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DTE

Proprietary Information – Withhold Under 10 CFR 2.390

TS 5.6.8

June 8, 2020
NRC-20-0009

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

Fermi 2 Power Plant
NRC Docket No. 50-341
NRC License No. NPF-43

Subject: Transmittal of Revision to the Pressure and Temperature Limits Report (PTLR)

References:
1) NRC Letter to DTE, "Fermi 2 – Issuance of Amendment Re: Relocation of Pressure and Temperature Curves to a Pressure Temperature Limits Report (TAC No. MF0446)," License Amendment 195, dated February 4, 2014 (ML13346B067)
2) NEDC-33178P-A, "GE Hitachi Nuclear Energy Methodology for Development of Reactor Pressure Vessel Pressure-Temperature Curves," Revision 1, dated June 2009
3) DTE Letter to NRC, "License Amendment Request to Revise Technical Specifications to Change Surveillance Intervals to Accommodate a 24-Month Fuel Cycle," NRC-19-0054, dated November 8, 2019 (ML19312A110)

In Reference 1, the Fermi 2 Technical Specifications (TS) were revised to relocate pressure and temperature limit curves to a Pressure and Temperature Limits Report (PTLR). Requirements for control of the PTLR were added to the Fermi 2 TS in Section 5.6.8. In accordance with TS 5.6.8.c, DTE Electric Company (DTE) transmits a revision of the PTLR to the NRC. The revised PTLR is based on the methodology in Reference 2, as required by TS 5.6.8.b. The PTLR was revised in support of GNF3 new fuel introduction for operating cycle 21 and planned future use of 24-month fuel cycles as requested in Reference 3. The revised PTLR is provided in Enclosure 2.

Enclosure 2 contains Proprietary Information – Withhold Under 10 CFR 2.390.
When separated from Enclosure 2, this document is decontrolled.

Enclosure 2 contains proprietary information as defined by 10 CFR 2.390. GE-Hitachi (GEH) and Electric Power Research Institute (EPRI), as the owners of the proprietary information, have executed the affidavits in Enclosure 1, which identify that the enclosed proprietary information has been handled and classified as proprietary, is customarily held in confidence, and has been withheld from public disclosure. A non-proprietary version of the documentation in Enclosure 2 is provided in Enclosure 3.

No new commitments are made in this letter.

Should you have any questions or require additional information, please contact Ms. Margaret Offerle, Manager – Nuclear Licensing, at (734) 586-5076.

Sincerely,

Peter Dietrich
Senior Vice President and Chief Nuclear Officer

Enclosures: 1) GEH and EPRI Affidavits for NEDC-33915P
2) NEDC-33915P, Revision 1 – PROPRIETARY
3) NEDO-33915, Revision 1 – NON-PROPRIETARY

cc:
NRC Project Manager
NRC Resident Office
Regional Administrator, Region III

Enclosure 1 to
NRC-20-0009

Fermi 2 NRC Docket No. 50-341
Operating License No. NPF-43

GEH and EPRI Affidavits for NEDC-33915P

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, Michelle P. Catts, state as follows:

(1) I am the Senior Vice President of Regulatory Affairs, GE-Hitachi Nuclear Energy Americas LLC (GEH), and have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in GEH proprietary report NEDC-33915P, "DTE Energy/Enrico Fermi Power Plant Unit 2 Pressure and Temperature Limits Report (PTLR) up to 52 Effective Full-Power Years," Revision 1, dated May 2020. GEH proprietary information in NEDC-33915P Revision 1 is identified by a dotted underline inside double square brackets. [[This sentence is an example.{3}]]. GEH proprietary information in figures and large objects is identified by double square brackets before and after the object. In each case, the superscript notation {3} refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner or licensee, GEH relies upon the exemption from disclosure set forth in the *Freedom of Information Act* ("FOIA"), 5 U.S.C. §552(b)(4), and the *Trade Secrets Act*, 18 U.S.C. §1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for trade secrets (Exemption 4). The material for which exemption from disclosure is here sought also qualifies under the narrower definition of trade secret, within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975 F.2d 871 (D.C. Cir. 1992), and Public Citizen Health Research Group v. FDA, 704 F.2d 1280 (D.C. Cir. 1983).

