temperature Limits - Reactor Coolant System," and its bases. These changes are being requested as a result of the information obtained from the review of the first surveillance capsule removed from the reactor vessel. Results of this review are contained in the Westinghouse Topical Report WCAP 10814, "Analysis of Capsule 'U' from the South Carolina Electric and Gas Company Virgil C. Summer Unit 1 Reactor Vessel Radiation Surveillance Program" transmitted to the NRC Staff by a letter dated November 8, 1985 from Mr. D. A. Nauman to Mr. H. R. Denton. SCE&G has determined that the proposed changes involve a no significant hazards determination.

The amendment will not:

1) involve a significant increase in the probability or consequences of an accident previously evaluated because the changes are being made to make the Technical Specifications more accurate as a result of the data obtained from the review of the first reactor vessel specimen;

2) create the possibility of a new or different kind of accident from any accident previously evaluated because the physical plant design is not being changed; or

3) involve a significant reduction in a margin of safety because the change will make the Technical Specifications reflect the requirements dictated by the predicted service life conditions of the reactor vessel.