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MATERIAL PROPERTY BASIS

CONTROLLING MATERIAL:	INTERMEDIATE SHELL PLATE B9004-1
INITIAL RT_{NDT}:	60°F
RT_{NDT} AFTER 15 EFPY:	1/4T, 140°F
	3/4T, 128°F

CURVES APPLICABLE FOR HEATUP RATES UP TO 60°F/HR FOR THE SERVICE PERIOD UP TO 15 EFPY.

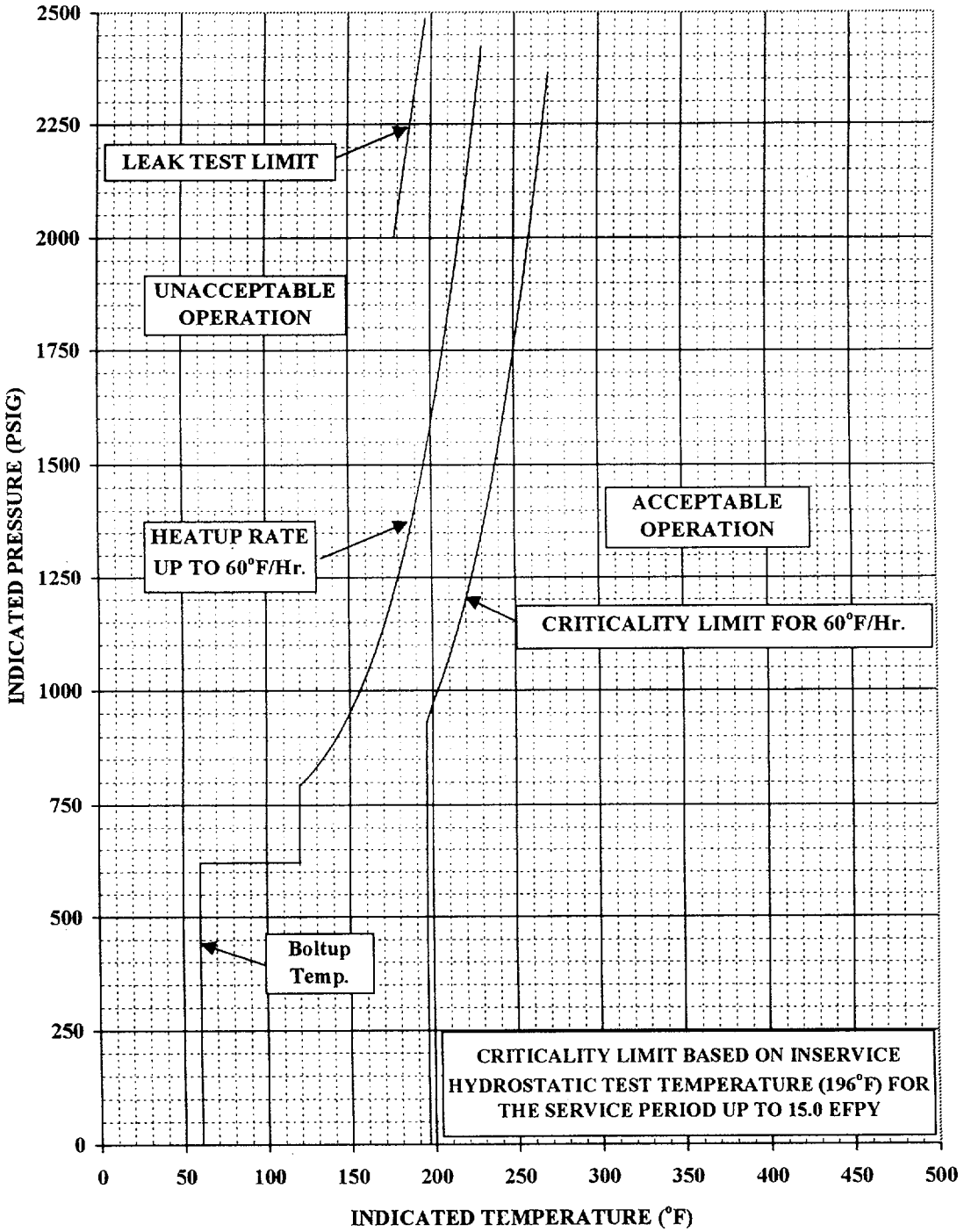

FIGURE 3.4-2
Beaver Valley Unit 2 Reactor Coolant System Heatup Limitations Applicable for the First 15 EFPY

MATERIAL PROPERTY BASIS

CONTROLLING MATERIAL: INTERMEDIATE SHELL PLATE B9004-1

INITIAL RT_{NDT}: 60°F

RT_{NDT} AFTER 15 EFPY: 1/4T, 140°F

3/4T, 128°F

CURVE APPLICABLE FOR COOLDOWN RATES UP TO 0°F/HR FOR THE SERVICE PERIOD UP TO 15 EFPY.

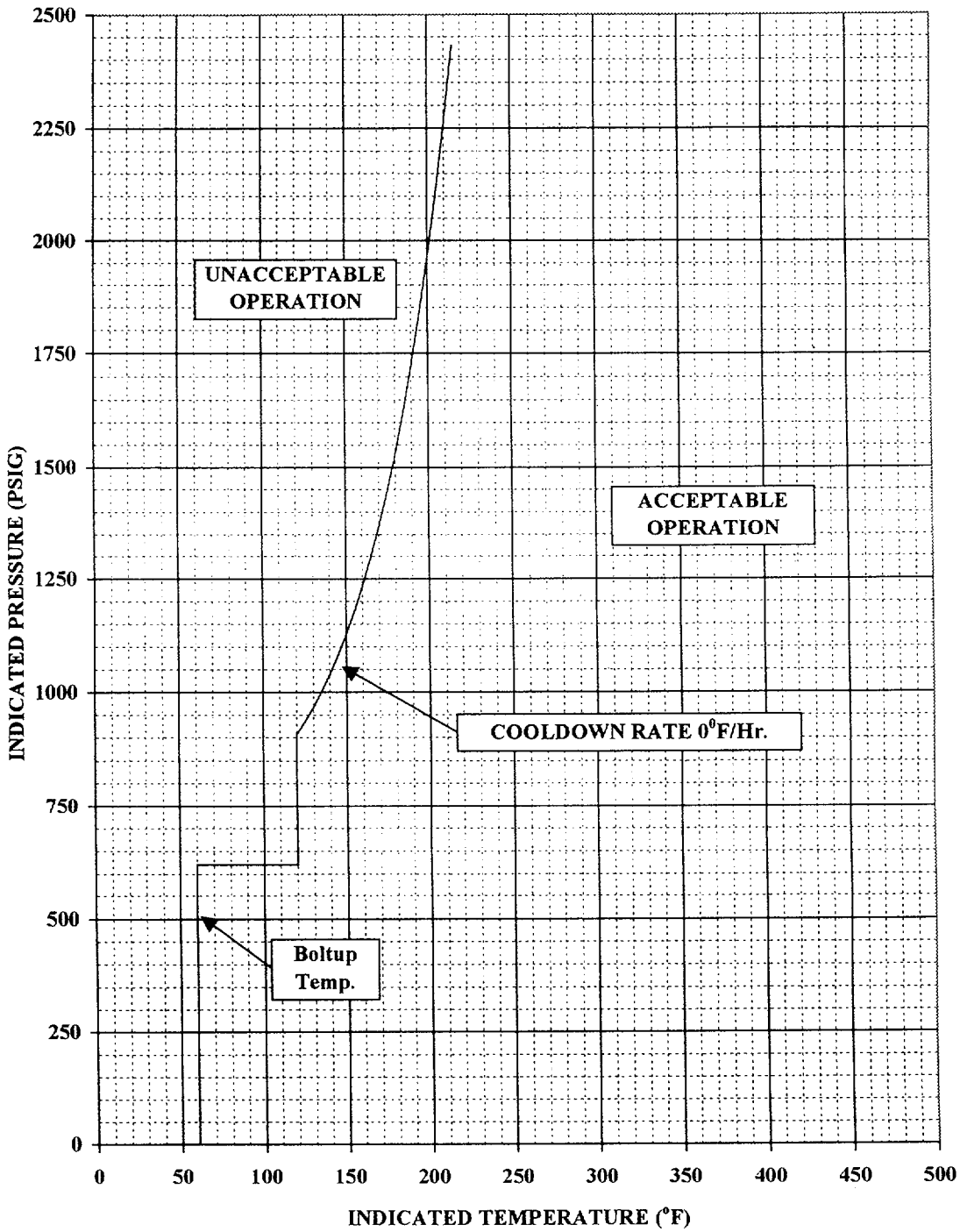

FIGURE 3.4-3 (Sheet 1 of 5)
Beaver Valley Unit 2 Reactor Coolant System Cooldown Limitations Applicable for the First 15 EFPY

MATERIAL PROPERTY BASIS

CONTROLLING MATERIAL: INTERMEDIATE SHELL PLATE B9004-1

INITIAL RT_{NDT}: 60°F

RT_{NDT} AFTER 15 EFPY: 1/4T, 140°F

3/4T, 128°F

CURVE APPLICABLE FOR COOLDOWN RATES UP TO 20°F/HR FOR THE SERVICE PERIOD UP TO 15 EFPY.

