ATTACHMENT B

RPV Thermal and Pressurization Limits
Revised Technical Specification Pages:

123
124
124A
125
128
128A
128B
139
139A

3.6 PRIMARY SYSTEM BOUNDARY

Applicability:

Applies to the operating status of the reactor coolant system.

Objective:

To assure the integrity and safe operation of the reactor coolant system

Specification:

A. Thermal and Pressurization Limitations

1. The average rate of reactor coolant temperature change during normal heatup or cooldown shall not exceed 100°F/hr when averaged over a one-hour period except when the vessel temperatures are above 450°F. The reactor vessel flange to adjacent reactor vessel shell temperature differential shall not exceed 145°F.

2. The reactor vessel shall not be pressurized for hydrostatic and/or leakage tests, and critical core operation shall not be conducted unless the reactor vessel temperatures are above those defined by the appropriate curves on Figures 3.6.1, 3.6.2, and 3.6.3. (Linear interpolation between curves is permitted). At stated pressure, the reactor vessel bottom head may be maintained at temperatures below those temperatures corresponding to the adjacent reactor vessel shell as shown in Figures 3.6.1 and 3.6.2.

4.6. PRIMARY SYSTEM BOUNDARY

Applicability:

Applies to the periodic examination and testing requirements for the reactor cooling system.

Objective:

To determine the condition of the reactor coolant system and the operation of the safety devices related to it.

Specification:

A. Thermal and Pressurization Limitations

1. During heatups and cooldowns, with the reactor vessel temperature less than or equal to 450°F, the temperatures at the following locations shall be permanently logged at least every 15 minutes until the difference between any two readings at individual locations taken over a 45 minute period is less than 5°F:

   a. Reactor vessel shell adjacent to reactor vessel flange

   b. Reactor vessel shell flange

   c. Recirculation loops A and B

2. Reactor vessel shell temperatures, including reactor vessel bottom head, and reactor coolant pressure shall be permanently logged at least every 15 minutes whenever the shell temperature is below 220°F and the reactor vessel is not vented.

   Test specimens of the reactor vessel base, weld and heat affected zone metal subjected to the highest fluence of greater than 1 Mev neutrons shall be installed in the reactor vessel adjacent to the vessel wall at the core midplane level. The specimens and sample program shall conform to the

3.6.A Thermal and Pressurization Limitations (Cont'd)

In the event this requirement is not met, achieve stable reactor conditions with reactor vessel temperature above that defined by the appropriate curve and obtain an engineering evaluation to determine the appropriate course of action to take.

3. The reactor vessel head bolting studs shall not be under tension unless the temperature of the vessel head flange and the head is greater than 55°F.

4. The pump in an idle recirculation loop shall not be started unless the temperatures of the coolant within the idle and operating recirculation loops are within 50°F of each other.

5. The reactor recirculation pumps shall not be started unless the coolant temperatures between the dome and the bottom head drain are within 145°F.

6. Thermal-Hydraulic Stability

Core thermal power shall not exceed 25% of rated thermal power without forced recirculation.

B. Coolant Chemistry

1. The reactor coolant system radioactivity concentration in water shall not exceed 20 microcuries of total iodine per ml of water.

4.6.A Thermal and Pressurization Limitations (Cont'd)

requirements of ASTM E 185-66. Selected neutron flux specimens shall be removed at the frequency required by Table 4.6.3 and tested to experimentally verify adjustments to Figures 3.6.1, 3.6.2, and 3.6.3 for predicted NDT temperature irradiation shifts.

3. When the reactor vessel head bolting studs are tensioned and the reactor is in a Cold Condition, the reactor vessel shell temperature immediately below the head flange shall be permanently recorded.

4. Prior to and during startup of an idle recirculation loop, the temperature of the reactor coolant in the operating and idle loops shall be permanently logged.

5. Prior to starting a recirculation pump, the reactor coolant temperatures in the dome and in the bottom head drain shall be compared and permanently logged.

B. Coolant Chemistry

1. a. A reactor coolant sample shall be taken at least every 96 hours and analyzed for radioactivity content.

b. Isotopic analysis of a reactor coolant sample shall be made at least once per month.

LIMITING CONDITION FOR OPERATION	SURVEILLANCE REQUIREMENTS
3.6.B Coolant Chemistry (Cont'd)	4.6.B Coolant Chemistry (Cont'd)
2. The reactor coolant water shall not exceed the following limits with steaming rates less than 100,000 pounds per hour, except as specified in 3.6.B.3: Conductivity ... 2 μmho/cm Chloride ion ... 0.1 ppm	2. During startups and at steaming rates less than 100,000 pounds per hour, a sample of reactor coolant shall be taken every four hours and analyzed for chloride content.
3. For reactor startups and for the first 24 hours after placing the reactor in the power operating condition, the following limits shall not be exceeded. Conductivity. . . 10 μmho/cm Chloride ion. . . 0.1 ppm	3. a. With steaming rates of 100,000 pounds per hour or greater, a reactor coolant sample shall be taken at least every 96 hours and analyzed for chloride ion content. b. When all continuous conductivity monitors are inoperable, a reactor coolant sample shall be taken at least daily and analyzed for conductivity and chloride ion content.
4. Except as specified in 3.6.B.3 above, the reactor coolant water shall not exceed the following limits when operating with steaming rates greater than or equal to 100,000 pounds per hour. Conductivity. . . 10 μmho/cm Chloride ion. . . 1.0 ppm	
5. If Specification 3.6.B cannot be met, an orderly shutdown shall be initiated and the reactor shall be in Hot Shutdown within 24 hrs. and Cold Shutdown within the next 8 hours.	
C. Coolant Leakage	C. Coolant Leakage
1. Any time irradiated fuel is in the reactor vessel and reactor coolant temperature is above 212°F, reactor coolant leakage into the primary containment from unidentified sources shall not exceed 5 gpm. In addition, the total reactor coolant system leakage into the primary containment shall not exceed 25 gpm	1. Reactor coolant system leakage shall be checked by the sump and air sampling system and recorded at least once per day.
2. Both the sump and air sampling systems shall be operable during reactor power operation. From and after the date that one of these systems is made or found to be inoperable for any reason, reactor	