(4) The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a and (4)b. Some examples of categories of information that fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by GEH's competitors without a license from GEH constitutes a competitive economic advantage over other companies;

b. Information that, if used by a competitor, would reduce its expenditure of resources or improve its competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

c. Information that reveals aspects of past, present, or future GEH customer-funded development plans and programs, resulting in potential products to GEH;

d. Information that discloses trade secret or potentially patentable subject matter for which it may be desirable to obtain patent protection.

(5) To address 10 CFR 2.390(b)(4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GEH, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GEH, not been disclosed publicly, and not been made available in public sources. All disclosures to third parties, including any required transmittals to the NRC, have been made, or must be made, pursuant to regulatory provisions for proprietary or confidentiality agreements or both that provide for maintaining the information in confidence. The initial designation of this information as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in the following paragraphs (6) and (7).

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, who is the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge, or who is the person most likely to be subject to the terms under which it was licensed to GEH.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist, or other equivalent authority for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GEH are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary and/or confidentiality agreements.

(8) The information identified in paragraph (2) is classified as proprietary because it contains the detailed GEH methodology for pressure-temperature curve analysis for the GEH Boiling Water Reactor (BWR). These methods, techniques, and data along with their application to the design, modification, and analyses associated with the pressure-temperature curves were achieved at a significant cost to GEH.

The development of the evaluation processes along with the interpretation and application of the analytical results is derived from the extensive experience databases that constitute a major GEH asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GEH's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GEH's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GEH. The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial. GEH's competitive advantage will be lost if its competitors are able to use the results of the GEH experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GEH would be lost if the information were disclosed to the public. Making such information available to competitors without there having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall and deprive GEH of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing and obtaining these very valuable analytical tools.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on this 14th day of May 2020.

Michelle P. Catts

Michelle P. Catts
Senior Vice President of Regulatory Affairs
GE-Hitachi Nuclear Energy Americas, LLC
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ELECTRIC POWER RESEARCH INSTITUTE

AFFIDAVIT

RE: Request for Withholding of the Following Proprietary Information Included In:

DTE Energy/Enrico Fermi Power Plant Unit 2,
Pressure and Temperature Limits Report (PTLR)
up to 52 Effective Full Power Years (EFPY),
NEDC-33915, Revision 1

I, Neil Wilmshurst, being duly sworn, depose and state as follows:

I am the Vice President and Chief Nuclear Officer at Electric Power Research Institute, Inc. whose principal office is located at 3420 Hillview Avenue, Palo Alto, California ("EPRI") and I have been specifically delegated responsibility for the above-listed Report which contains EPRI Proprietary Information that is sought under this Affidavit to be withheld "Proprietary Information". I am authorized to apply to the U.S. Nuclear Regulatory Commission ("NRC") for the withholding of the Proprietary Information on behalf of EPRI.

EPRI Proprietary Information is identified in the above referenced report with text inside double brackets. Examples of such identification is as follows:

[[This sentence is an example{E}]]

Tables containing EPRI Proprietary Information are identified with double brackets before and after the object. In each case the superscript notation {E} refers to this affidavit and all the bases included below, which provide the reasons for the proprietary determination.

EPRI requests that the Proprietary Information be withheld from the public on the following bases:

Withholding Based Upon Privileged And Confidential Trade Secrets Or Commercial Or Financial Information (see e.g. 10 C.F.R. §2.390(a)(4))::

a. The Proprietary Information is owned by EPRI and has been held in confidence by EPRI. All entities accepting copies of the Proprietary Information do so subject to written agreements imposing an obligation upon the recipient to maintain the confidentiality of the Proprietary Information. The Proprietary Information is disclosed only to parties who agree, in writing, to preserve the confidentiality thereof.

b. EPRI considers the Proprietary Information contained therein to constitute trade secrets of EPRI. As such, EPRI holds the information in confidence and disclosure thereof is strictly limited to individuals and entities who have agreed, in writing, to maintain the confidentiality of the Information.

c. The information sought to be withheld is considered to be proprietary for the following reasons. EPRI made a substantial economic investment to develop the Proprietary Information and, by prohibiting public disclosure, EPRI derives an economic benefit in the form of licensing royalties and other additional fees from the confidential nature of the Proprietary Information. If the Proprietary Information were publicly available to consultants and/or other businesses providing services in the electric and/or nuclear power industry, they would be able to use the Proprietary Information for their own commercial benefit and profit and without expending the substantial economic resources required of EPRI to develop the Proprietary Information.