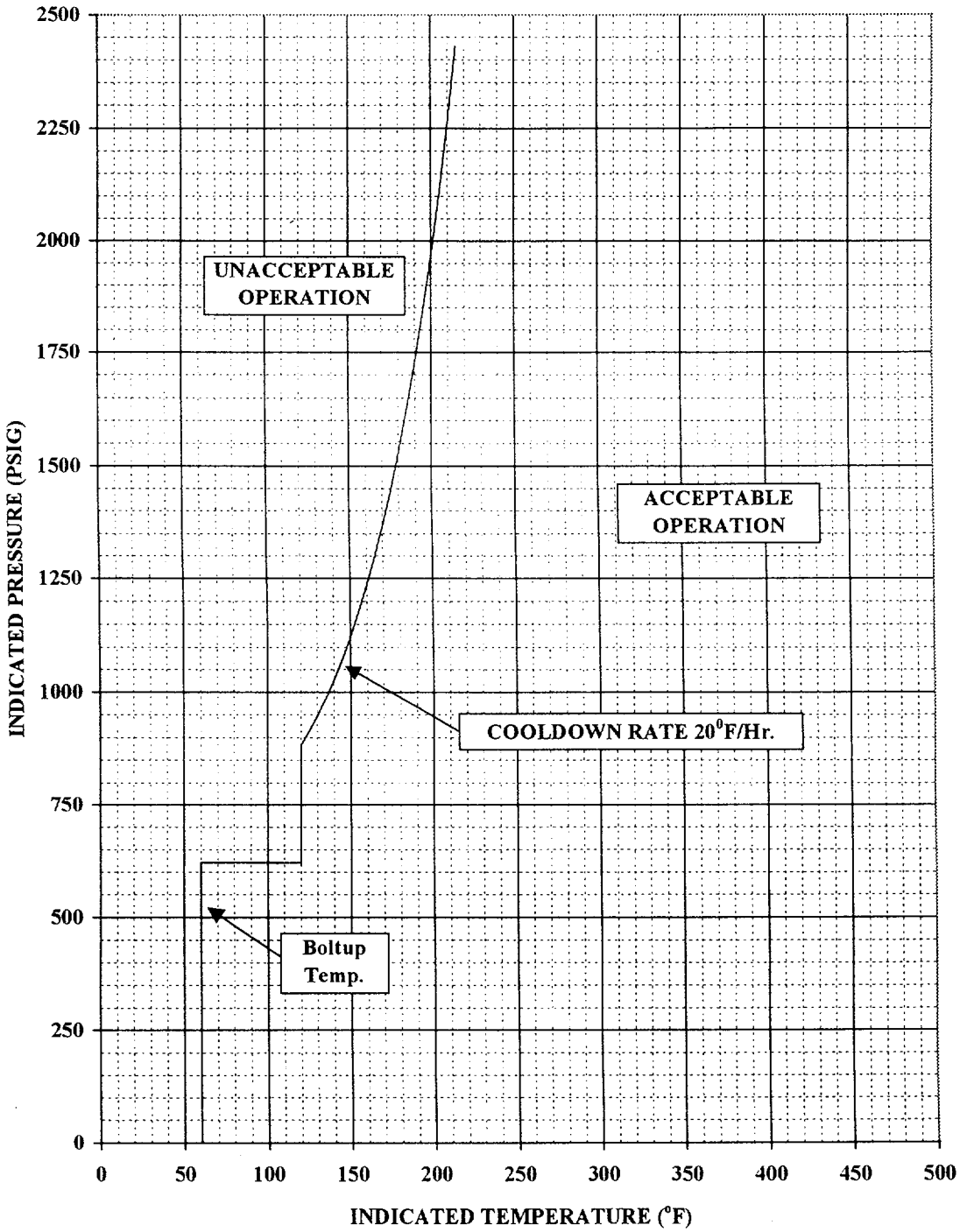

FIGURE 3.4-3 (Sheet 2 of 5)
Beaver Valley Unit 2 Reactor Coolant System Cooldown Limitations Applicable for the First 15 EFPY

MATERIAL PROPERTY BASIS

CONTROLLING MATERIAL: INTERMEDIATE SHELL PLATE B9004-1

INITIAL RT_{NDT}: 60°F

RT_{NDT} AFTER 15 EFPY: 1/4T, 140°F

3/4T, 128°F

CURVE APPLICABLE FOR COOLDOWN RATES UP TO 40°F/HR FOR THE SERVICE PERIOD UP TO 15 EFPY.

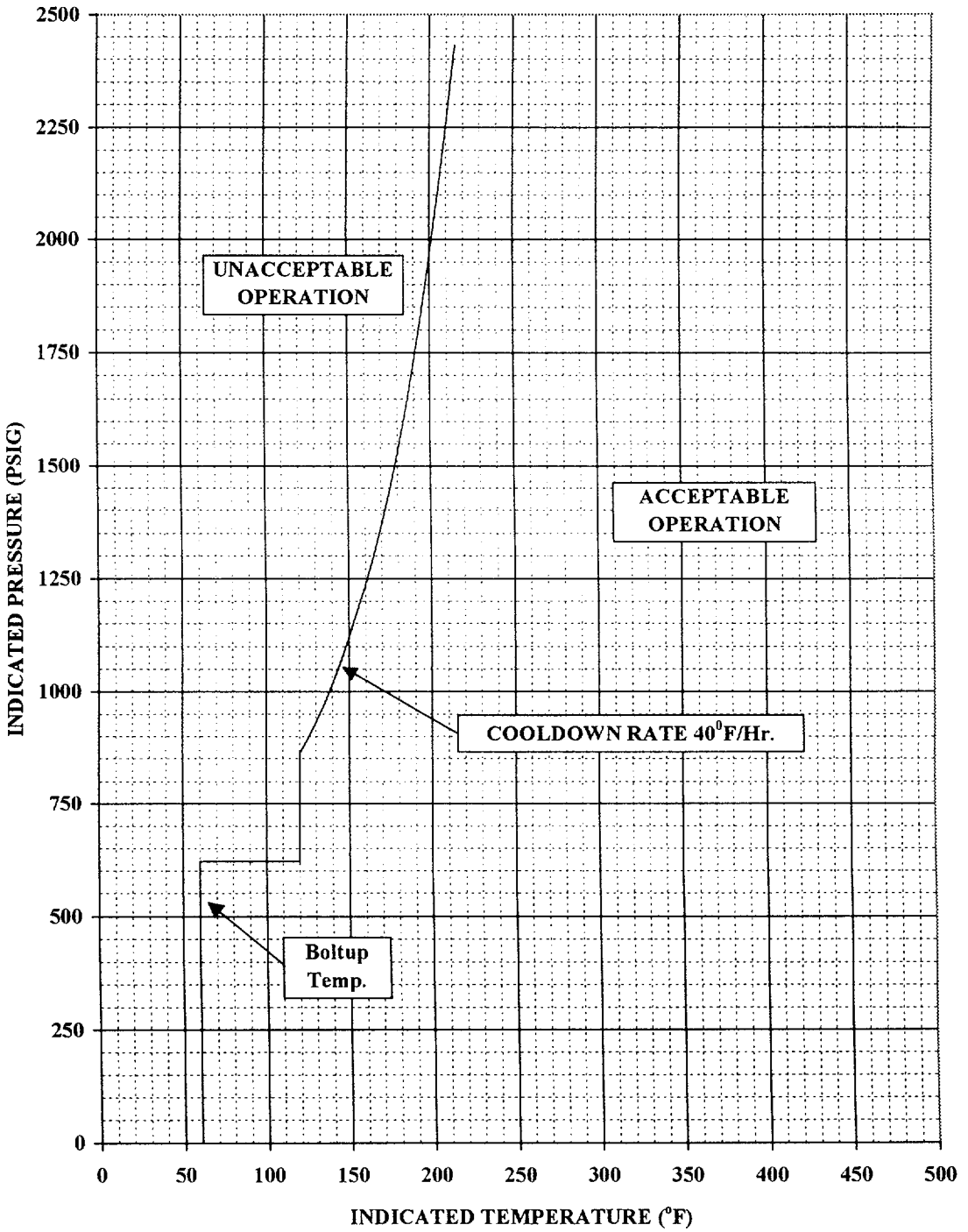

FIGURE 3.4-3 (Sheet 3 of 5)
Beaver Valley Unit 2 Reactor Coolant System Cooldown Limitations Applicable for the First 15 EFPY