TABLE 4.6.3
REACTOR VESSEL MATERIAL
SURVEILLANCE PROGRAM WITHDRAWAL SCHEDULE

Capsule Number	Effective Full Power Years (EFPY)
1	4.17
2	15 (approx.)
3	32 (End of Life)

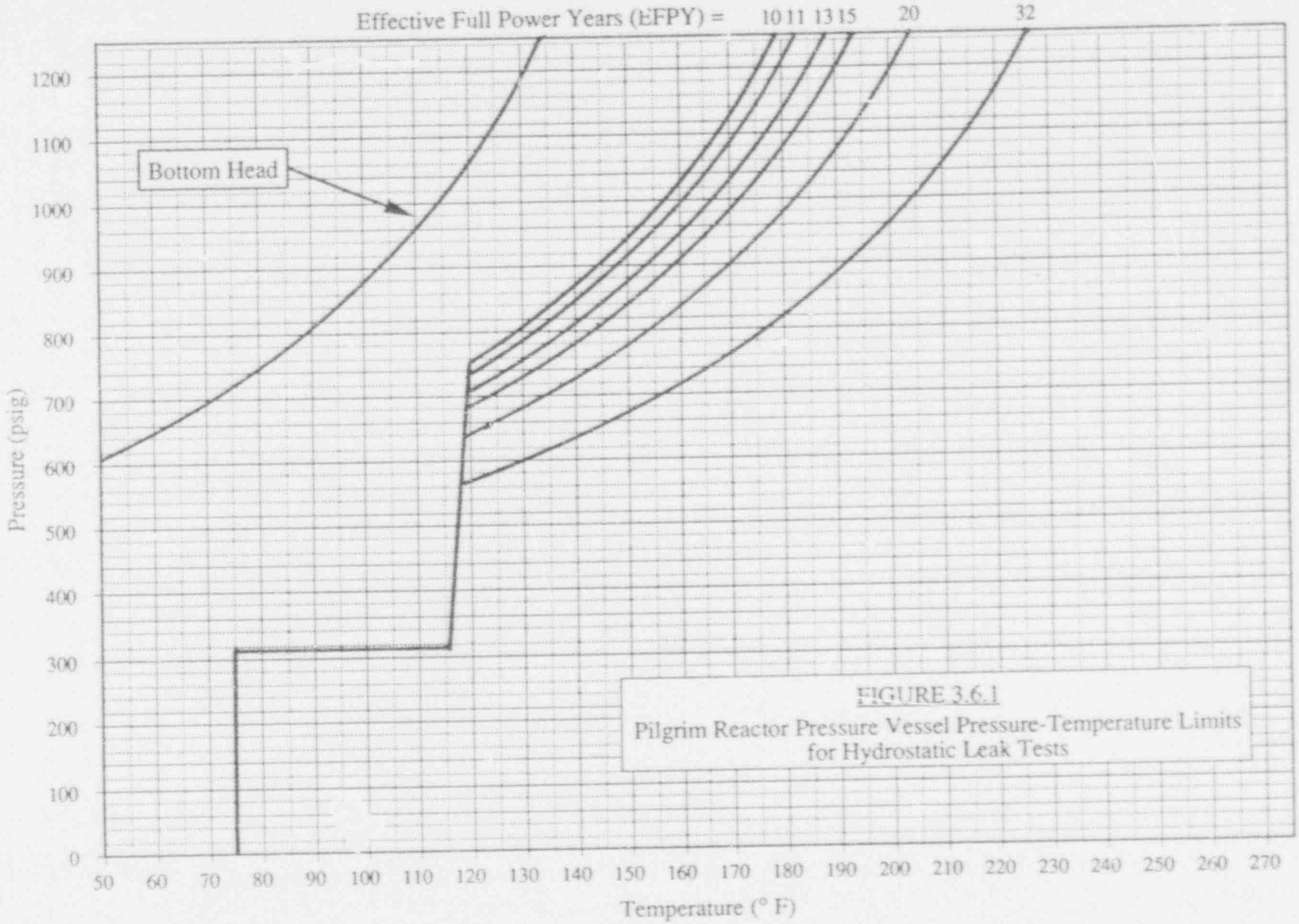


FIGURE 3.6.1
Pilgrim Reactor Pressure Vessel Pressure-Temperature Limits for Hydrostatic Leak Tests