d. EPRI's classification of the Proprietary Information as trade secrets is justified by the Uniform Trade Secrets Act which California adopted in 1984 and a version of which has been adopted by over forty states. The California Uniform Trade Secrets Act, California Civil Code §§3426 – 3426.11, defines a "trade secret" as follows:

> "'Trade secret' means information, including a formula, pattern, compilation, program device, method, technique, or process, that:
>
> (1) Derives independent economic value, actual or potential, from not being generally known to the public or to other persons who can obtain economic value from its disclosure or use; and
>
> (2) Is the subject of efforts that are reasonable under the circumstances to maintain its secrecy."

e. The Proprietary Information contained therein are not generally known or available to the public. EPRI developed the Information only after making a determination that the Proprietary Information was not available from public sources. EPRI made a substantial investment of both money and employee hours in the development of the Propretary Information. EPRI was required to devote these resources and effort to derive the Proprietary Information. As a result of such effort and cost, both in terms of dollars spent and dedicated employee time, the Proprietary Information is highly valuable to EPRI.

f. A public disclosure of the Proprietary Information would be highly likely to cause substantial harm to EPRI's competitive position and the ability of EPRI to license the Proprietary Information both domestically and internationally. The Proprietary Information and Report can only be acquired and/or duplicated by others using an equivalent investment of time and effort.

I have read the foregoing and the matters stated herein are true and correct to the best of my knowledge, information and belief. I make this affidavit under penalty of perjury under the laws of the United States of America and under the laws of the State of North Carolina.

Executed at 1300 W WT Harris Blvd, Charlotte, NC being the premises and place of business of Electric Power Research Institute, Inc.

Date: 5-13-2020

[signature]

Neil Wilmshurst

(State of North Carolina)
(County of Mecklenburg)

Subscribed and sworn to (or affirmed) before me on this 13 day of May, 2020 by Neil Wilmsworst, proved to me on the basis of satisfactory evidence to be the person(s) who appeared before me.

Signature ______________________ (Seal)

SANDRA B SHERIFF
Notary Public
Cabarrus
County
NORTH CAROLINA

My Commission Expires 12 day of August, 20__

Enclosure 3 to
NRC-20-0009

Fermi 2 NRC Docket No. 50-341
Operating License No. NPF-43

NEDO-33915, Revision 1 – NON-PROPRIETARY
DTE Energy/Enrico Fermi Power Plant Unit 2 Pressure and Temperature Limits Report (PTLR) up to 52 Effective Full-Power Years

GE Hitachi Nuclear Energy

NEDO-33915
Revision 1
May 2020

Non - Proprietary Information

DTE Energy/Enrico Fermi Power Plant Unit 2

Pressure and Temperature Limits Report (PTLR)

up to 52 Effective Full-Power Years

INFORMATION NOTICE

This is a non-proprietary version of the document NEDC-33915P, Revision 1, which has the proprietary information removed. Portions of the document that have been removed are indicated by open and closed brackets as shown here [[ ]].

IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT

Please Read Carefully

Revision Summary

Revision	Description
0	Initial Issue
1	The ART for the N16 WLI nozzles was revised. The Fermi Unit 2 PTLR has been updated to incorporate the new ART. All changes are identified by revision bars in the right margin. References 6 and 7 are no longer applicable and have been removed. Any instances of "N12" were corrected to "N16" for the WLI nozzle. Updated reference pointers.

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ACRONYMS

Acronym	Definition
%Cu	Weight percent Copper
%Ni	Weight percent Nickel
1/4T	¼ depth into the vessel wall from the inside diameter
3/4T	¾ depth into the vessel wall from the inside diameter
ART	Adjusted Reference Temperature
ASME	American Society of Mechanical Engineers
BAF	Bottom of Active Fuel
BTP	Branch Technical Position
BWR	Boiling Water Reactor
BWR/6	BWR Product Line 6
BWRVIP	BWR Vessel and Internals Project
CE	Combustion Engineering
CF	Chemistry Factor
CMTR	Certified Material Test Report
CRD	Control Rod Drive
Curve A	P-T Curves Applicable to Hydrotest (or Pressure Test) Operation
Curve B	P-T Curves Applicable to Core Not Critical Operation
Curve C	P-T Curves Applicable to Core Critical Operation
°F	Degree Fahrenheit
ΔT	Δ Temperature