MATERIAL PROPERTY BASIS

CONTROLLING MATERIAL: INTERMEDIATE SHELL PLATE B9004-1

INITIAL RT_{NDT}: 60°F

RT_{NDT} AFTER 15 EFPY: 1/4T, 140°F

3/4T, 128°F

CURVE APPLICABLE FOR COOLDOWN RATES UP TO 60°F/HR FOR THE SERVICE PERIOD UP TO 15 EFPY.

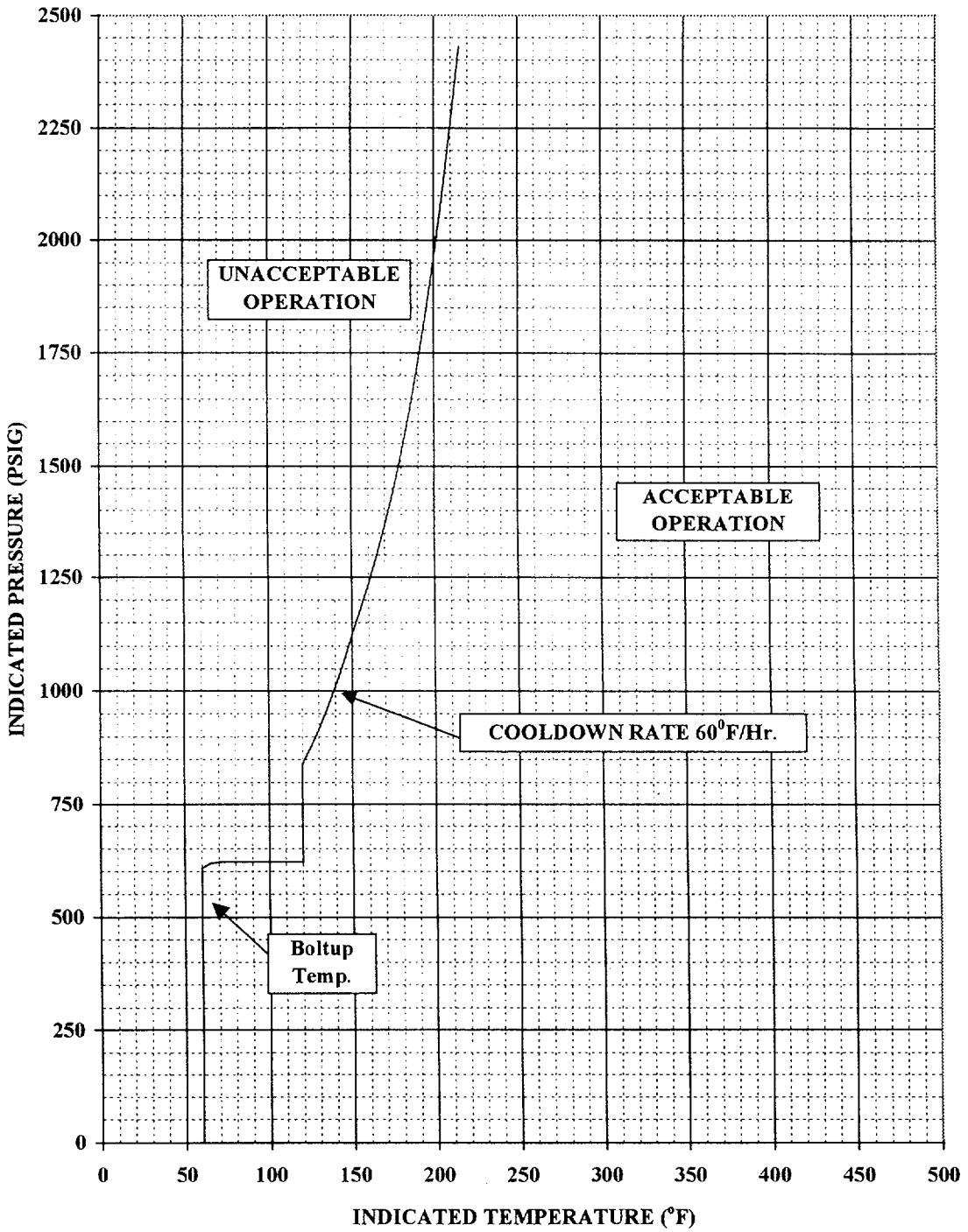

FIGURE 3.4-3 (Sheet 4 of 5)
Beaver Valley Unit 2 Reactor Coolant System Cooldown Limitations Applicable for the First 15 EFPY

MATERIAL PROPERTY BASIS

CONTROLLING MATERIAL: INTERMEDIATE SHELL PLATE B9004-1

INITIAL RT_{NDT}: 60°F

RT_{NDT} AFTER 15 EFPY: 1/4T, 140°F

3/4T, 128°F

CURVE APPLICABLE FOR COOLDOWN RATES UP TO 100°F/HR FOR THE SERVICE PERIOD UP TO 15 EFPY.