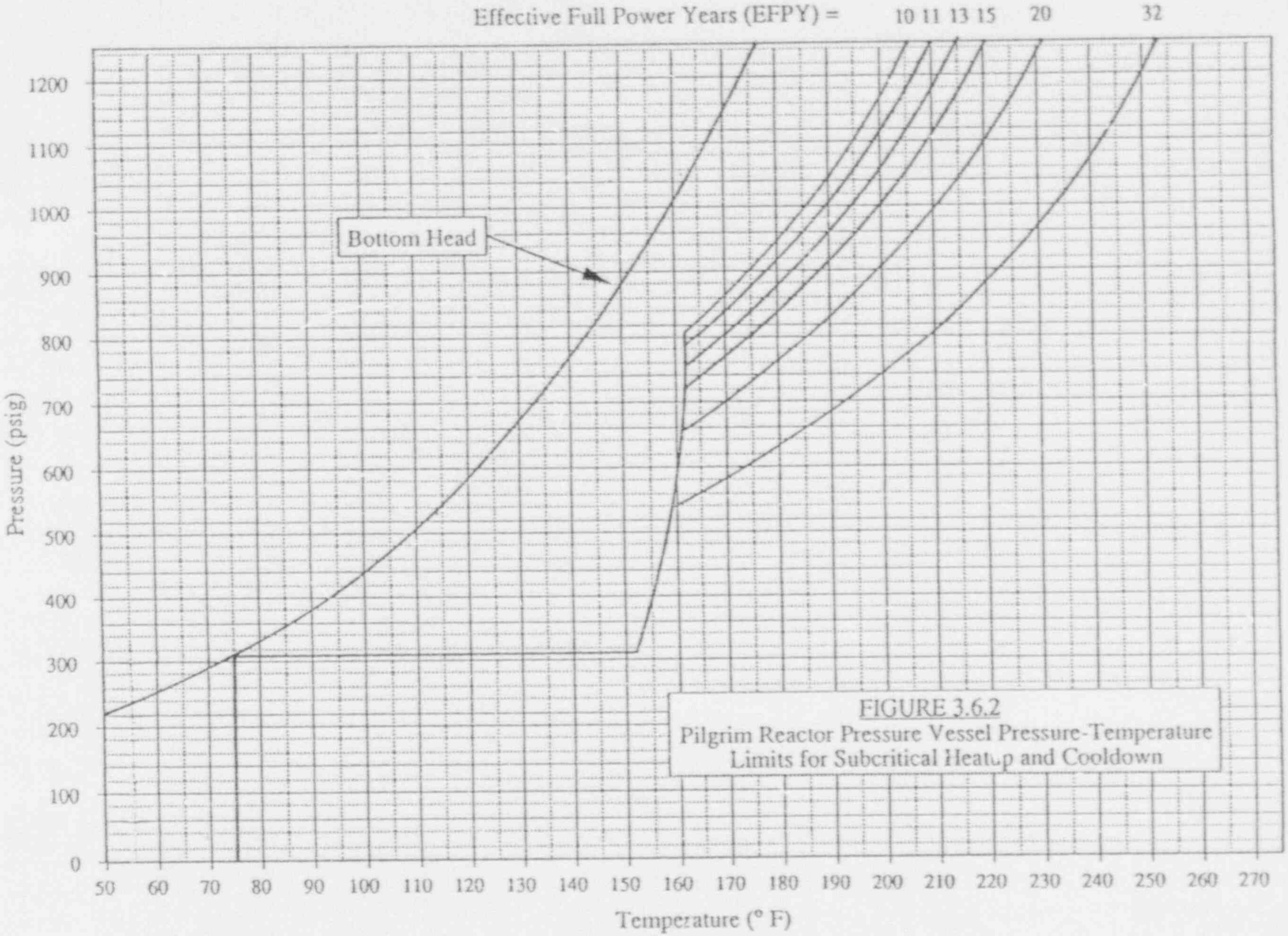
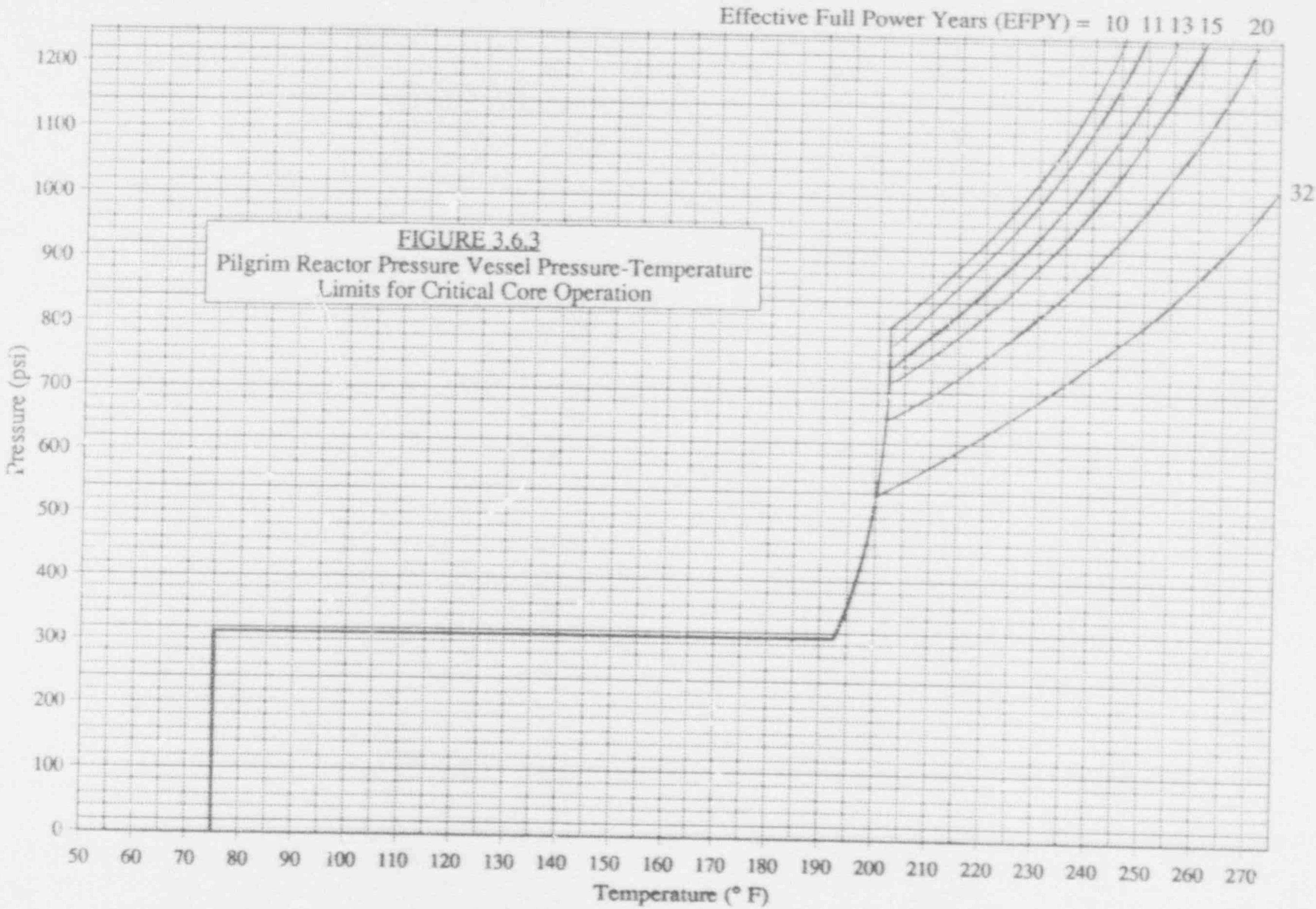