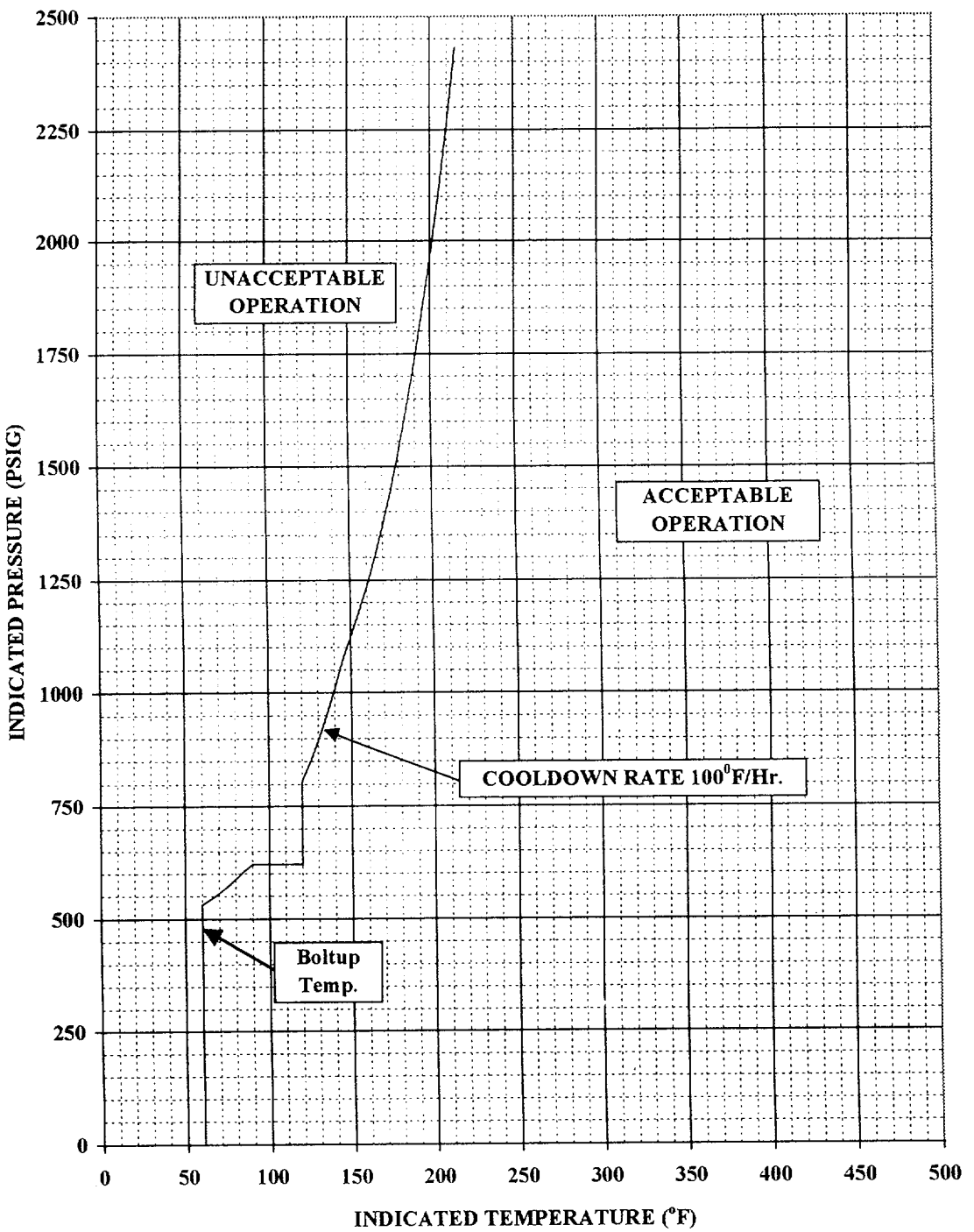

FIGURE 3.4-3 (Sheet 5 of 5)
Beaver Valley Unit 2 Reactor Coolant System Cooldown Limitations Applicable for the First 15 EFPY

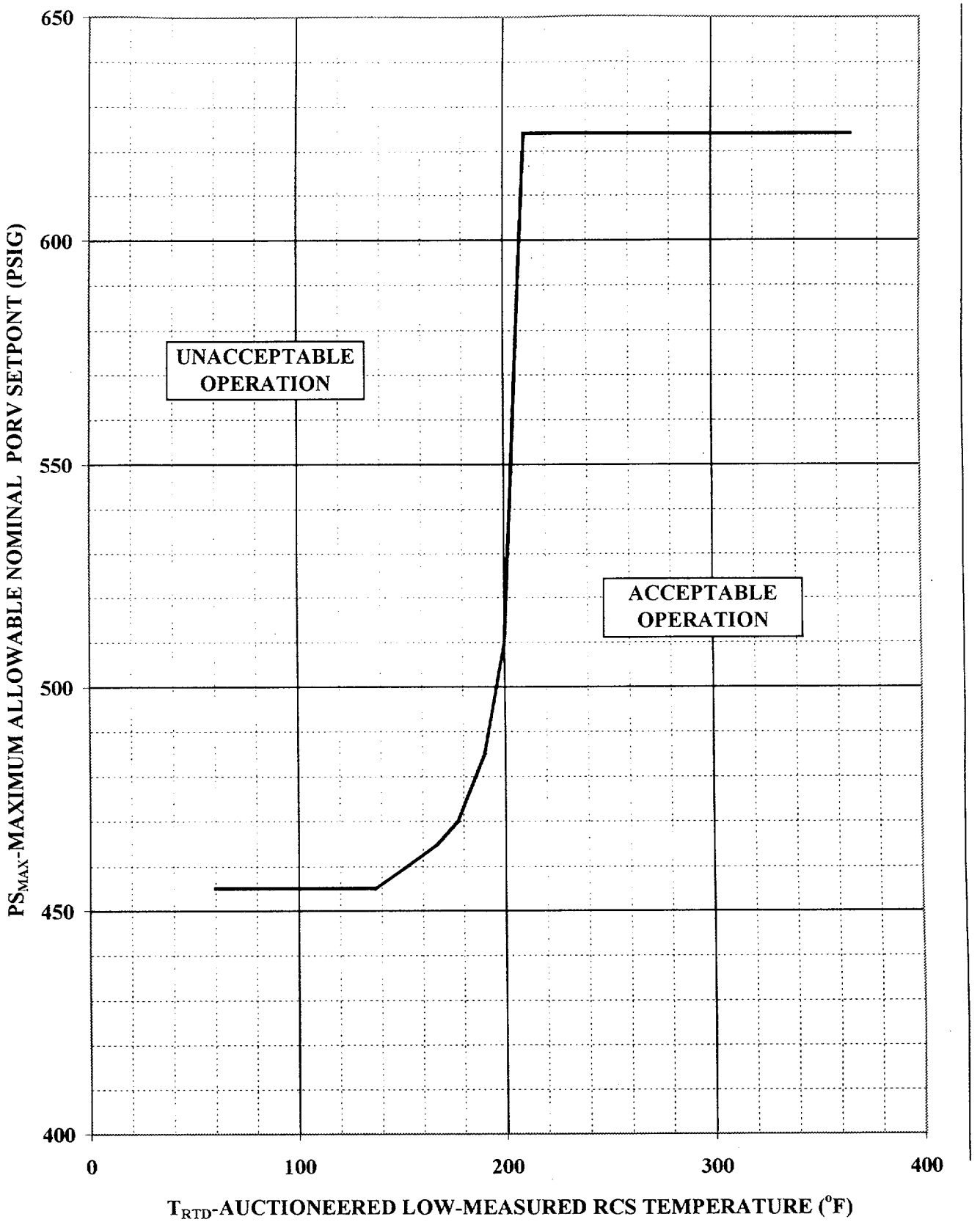

FIGURE 3.4-4

MAXIMUM ALLOWABLE NOMINAL PORV SETPOINT
FOR THE OVERPRESSURE PROTECTION SYSTEM

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

The heatup limit curve, Figure 3.4-2, is a composite curve which was prepared by determining the most conservative case, with either the inside or outside wall controlling, for any heatup rate up to 60°F per hour. The cooldown limit curves, Figures 3.4-3 (Sheets 1 through 5), are composite curves which were prepared based upon the same type analysis with the exception that the controlling location is always the inside wall where the cooldown thermal gradients tend to produce tensile stresses while producing compressive stresses at the outside wall. The heatup and cooldown curves were prepared based upon the most limiting value of the predicted adjusted reference temperature at the end of 15 EFPY.

The reactor vessel materials have been tested to determine their initial RT_{NDT}; the results of these tests are shown in Table B 3/4.4-1. Reactor operation and resultant fast neutron (E >1 Mev) irradiation will cause an increase in the RT_{NDT}. Therefore, an adjusted reference temperature, based upon the fluence, copper content and nickel content of the material in question, can be predicted using WCAP-15139 and Regulatory Guide 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials." The heatup and cooldown limit curves, Figures 3.4-2 and 3.4-3 (Sheets 1 through 5), include predicted adjustments for this shift in RT_{NDT}.

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 (T_{NDT}) 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 and nickel) present in reactor vessel steels. The Regulatory Guide 1.99 Revision 2 curves which show the effect of fluence and copper content on upper shelf energy (USE) for reactor vessel steels are shown in Figure B 3/4 4-1.

TABLE B 3/4.4-1
REACTOR VESSEL TOUGHNESS DATA[1]

COMPONENT	CODE NO.	MATERIAL SPEC. NO.	Cu %	Ni %	P %	T_{NDT} °F	50 FT/LB 35 MIL TEMP °F	RT_{NDT} °F	USE FT-LBS.
Closure Head Dome	B9008-1	A533B, CL. 1	.13	.54	.013	-20	50	-10	137
Closure Head Flange	B9002-1	A508, CL. 2	---	.74	.012	-10	<40	-10	136
Vessel Flange	B9001-1	A508, CL. 2	---	.73	.010	0	<10	0	132.5
Inlet Nozzle	B9011-1	A508, CL. 2	---	.88	.006	0	<10	0	104
Inlet Nozzle	B9011-2	A508, CL. 2	---	.88	.010	10	<10	10	115
Inlet Nozzle	B9011-3	A508, CL. 2	---	.84	.009	20	<40	20	122
Outlet Nozzle	B9012-1	A508, CL. 2	---	.71	.007	-10	< 0	-10	137
Outlet Nozzle	B9012-2	A508, CL. 2	---	.74	.006	-10	< 0	-10	121
Outlet Nozzle	B9012-3	A508, CL. 2	---	.68	.008	-10	< 0	-10	112
Nozzle Shell	B9003-1	A533B, CL. 1	.13	.61	.008	-10	110	50	91
Nozzle Shell	B9003-2	A533B, CL. 1	.12	.58	.009	0	120	60	79.5
Nozzle Shell	B9003-3	A533B, CL. 1	.13	.61	.008	-10	110	50	97.5
Inter. Shell	B9004-1	A533B, CL. 1	.07	.53	.010	0	120	60	83
Inter. Shell	B9004-2	A533B, CL. 1	.07	.59	.007	-10	100	40	75.5
Lower Shell	B9005-1	A533B, CL. 1	.08	.59	.009	-50	88	28	82
Lower Shell	B9005-2	A533B, CL. 1	.07	.58	.009	-40	93	33	77.5
Bottom Head Torus	B9010-1	A533B, CL. 1	.15	.49	.007	-30	56	-4	97
Bottom Head Dome	B9009-1	A533B, CL. 1	.14	.53	.007	-30	35	-25	116
Weld (Inter. & Lower Shell Long. Seams & Girth Seam)*			.08	.07	.008	-30	<30	-30	144.5
HAZ (Plate B9004-2)			---	---	----	-80	40	-20	76

* Same heat of wire and lot of flux used in all seams including surveillance weldment.