FIGURE 3.6.2
Pilgrim Reactor Pressure Vessel Pressure-Temperature Limits for Subcritical Heatup and Cooldown

FIGURE 3.6.3
Pilgrim Reactor Pressure Vessel Pressure-Temperature Limits for Critical Core Operation



Bases:

3.6.A and 4.6.A

Thermal and Pressurization Limitations (Cont'd)

The reactor coolant system is a primary barrier against the release of fission products to the environs. In order to provide assurance that this barrier is maintained at a high degree of integrity, restrictions have been placed on the operating conditions to which it can be subjected.

Appendix G to 10CFR50 defines the temperature-pressurization restrictions for hydrostatic and leak tests, pressurization, and critical operation. These limits have been calculated for Pilgrim and are contained in Figures 3.6.1, 3.6.2, and 3.6.3.

The bottom head, defined as the spherical portion of the reactor vessel located below the lower circumferential weld, was also evaluated. Reference transition temperatures (RT_{NDT}) were developed for the bottom head and the resulting pressure vs. temperature curves plotted on Figures 3.6.1 and 3.6.2. It has been determined that the bottom head temperatures are allowed to lag the vessel shell temperatures, Reference: Teledyne Engineering Services (TES) report TR-6051C-1, dated June 27, 1986. The referenced analysis utilizes the stress results established in the Combustion Engineering Inc., Pilgrim Reactor Vessel Design Report, No. CENC 1139, dated 1971, and combines the stress analysis results, specific to the bottom head, with the pressurization temperatures necessary to maintain fracture toughness requirements in accordance with the ASME Boiler and Pressure Vessel Code, Section III, the criteria of 10CFR Part 50, Appendix G, and the supplementary guidelines of Reg. Guide 1.99, Rev. 2.

For Pilgrim pressure-temperature restrictions, two locations in the reactor vessel are limiting. The closure region controls at lower pressures and the beltline controls at higher pressures.

The nil-ductility transition (NDT) temperature is defined as the temperature below which ferritic steel breaks in a brittle rather than ductile manner. Radiation exposure from fast neutrons (>1 mev) above about 10^{17} nvt may shift the NDT temperature of the vessel metal above the initial value. Impact tests from the first material surveillance capsule removed at 4.17 EFPY indicated a maximum RT_{NDT} shift of 55°F for the weld specimens.

Neutron flux wires and samples of vessel material are installed in the reactor vessel adjacent to the vessel wall at the core midplane level. The wires and samples will be periodically removed and tested to experimentally verify the values used for Figures 3.6.1, 3.6.2, and 3.6.3. The withdrawal schedule of Table 4.6.3 has been established as required by 10CFR50, Appendix H.

The RT_{NDT} of the closure region is - 5°F. The initial RT_{NDT} for the beltline weld and basemetal are -50°F and 0°F respectively. These RT_{NDT} temperatures are based upon unirradiated test data, adjusted for specimen orientation in accordance with USNRC Branch Technical Position MTEB 5-2.

Bases:

3.6.A and 4.6.A Thermal and Pressurization Limitations (Cont'd)

The closure and bottom head regions are not exposed to neutron fluence (> 1 Mev) over the vessel life sufficient to cause a shift in RT_{NDT}. The pressure-temperature limitations (Figures 3.6.1, 3.6.2, and 3.6.3) of the closure and bottom head regions will therefore remain constant throughout vessel life. Only the beltline region of the reactor vessel will experience a shift in RT_{NDT} with a resultant increase in Pressure-Temperature limits.

The curves apply to 100% bolt preload condition, but are conservative for lesser bolt preload conditions.

For critical core operation when the water level is within the normal range for power operation and the pressure is less than 20% of the preservice system hydrostatic test pressure (313 psi), the minimum permissible temperature of the highly stressed regions of the closure flange is RT_{NDT} + 60 = 55°F. A conservative cutoff limit of 75°F was chosen as shown on Figure 3.6.3 and as permitted by 10CFR50 Appendix G, paragraph IV. A.3. This same cutoff is included in the limits for hydrostatic and leak tests and for non-critical operation, as shown on Figures 3.6.1 and 3.6.2 respectively, in order to be consistant with the limits for critical operation.

The closure region is more limiting than the feedwater nozzle with regards to both stress intensity and RT_{NDT}. Therefore the pressure-temperature limits of the closure are controlling.

The adjusted reference temperature shift is based on Regulatory Guide 1.99, Revision 2, dated May 1988; the analytical results of General Electric Report MDE 277-1285, Revision 1, dated January 21, 1985, regarding projected neutron fluence; and Teledyne Engineering Services Reports, TR-6052B-1, Revision 1, dated June 26, 1986, as supplemented by TR-7487, dated April 16, 1991, for RT_{NDT} vs. fluence as a function of temperature and pressure, and TR-6052C-1, dated June 27, 1986, for the RPV bottom head pressurization temperatures.

ATTACHMENT C

RPV Thermal and Pressurization Limits
Marked-Up Technical Specification Pages

3.6 PRIMARY SYSTEM BOUNDARY

Applicability:

Applies to the operating status of the reactor coolant system.

Objective:

To assure the integrity and safe operation of the reactor coolant system.

Specification:

A. Thermal and Pressurization Limitations

1. The average rate of reactor coolant temperature change during normal heatup or cooldown shall not exceed 100°F/hr when averaged over a one-hour period except when the vessel temperatures are above 450°F. The shell flange to shell temperature differential shall not exceed 145°F.

   reactor vessel

   adjacent reactor vessel

2. The reactor vessel shall not be pressurized for hydrostatic and/or leakage tests, and critical core operation shall not be conducted unless the reactor vessel temperatures are is above that defined by the appropriate curves on Figures 3.6.1 and 3.6.2. In the event this requirement is not met, achieve stable reactor conditions with reactor vessel temperature above that defined by the appropriate curve and obtain an engineering evaluation to determine the appropriate course of action to take.

   Insert "A" here

4.6 PRIMARY SYSTEM BOUNDARY

Applicability:

Applies to the periodic examination and testing requirements for the reactor cooling system.

Objective:

To determine the condition of the reactor coolant system and the operation of the safety devices related to it.

Specification:

A. Thermal and Pressurization Limitations

   with the reactor vessel temperatures less than or equal to 450°F,

1. During heatups and cooldowns, the following temperatures shall be permanently logged at least every 15 minutes until the difference between any two readings taken over a 45 minute period is less than 5°F.

   At the following locations

   at individual locations

   a. Reactor vessel shell adjacent to shell flange

      reactor vessel

   b. Reactor vessel shell flange

   c. Recirculation loops A and B

   Insert "B" here

2. Reactor vessel shell temperatures and reactor coolant pressure shall be permanently logged at least every 15 minutes whenever the shell temperature is below 220°F and the reactor vessel is not vented.

   Test specimens of the reactor vessel base, weld and heat affected zone metal subjected to the highest fluence of greater than 1 Mev neutrons shall be installed in the reactor vessel adjacent to the vessel wall at the core midplane level. The specimens and sample program shall conform to the requirements of ASTM E 185-66. Selected

3.6.A Thermal and Pressurization Limitations (Cont'd)

3. The reactor vessel head bolting studs shall not be under tension unless the temperature of the vessel head [illegible] and the head is greater than [illegible]°F.

4. The pump in an idle recirculation loop shall not be started unless the temperatures of the coolant within the idle and operating recirculation loops are within 50°F of each other.

5. The reactor recirculation pumps shall not be started unless the coolant temperatures between the dome and the bottom head drain are within 145°F.

6. Thermal-Hydraulic Stability

Core thermal power shall not exceed 25% of rated thermal power without forced recirculation.

B. Coolant Chemistry

1. The reactor coolant system radioactivity concentration in water shall not exceed 20 microcuries of total iodine per ml of water.

2. The reactor coolant water shall not exceed the following limits with steaming rates less than 100,000 pounds per hour, except as specified in 3.6.B.3:

Conductivity ... 2 µmho/cm

Chloride ion ... 0.1 ppm

4.6.A Thermal and Pressurization Limitations (Cont'd)

neutron flux specimens shall be removed at the frequency required by Table 4.6.3 and tested to experimentally verify adjustments to Figures 3.6.1 and 3.6.2 [and 3.6.3] for predicted NDTT [temperatures] irradiation shifts.

3. When the reactor vessel head bolting studs are tensioned and the reactor is in a Cold Condition, the reactor vessel shell temperature immediately below the head flange shall be permanently recorded.

4. Prior to and during startup of an idle recirculation loop, the temperature of the reactor coolant in the operating and idle loops shall be permanently logged.

5. Prior to starting a recirculation pump, the reactor coolant temperatures in the dome and in the bottom head drain shall be compared and permanently logged.

B. Coolant Chemistry

1. a. A reactor coolant sample shall be taken at least every 96 hours and analyzed for radioactivity content.

   b. Isotopic analysis of a reactor coolant sample shall be made at least once per month.

2. During startups and at steaming rates less than 100,000 pounds per hour, a sample of reactor coolant shall be taken every four hours and analyzed for ~~chlorine~~ [chloride] content.