(1) For evaluation of Inservice Reactor Vessel Irradiation damage assessments, the best estimate chemistry values reported in the latest response to Generic Letter 92-01 or equivalent document are applicable.

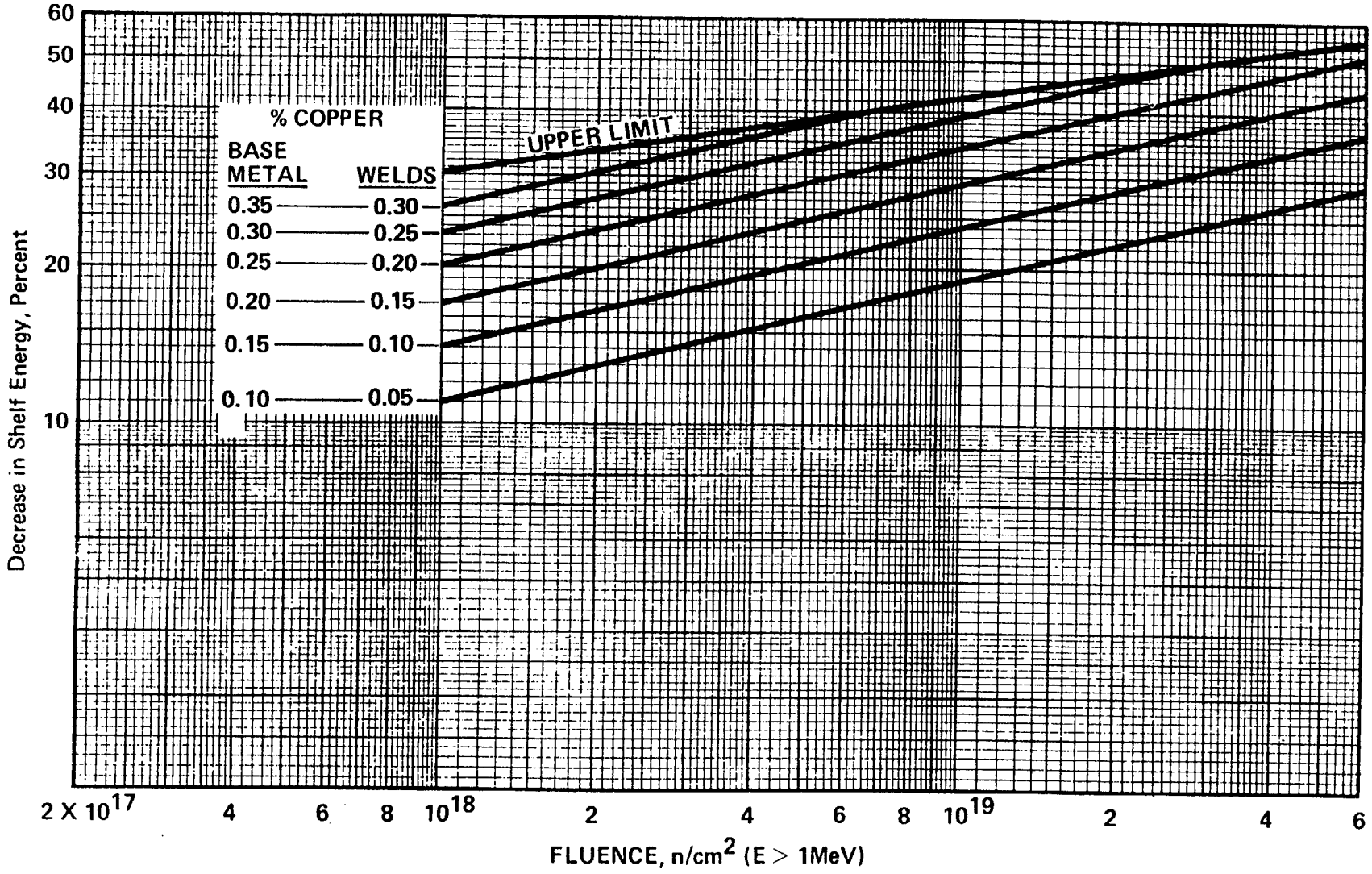

FIGURE B 3/4 4-1
PREDICTED DECREASE IN SHELF ENERGY AS A FUNCTION OF COPPER CONTENT AND FLUENCE

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

Given the copper and nickel contents of the most limiting material, the radiation-induced ΔRT_{NDT} can be predicted by the equation: $\Delta RT_{NDT} = (CF) f^{(0.28 - 0.1 \text{ Log } f)}$. Fast-neutron fluence (E > 1 Mev) at the 1/4 T (wall thickness) and 3/4 T (wall thickness) vessel locations can be generated as a function of full-power service life. 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 Beaver Valley Unit 2 reactor vessel materials are presented in Table B 3/4.4-1. The fracture toughness properties of the ferritic material in the reactor coolant pressure boundary are determined in accordance with the 1972 Summer Addenda to Section III of the ASME Boiler and Pressure Vessel Code.

The pressure-temperature limit curves are developed using Code Case N-640. One of the safety margins incorporated into the curves is the lower bound fracture toughness curve. The lower bound fracture toughness curves available in Appendix G to Section XI use the reference stress intensity factor K_{IA}. The pressure-temperature limit curves based on Code Case N-640 use the reference stress intensity factor K_{IC}. K_{IA} is a fracture toughness curve which is a lower bound on all static, dynamic and arrest fracture toughness, and K_{IC} is a fracture toughness curve which is a lower bound on static fracture toughness only. The only change that is made when generating the revised pressure-temperature limits curve with K_{IC} is the lower bound fracture toughness curve selected. All other margins involved in the generation process remain unchanged. Since the heatup and cooldown process is a very slow one, with the fastest rate allowed being 100°F per hour, the rate of change of pressure and temperature is considered constant so that the stress is essentially constant. Both heatup and cooldown correspond to static loading, with regard to fracture toughness. The only time when dynamic loading can occur and where the dynamic/arrest toughness K_{IA} should be used for the reactor pressure vessel is when a crack is running. This might happen during a pressurized thermal shock event, but not during heatup and cooldown. Therefore, the static toughness K_{IC} lower bound toughness is used to generate the pressure-temperature limit curves.

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 and cooldown cannot be greater than the reference stress intensity factor, K_{IC}, for the metal temperature at

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

that time. K_{IC} is obtained from the reference fracture toughness curve, defined by Code Case N-640. The K_{IC} curve is given by the equation:

$$K_{IC} = 33.2 + 20.734 * e^{[0.02(T-RT_{NDT})]} \quad (4\text{-}1)$$

where K_{IC} 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 by Code Case N-640 as follows:

$$C\ K_{IM} + K_{It} \leq K_{IC} \quad (4\text{-}2)$$

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
- K_{IC} is a function of temperature relative to the RT_{NDT} of the material
- 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_{IC} is determined by the metal temperature at the tip of the postulated flaw at the 1/4 T and 3/4 T location, 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 4-2, 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 increases 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.

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

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_{IC} 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_{IC} 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.

Heatup

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_{IC} for the 1/4 T crack during heatup is lower than the K_{IC} 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_{IC}'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.

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

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, as documented in WCAP-15139, are produced as follows: A composite curve is constructed 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.