TABLE 4.6.3
REACTOR VESSEL MATERIAL
SURVEILLANCE PROGRAM WITHDRAWAL SCHEDULE

Capsule Number	Effective Full Power Years (EFPY)	Fluence (n/cm^2) (1/4 T)	RT_{NDT} (weld metal) (°F)
1	4.17	1.8×10^{17}	55
2	15 (approx.)	6.3×10^{17} (approx.)	91
3	32 (End of Life)	1.4×10^{18} (approx.)	136

LIMITING CONDITION FOR OPERATION | SURVEILLANCE REQUIREMENTS

3.6.B Coolant Chemistry (Cont'd)

3. For reactor startups and for the first 24 hours after placing the reactor in the power operating condition, the following limits shall not be exceeded.

   Conductivity...10 umho/cm

   Chloride ion...0.1 ppm

4. Except as specified in 3.6.B.3 above, the reactor coolant water shall not exceed the following limits when operating with steaming rates greater than or equal to 100,000 pounds per hour.

   Conductivity...10 umho/cm

   Chloride ion...1.0 ppm

5. If Specification 3.6.B cannot be met, an orderly shutdown shall be initiated and the reactor shall be in Hot Shutdown within 24 hrs. and Cold Shutdown within the next 8 hours.

C. Coolant Leakage

1. Any time irradiated fuel is in the reactor vessel and reactor coolant temperature is above 212°F, reactor coolant leakage into the primary containment from unidentified sources shall not exceed 5 gpm. In addition, the total reactor coolant system leakage into the primary containment shall not exceed 25 gpm.

2. Both the sump and air sampling systems shall be operable during reactor power operation. From and after the date that one of these systems is made or found to be inoperable for any reason, reactor

4.6.B Coolant Chemistry (Cont'd)

3. a. With steaming rates of 100,000 pounds per hour or greater, a reactor coolant sample shall be taken at least every 96 hours and analyzed for chloride ion content.

   b. When all continuous conductivity monitors are inoperable, a reactor coolant sample shall be taken at least daily and analyzed for conductivity and chloride ion content.

C. Coolant Leakage

1. Reactor coolant system leakage shall be checked by the sump and air sampling system and recorded at least once per day.

FIGURE 3.6.1

PILGRIM REACTOR VESSEL

PRESSURE - TEMPERATURE LIMITS

HYDROSTATIC AND LEAK TESTS

Replace with new Figure 3.6.1

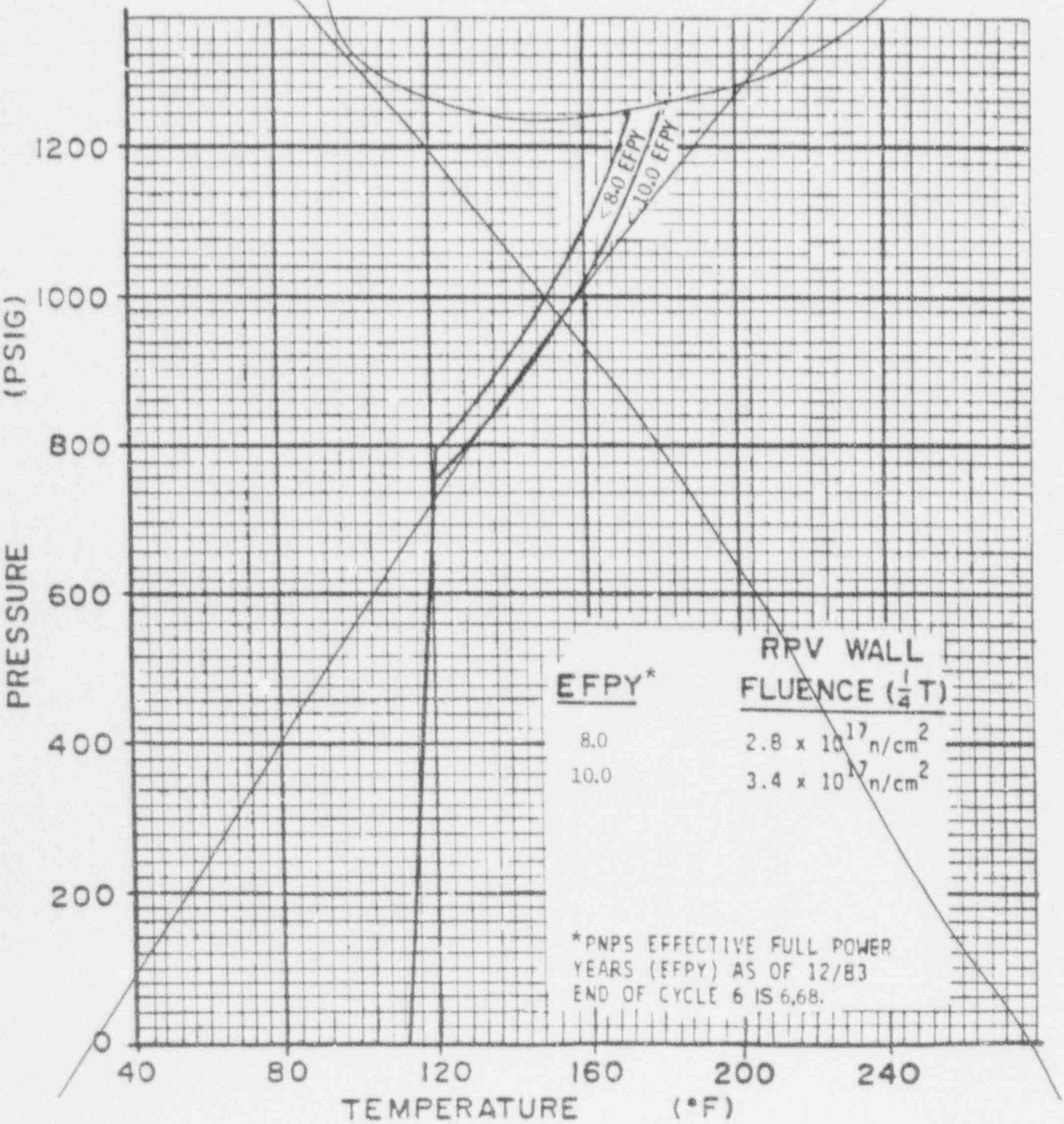


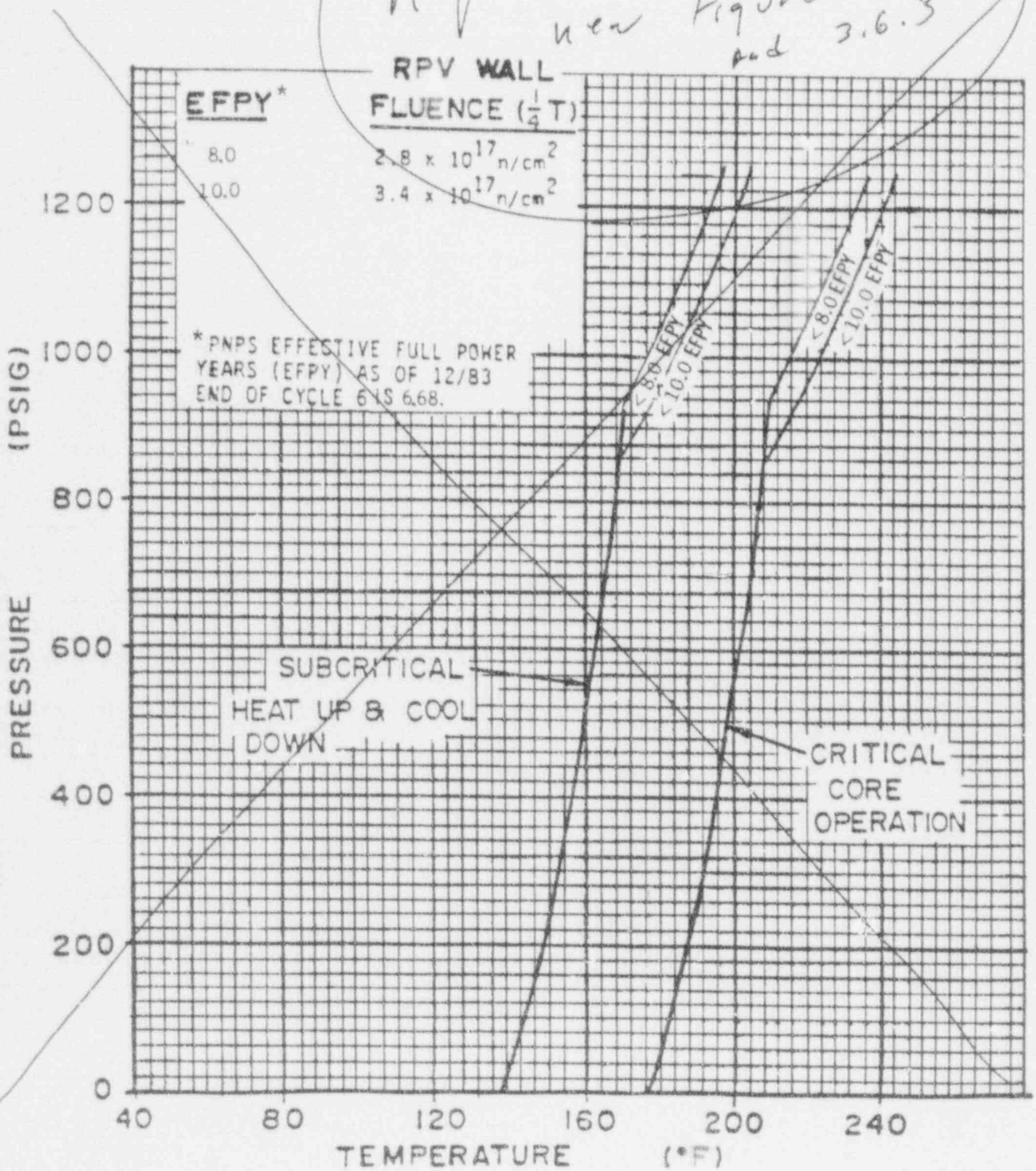
FIGURE 3.6.2

PILGRIM REACTOR VESSEL

PRESSURE - TEMPERATURE LIMITS

SUBCRITICAL/CRITICAL HEAT UP & COOL DOWN

Replace with new Figures 3.6.2 and 3.6.3



Bases:

3.6.A and 4.6.A

Thermal and Pressurization Limitations (Cont'd)

The reactor coolant system is a primary barrier against the release of fission products to the environs. In order to provide assurance that this barrier is maintained at a high degree of integrity, restrictions have been placed on the operating conditions to which it can be subjected.

Appendix G to 10CFR50 defines the temperature-pressurization restrictions for hydrostatic and leak tests, pressurization, and critical operation. These limits have been calculated for Pilgrim and are contained in Figures 3.6.1 and 3.6.2, and 3.6.3.