The actual shift in RT_{NDT} of the vessel material will be established periodically during operation by removing and evaluating, in accordance with 10 CFR 50 Appendix H, reactor vessel material irradiation surveillance specimens installed near the inside wall of the reactor vessel in the core area. Since the neutron spectra at the irradiation samples and vessel inside radius are essentially identical, the measured transition shift for a sample can be applied with confidence to the adjacent section of the reactor vessel. The heatup and cooldown curves must be recalculated when the ΔRT_{NDT} determined from the surveillance capsule is different from the calculated ΔRT_{NDT} for the equivalent capsule radiation exposure.

The pressure-temperature limit lines shown on Figure 3.4-2 for reactor criticality and for inservice leak and hydrostatic testing have been provided to assure compliance with the minimum temperature requirements of Appendix G to 10 CFR 50 for reactor criticality and for inservice leak and hydrostatic testing. These pressure-temperature limit lines on Figures 3.4-2 and 3.4-3 (Sheets 1 through 5) for boltup temperature are provided to ensure compliance with the minimum temperature requirements of Appendix G to ASME Section XI for

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

vessel closure head flange boltup. It recommends that when the flange and adjacent shell region are stressed by the full intended bolt preload the minimum metal temperature in the stressed region is at least the initial RT_{NDT} temperature for the material in the stressed regions.

The number of reactor vessel irradiation surveillance specimens and the frequencies for removing and testing these specimens are provided in UFSAR Table 5.3-6 to assure compliance with the requirements of Appendix H to 10 CFR Part 50.

The limitations imposed on the pressurizer heatup and cooldown rates and auxiliary spray water temperature differential are provided to assure that the pressurizer is operated within the design criteria assumed for the fatigue analysis performed in accordance with the ASME Code requirements.

Pressure-temperature limit curves shown in Figure B 3/4 4-2 were developed for the limiting ferritic steel component within an isolated reactor coolant loop. The limiting component is the steam generator channel head to tubesheet region. This figure provides the ASME III, Appendix G limiting curve which is used to define operational bounds, such that when operating with an isolated loop the analyzed pressure-temperature limits are known. The temperature range provided bounds the expected operating range for an isolated loop and Code Case N-640.

OVERPRESSURE PROTECTION SYSTEMS

BACKGROUND

The overpressure protection system (OPPS) controls RCS pressure at low temperatures so the integrity of the reactor coolant pressure boundary (RCPB) is not compromised by violating the pressure and temperature (P/T) limits of 10 CFR 50, Appendix G. The reactor vessel is the limiting RCPB component for demonstrating such protection. The maximum setpoint for the power operated relief valves (PORVs) and the maximum RCS pressure for the existing RCS cold leg temperature during cooldown, shutdown, and heatup meet the 10 CFR 50, Appendix G requirements during the OPPS MODES.

The reactor vessel material is less tough at low temperatures than at normal operating temperature. As the vessel neutron exposure accumulates, the material toughness decreases and becomes less resistant to pressure stress at low temperatures. RCS pressure, therefore, is maintained low at low temperatures and is increased only as temperature is increased.

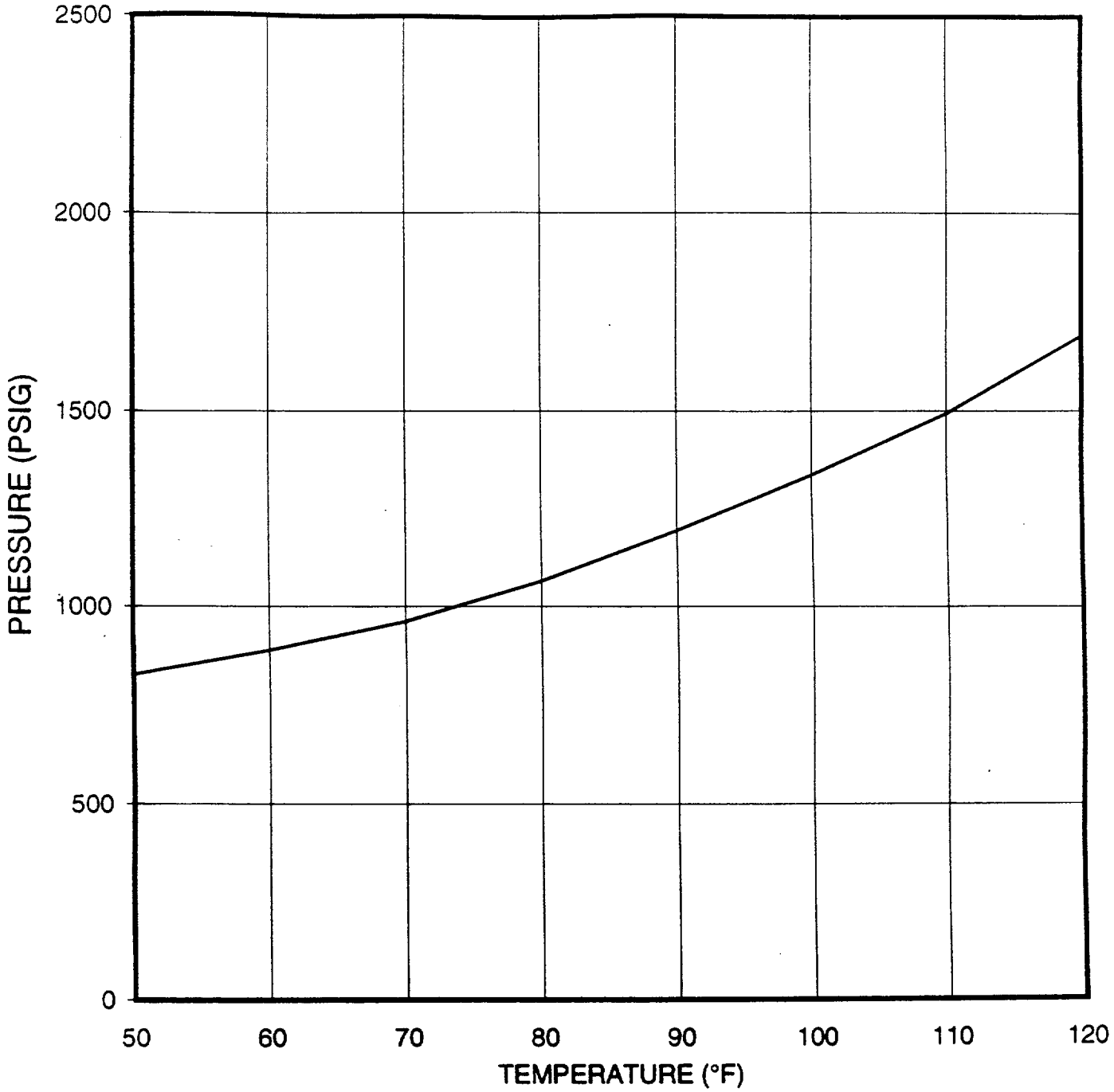

FIGURE B 3/4 4-2

ISOLATED LOOP PRESSURE-TEMPERATURE LIMIT CURVE

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

BACKGROUND (Continued)

The potential for vessel overpressurization is most acute when the RCS is water solid, occurring only during shutdown; 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.

LCO 3.4.9.3, "Overpressure Protection Systems," provides RCS overpressure protection by having a minimum coolant input capability and having adequate pressure relief capacity. Limiting coolant input capability requires deactivating all but one charging pump and isolating the accumulators. The pressure relief capacity requires either two redundant RCS relief valves or a depressurized RCS and an RCS vent of sufficient size. One RCS relief valve or the open RCS vent is the overpressure protection device that acts to terminate an increasing pressure event.

With minimum coolant input capability, the ability to provide core coolant addition is restricted. The LCO does not require the makeup control system deactivated or the safety injection (SI) actuation circuits blocked. Due to the lower pressures in the OPPS MODES and the expected core decay heat levels, the makeup system can provide adequate flow via the makeup control valve and, if needed, until the charging pump is actuated by SI.

The OPPS for pressure relief consists of two PORVs with reduced lift settings or a depressurized RCS and an RCS vent of sufficient size. Two RCS relief valves are required for redundancy. One RCS relief valve has adequate relieving capability to keep from overpressurization for the required coolant input capability.