Insert "C" here

For Pilgrim pressure-temperature restrictions, two locations in the reactor vessel are limiting. The closure region controls at lower pressures and the beltline controls at higher pressures.

The nil-ductility transition (NDT) temperature is defined as the temperature below which ferritic steel breaks in a brittle rather than ductile manner. Radiation exposure from fast neutrons (>1 mev) above about 10^{17} nvt may shift the NDT temperature of the vessel metal above the initial value. Impact tests from the first material surveillance capsule removed from the reactor vessel have established the magnitude of the RT_{NDT} shift for the beltline. The shift, which is greatest for the weld metal, is tabulated below for various fluence levels and EFPY of operation:

Insert "D" here

RPV Wall Fluence (1/4T)	RT_{NDT}
2.8×10^{17} n/cm²	61°F
3.4×10^{17} n/cm²	68°F

Neutron flux wires and samples of vessel material are installed in the reactor vessel adjacent to the vessel wall at the core midplane level. The wires and samples will be periodically removed and tested to experimentally verify the values used for Figures 3.6.1 and 3.6.2. And 3.6.3 The withdrawal schedule of Table 4.6.3 has been established as required by 10CFR50, Appendix H.

The pressure-temperature limitations of Figures 3.6.1 and 3.6.2 applicable to the beltline reflect an initial RT_{NDT} of 0°F. This initial value is based

Insert "E" here

Bases:

3.6.A and 4.6.A

Thermal and Pressurization Limitations (Cont'd)

on unirradiated test data adjusted for specimen orientation in accordance with USNRC Branch Technical Position MTEB 5-2.

The pressure-temperature limitations of Figures 3.6.1 and 3.6.2 applicable to the closure region reflect an RT_{NDT} of -5°F, also based on test data adjusted for specimen orientation. The curves apply to 100% bolt preload condition, but are conservative for lesser bolt preload conditions.

For critical core operation when the water level is within the normal range for power operation and the pressure is less than 20% of the preservice system hydrostatic test pressure (313 psi), the minimum permissible temperature of the highly stressed regions of the closure flange is RT_{NDT} + 60 = 55°F.

Insert "F" here

The closure region is more limiting than the feedwater nozzle with regards to both stress intensity and RT_{NDT}. Therefore the pressure-temperature limits of the closure are controlling.

Insert "G" here

Proposed Technical Specification Changes:

Insert "A":

, and 3.6.3. (Linear interpolation between curves is permitted.)

At stated pressure, the reactor vessel bottom head may be maintained at temperatures below those temperatures corresponding to the adjacent reactor vessel shell as shown in Figures 3.6.1 and 3.6.2.

Insert "B":

including reactor vessel bottom head,

Insert "C":

The bottom head, defined as the spherical portion of the reactor vessel located below the lower circumferential weld, was also evaluated. Reference transition temperatures (RT_{NDT}) were developed for the bottom head and the resulting pressure vs. temperature curves plotted on Figures 3.6.1 and 3.6.2. It has been determined that the bottom head temperatures are allowed to lag the vessel shell temperatures, Reference: Teledyne Engineering Services (TES) report TR-6051C-1, dated June 27, 1986. The referenced analysis utilizes the stress results established in the Combustion Engineering Inc., Pilgrim Reactor Vessel Design Report, No. CENC 1139, dated 1971, and combines the stress analysis results, specific to the bottom head, with the pressurization temperatures necessary to maintain fracture toughness requirements in accordance with the ASME Boiler and Pressure Vessel Code, Section III, the criteria of 10CFR Part 50, Appendix G, and the supplementary guidelines of Reg. Guide 1.99, Rev. 2.

Insert "D":

Impact tests from the first material surveillance capsule removed at 4.17 EFPY indicated a maximum RT_{NDT} shift of 55°F for the weld specimens.

Insert "E":

The RT_{NDT} of the closure region is - 5°F. The initial RT_{NDT} for the beltline weld and basemetal are -50°F and 0°F respectively. These RT_{NDT} temperatures are based upon unirradiated test data, adjusted for specimen orientation in accordance with USNRC Branch Technical Position MTEB 5-2. The closure and bottom head regions are not exposed to neutron fluence (> 1 Mev) over the vessel life sufficient to cause a shift in RT_{NDT}. The pressure-temperature limitations (Figures 3.6.1, 3.6.2, and 3.6.3) of the closure and bottom head regions will therefore remain constant throughout vessel life. Only the beltline region of the reactor vessel will experience a shift in RT_{NDT} with a resultant increase in Pressure-Temperature limits.

Insert "F":

A conservative cutoff limit of 75°F was chosen as shown on Figure 3.6.3 and as permitted by 10CFR50 Appendix G, paragraph IV. A.3. This same cutoff is included in the limits for hydrostatic and leak tests and for non-critical operation, as shown on Figures 3.6.1 and 3.6.2 respectively, in order to be consistant with the limits for critical operation.

Insert "G":

The adjusted reference temperature shift is based on Regulatory Guide 1.99, Revision 2, dated May 1988; the analytical results of General Electric Report MDE 277-1285, Revision 1, dated January 21, 1985, regarding projected neutron fluence; and Teledyne Engineering Services Reports, TR-6052B-1, Revision 1, dated June 26, 1986, as supplemented by TR-7487, dated April 16, 1991, for RT_{NDT} vs. fluence as a function of temperature and pressure, and TR-6052C-1, dated June 27, 1986, for the RPV bottom head pressurization temperatures.