PORV REQUIREMENTS

As designed for the OPPS System, each PORV is signaled to open if the RCS pressure approaches a limit determined by the OPPS actuation logic. The OPPS actuation logic monitors both RCS temperature and RCS pressure and determines when a condition not acceptable in the limits is approached. The wide range RCS temperature indications are auctioneered to select the lowest temperature signal. The lowest temperature signal is processed through a function generator that calculates a pressure limit for that temperature. The calculated pressure limit is then compared with the indicated RCS pressure from a wide range pressure channel. If the indicated pressure meets or exceeds the calculated value, a PORV is signaled to open. Having the setpoints of both valves within the limits ensures that the Appendix G limits will not be exceeded in any analyzed event. When a

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

PORV REQUIREMENTS (Continued)

PORV is opened in an increasing pressure transient, the release of coolant will cause the pressure increase to slow and reverse. As the PORV releases coolant, the RCS pressure decreases until a reset pressure is reached and the valve is signaled to close. The pressure continues to decrease below the reset pressure as the valve closes.

The low limit on pressure during the transient is typically established based solely on an operational consideration for the Reactor Coolant Pump (RCP) No. 1 seal to maintain a nominal differential pressure across the seal faces for proper film-riding performance. The upper limit (based on the minimum of the steady-state 10 CFR 50 Appendix G requirement and the PORV piping limitations) and the RCP No. 1 seal performance criteria create a pressure range from which the setpoints for both PORVs are selected. When there is insufficient range between the upper and lower pressure limits to select the PORV setpoints to provide protection against violating both limits, setpoint selection to provide protection against the upper limit violation takes precedence.

RCS VENT REQUIREMENTS

Once the RCS is depressurized, a vent exposed to the containment atmosphere will maintain the RCS at containment ambient pressure in an RCS overpressure transient, if the relieving requirements of the transient do not exceed the capabilities of the vent. Thus, the vent path must be capable of relieving the flow resulting from the limiting OPPS mass or heat input transient, and maintaining pressure below the P/T limits. The required vent capacity may be provided by one or more vent paths.

For an RCS vent to meet the flow capacity requirement, it may be satisfied by removing a pressurizer safety valve or establishing an opening between the RCS and the containment atmosphere of the required size through any positive means available which cannot be inadvertently defeated. The vent path(s) must be above the level of reactor coolant, so as not to drain the RCS when open.

APPLICABLE SAFETY ANALYSES

Safety analyses demonstrate that the reactor vessel is adequately protected against exceeding the P/T limits when low RCS temperature conditions exist. At the enable temperature and below, overpressure prevention is provided by two OPERABLE RCS relief valves or a depressurized RCS and a sufficient sized RCS vent.

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

APPLICABLE SAFETY ANALYSES (Continued)

The actual temperature at which the pressure in the P/T limit curve falls below the OPPS setpoint increases as the reactor vessel material toughness decreases due to neutron embrittlement. Each time the heatup and cooldown curves are revised, the OPPS must be re-evaluated to ensure its functional requirements can still be met.

The heatup and cooldown curves represent the Appendix G limits that define OPPS operation. Any change to the RCS that may affect OPPS operation must be evaluated against the analyses to determine the impact of the change on the OPPS acceptance limits.

Transients that are capable of overpressurizing the RCS are categorized as either mass or heat input transients, examples of which follow:

MASS INPUT TYPE TRANSIENTS

a. Inadvertent safety injection; or

b. Charging/letdown flow mismatch.

HEAT INPUT TYPE TRANSIENTS

a. Inadvertent actuation of pressurizer heaters;

b. Loss of RHR cooling; or

c. Reactor coolant pump (RCP) startup with temperature asymmetry within the RCS or between the RCS and steam generators.

The following are required during the OPPS MODES to ensure that mass and heat input transients do not occur, which either of the OPPS overpressure protection means cannot handle:

a. Deactivating all but one charging pump OPERABLE;

b. Deactivating the accumulator discharge isolation valves in their closed positions; and

c. Disallowing start of an RCP if secondary temperature is more than 50°F above primary temperature in any one loop. LCO 3.4.1.6, "Reactor Coolant Pump Startup," provides this protection.

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

HEAT INPUT TYPE TRANSIENTS (Continued)

The analyses demonstrate that either one RCS relief valve or the depressurized RCS and RCS vent can maintain the RCS pressure below the limits when only one charging pump is actuated by SI. Thus, the LCO allows only one charging pump OPERABLE during the OPPS MODES. Since neither one RCS relief valve nor the RCS vent can handle a full SI actuation, the LCO also requires the accumulators isolated.

The isolated accumulators must have their discharge valves closed with power removed. Fracture mechanics analyses established the temperature of OPPS Applicability at the enable temperature.

PORV PERFORMANCE

The fracture mechanics analyses show that the vessel is protected when the PORVs are set to open at or below the limit. The setpoint is derived by analyses that model the performance of the OPPS assuming the limiting transient of SI actuation of one charging pump. These analyses consider pressure overshoot and undershoot beyond the PORV opening and closing, resulting from signal processing and valve stroke times. The PORV setpoints at or below the derived limit ensure the P/T limits will be met.

The Maximum Allowed Nominal PORV Setpoint for the OPPS is derived by analysis which models the performance of the OPPS assuming various mass input and heat input transients. Operation with a PORV setpoint less than or equal to the maximum allowable nominal setpoint ensures that Appendix G limits will not be violated with consideration for: (1) a maximum pressure overshoot beyond the PORV setpoint which can occur as a result of time delays in signal processing and valve opening; (2) a 50°F heat transport effect made possible by the geometrical relationship of the reactor vessel and the RCS wide range temperature indicator used for OPPS; (3) instrument uncertainties; (4) single failure; and (5) the pressure difference between the wide range pressure transmitter and the reactor vessel limiting beltline region.

The PORV setpoint will be updated when the revised P/T limits conflict with the OPPS analysis limits. The P/T limits are periodically modified as the reactor vessel material toughness decreases due to neutron embrittlement caused by neutron irradiation. Revised limits are determined using neutron fluence projections and the results of examinations of the reactor vessel material irradiation surveillance specimens. The Bases for LCO 3.4.9.1, "Pressure/Temperature Limits," discuss these examinations.

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

PORV PERFORMANCE (Continued)

The PORVs are considered active components. Thus, the failure of one PORV is assumed to represent the worst case, single active failure.

RCS VENT PERFORMANCE

With the RCS depressurized, analyses show that a PORV or equivalent opening with a vent size of 3.14 square inches is capable of mitigating the allowed OPPS overpressure transient. The capacity of a vent this size is greater than the flow of the limiting transient for the OPPS configuration, SI actuation with one charging pump OPERABLE, maintaining RCS pressure less than the maximum pressure on the P/T limit curve.

The RCS vent size is based on the PORV size, therefore, the vent is bounded by the PORV analyses.

The RCS vent is passive and is not subject to active failure.

LCO

This LCO requires that the OPPS is OPERABLE. The OPPS is OPERABLE when the minimum coolant input and pressure relief capabilities are OPERABLE. Violation of this LCO could lead to the loss of low temperature overpressure mitigation and violation of the limits as a result of an operational transient.

The Maximum Allowable Nominal Setpoint Curve defines the maximum nominal setpoint at which the PORVs can be set which will ensure that Appendix G limits are not exceeded. To maximize operating margin, the setpoint for the higher PORV is set at the Maximum Allowable Nominal Operating Curve within the respective instrumentation loop calibration tolerance band. The PORV setpoint uncertainty is calculated with reference to the methodology in ISA 67.04-1994 for performing instrumentation uncertainty calculations. The instrumentation calibration tolerances are provided in plant procedures. The overall setpoint calculation accounts for the instrumentation calibration tolerances in the uncertainty calculation.

Since actuation of both PORVs can result in excessive undershoot below the PORV setpoint, the lower PORV setpoints are staggered by an amount greater than or equal to the limiting overshoot (from either the mass injection or heat addition events). The staggered setpoints are provided in plant procedures.

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

LCO (Continued)

To limit the coolant input capability, the LCO requires one charging pump capable of injecting into the RCS and all accumulator discharge isolation valves closed and immobilized. The LCO is qualified by a note that permits two pumps capable of RCS injection for less than or equal to 15 minutes to allow for pump swaps. This note also allows all charging pumps capable of injecting into the RCS during a change from MODE 3 to MODE 4 to be OPERABLE for a limited period of time.

The LCO is also qualified by a note stating that accumulator isolation with power removed from the discharge isolation valves is only required when the accumulator pressure is greater than or at the maximum RCS pressure for the existing temperature, as allowed by the P/T limit curves. This note permits the accumulator discharge isolation valve surveillance to be performed only under these pressure and temperature conditions.

Operation above 350°F but less than 375°F with only one centrifugal charging pump OPERABLE is allowed for up to 4 hours. As shown by analysis, LOCAs occurring at low temperature, low pressure conditions can be successfully mitigated by the operation of a single centrifugal charging pump and a single LHSI pump with no credit for accumulator injection. Given the short time duration that the condition of having only one centrifugal charging pump OPERABLE is allowed and the probability of a LOCA occurring during this time, the failure of the single centrifugal charging pump is not assumed.

Operation below 350°F but greater than 325°F with all centrifugal charging pumps OPERABLE is allowed for up to 4 hours immediately following a change from MODE 3 to MODE 4. This provides a reasonable period of time for the operators to secure an OPERABLE pump following entry into MODE 4. Since the charging pump is required to be OPERABLE in MODE 3, but is not required in MODE 4 due to OPPS limitations, some time constraints for making the transition must be identified. During low pressure, low temperature operation, all automatic Safety Injection actuation signals are blocked. In normal conditions, a single failure of the ESF actuation circuitry will result in the starting of at most one train of Safety Injection (one centrifugal charging pump, and one LHSI pump). For temperatures above 325°F, an overpressure event occurring as a result of starting these two pumps can be successfully mitigated by operation of both PORVs without exceeding Appendix G limits. Given the short time duration that this condition is allowed and the low probability of a single failure causing an overpressure event during this time, the single failure of a PORV is not assumed. Initiation of both trains

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

LCO (Continued)

of Safety Injection during this 4-hour time frame due to operator error or a single failure occurring during testing of a redundant channel are not considered to be credible accidents.

The elements of the LCO that provide low temperature overpressure mitigation through pressure relief are:

a. Two OPERABLE PORVS; a PORV is OPERABLE for OPPS when its block valve is open, its lift setpoint is set to the limit and testing proves its ability to open at this setpoint, and motive power is available to the two valves and their control circuits; or

b. A depressurized RCS and an RCS vent.

An RCS vent is OPERABLE when open with an area of 3.14 square inches.

Each of these methods of overpressure prevention is capable of mitigating the limiting OPPS transient.

APPLICABILITY

This LCO is applicable in MODE 4 when any RCS cold leg temperature is less than or equal to the enable temperature, in MODE 5, and in MODE 6 when the reactor vessel head is on. When the reactor vessel head is off, overpressurization cannot occur.

Low temperature overpressure prevention is most critical during shutdown when the RCS is water solid, and a mass or heat input transient can cause a very rapid increase in RCS pressure when little or no time allows operator action to mitigate the event.

ACTION

a. With two or more charging pumps capable of injecting into the RCS, RCS overpressurization is possible.

   To immediately initiate action to restore restricted coolant input capability to the RCS reflects the urgency of removing the RCS from this condition.

b. An unisolated accumulator requires isolation within 1 hour. This is only required when the accumulator pressure is at or more than the maximum RCS pressure for the existing temperature allowed by the P/T limit curves.

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

ACTION (Continued)

If isolation is needed and cannot be accomplished in 1 hour, the ACTION provides two options, either of which must be performed in the next 12 hours. By increasing the RCS temperature to more than the enable temperature, the accumulator pressure cannot exceed the OPPS limits if the accumulators are fully injected. Depressurizing the accumulators below the OPPS limit also gives this protection.

The completion times are based on operating experience that these activities can be accomplished in these time periods indicating that an event requiring OPPS is not likely in the allowed times.

c. In MODE 4 when any RCS cold leg temperature is less than or equal to the enable temperature, with one required RCS relief valve inoperable, the RCS relief valve must be restored to OPERABLE status within a completion time of 7 days. Two RCS relief valves are required to provide low temperature overpressure mitigation while withstanding a single failure of an active component. The exception to Specification 3.0.4 will permit plant heatup with one inoperable PORV. Continued operation is permitted with one PORV inoperable.

The completion time considers the facts that only one of the RCS relief valves is required to mitigate an overpressure transient and that the likelihood of an active failure of the remaining valve path during this time period is very low. If plant operation results in transitioning to MODE 5, the completion time to restore an inoperable PORV may not exceed 7 days as required by this ACTION.

d. The consequences of operational events that will overpressurize the RCS are more severe at lower temperature. Thus, with one of the two RCS relief valves inoperable in MODE 5 or in MODE 6 with the head on, the completion time to restore two valves to OPERABLE status is 24 hours.

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

ACTION (Continued)

The completion time represents a reasonable time to investigate and repair several types of relief valve failures without exposure to a lengthy period with only one OPERABLE RCS relief valve to protect against overpressure events. If a PORV is inoperable when the plant enters MODE 5 from MODE 4, the completion time to restore an inoperable PORV changes to 24 hours but the cumulative inoperable time may not exceed 7 days before taking action to depressurize and vent.

e. The RCS must be depressurized and a vent must be established within 12 hours when both required RCS relief valves are inoperable. The vent must be sized greater than or equal to 3.14 square inches to ensure that the flow capacity is greater than that required for the worst case mass input transient reasonable during the applicable MODES. This action is needed to protect the RCPB from a low temperature overpressure event and a possible brittle failure of the reactor vessel.

The completion time considers the time required to place the plant in this condition and the relatively low probability of an overpressure event during this time period due to increased operator awareness of administrative control requirements.

SURVEILLANCE REQUIREMENTS (SR)

SR 4.4.9.3.1

To minimize the potential for a low temperature overpressure event by limiting the mass input capability, a maximum of one charging pump is OPERABLE with the others verified deactivated with power removed and the accumulator discharge isolation valves are verified closed and locked out.

The frequency of 12 hours is sufficient, considering other indications and alarms available to the operator in the control room, to verify the required status of the equipment.

SR 4.4.9.3.1.b allows opening the accumulator discharge isolation valves to perform accumulator discharge check valve testing.

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

SURVEILLANCE REQUIREMENTS (SR) (Continued)

SR 4.4.9.3.2

The PORV block valve must be verified open every 72 hours to provide the flow path for each required PORV to perform its function when actuated. The valve must be remotely verified open in the main control room. This surveillance is performed if the PORV satisfies the LCO.

The block valve is a remotely controlled, motor operated valve. The power to the valve operator is not required removed, and the manual operator is not required locked in the inactive position. Thus, the block valve can be closed in the event the PORV develops excessive leakage or does not close (sticks open) after relieving an overpressure situation.

The 72 hour frequency is considered adequate in view of other administrative controls available to the operator in the control room, such as valve position indication, that verify that the PORV block valve remains open.

The SR is required to be performed prior to entering the condition for the OPPS to be OPERABLE. This assures low temperature overpressure protection is available when the RCS cold leg temperature is less than or equal to the enable temperature. Performing the surveillance every 31 days on each required PORV permits verification and adjustment, if necessary, of its lift setpoint, and considers instrumentation reliability which has been shown through operating experience to be acceptable. The CHANNEL FUNCTIONAL TEST will verify the setpoint is within the allowed maximum limits. PORV actuation could depressurize the RCS and is not required.

Performance of a CHANNEL CALIBRATION on each required PORV actuation channel is required every 18 months to adjust the whole channel so that it responds and the valve opens within the required range and accuracy to known input.

3/4.4.9 PRESSURE/TEMPERATURE LIMITS (Continued)

SURVEILLANCE REQUIREMENTS (SR) (Continued)

SR 4.4.9.3.3

The RCS vent of greater than or equal to 3.14 square inches is proven OPERABLE by verifying its open condition either:

a. Once every 12 hours for an open vent or valve that cannot be locked, except

b. Once every 31 days for a valve that is locked, or provided with remote position indication, or sealed, or secured in position. A removed pressurizer safety valve fits this category.

The passive vent arrangement must only be open to be OPERABLE. This surveillance is required to be performed if the vent is being used to satisfy the pressure relief requirements of the LCO.

3/4.4.10 STRUCTURAL INTEGRITY

The inservice inspection and testing programs for ASME Code Class 1, 2 and 3 components ensure that the structural integrity and operational readiness of these components will be maintained at an acceptable level throughout the life of the plant. These programs are in accordance with Section XI of the ASME Boiler and Pressure Vessel Code and applicable Addenda as required by 10 CFR Part 50.55a(g) except where specific written relief has been granted by the Commission pursuant to 10 CFR Part 50.55a (g)(6)(i).