Acronym	Definition
EFPY	Effective Full Power Years
EPRI	Electric Power Research Institute
Fermi 2	Enrico Fermi Power Plant 2
FW	Feedwater
GE	General Electric Company
GEH	GE Hitachi Nuclear Energy
GNF3	Global Nuclear Fuel 3
ID	Inside Diameter
ISP	Integrated Surveillance Program
K_I	Stress Intensity Factor
K_{Ir}	Allowable Fracture Toughness
LTR	Licensing Topical Report
MTEB	Materials Engineering Branch
N16	Water Level Instrumentation Nozzle
NFI	New Fuel Introduction
n/cm^2	neutrons per square centimeter (measure of fluence)
NRC (or USNRC)	United States Nuclear Regulatory Commission
P/T	Pressure/Temperature
P-T	Pressure-Temperature
PTLR	Pressure and Temperature Limits Report
PVP	Pressure Vessels and Piping

Acronym	Definition
PVRC	Pressure Vessel Research Council
RCPB	Reactor Coolant Pressure Boundary
RCS	Reactor Coolant System
RFO	Refueling Outage
RG 1.190	Regulatory Guide 1.190
RG 1.99	Regulatory Guide 1.99, Revision 2
RPV	Reactor Pressure Vessel
RT_{NDT}	Reference Temperature of Nil Ductility Transition
RVID	Reactor Vessel Integrity Database (by NRC)
σ_i	Standard Deviation on Initial RT_{NDT}
Shell #	RPV Shell Ring Number (see Figure B-1)
SSP	Supplemental Surveillance Program
T	Temperature
TAF	Top of Active Fuel
TS	Technical Specification
UFSAR	Updated Final Safety Analysis Report
US	United States
WLI	Water Level Instrumentation
WRC	Welding Research Council

1.0 Purpose

The purpose of the Enrico Fermi Power Plant 2 (Fermi 2) Pressure and Temperature Limits Report (PTLR) is to present operating limits relating to:

1. Reactor Coolant System (RCS) Pressure versus Temperature limits during Heatup, Cooldown and Hydrostatic/Class 1 Leak Testing;
2. RCS Heatup and Cooldown rates;
3. Reactor Pressure Vessel (RPV) to RCS coolant delta temperature (ΔT) requirements during Recirculation Pump startups;
4. RPV bottom head coolant temperature to RPV coolant temperature ΔT requirements during Recirculation Pump startups;
5. RPV head flange bolt-up temperature limits.

This report has been prepared in accordance with the requirements of Technical Specification (TS) 5.6.8, Reactor Coolant System (RCS) Pressure and Temperature Limits Report (PTLR).

2.0 Applicability

This report is applicable to the Fermi 2 RPV for up to 52 Effective Full Power Years (EFPY).

The following TS is affected by the information contained in this report:

TS 3.4.10 RCS Pressure and Temperature (P/T) Limits

3.0 Methodology

The limits in this report were derived from the NRC-approved methods listed in TS 5.6.8, using the specific revisions listed below:

1. The neutron fluence was calculated per *Licensing Topical Report, General Electric Methodology for Reactor Pressure Vessel Fast Neutron Flux Evaluation*, NEDC-32983P-A, Revision 2, January 2006, approved in Reference 1.
2. The pressure and temperature limits were calculated per *GE Hitachi Nuclear Energy Methodology for Development of Reactor Pressure Vessel Pressure-Temperature Curves*, NEDC-33178P-A, Revision 1, June 2009, approved in Reference 2.

This PTLR incorporates the following items and changes:

- Initial issuance of the PTLR for Global Nuclear Fuel 3 (GNF3) New Fuel Introduction (NFI) and 24-month cycle extension for Fermi 2

- Application of GEH Topical Report for Fermi 2 Pressure-Temperature (P-T) Curves
- Incorporation of new fluence results for 52 EFPY
- Application of the Integrated Surveillance Program (ISP) testing and analysis results that are applicable to Fermi 2 P-T curves
- Application of Materials Engineering Branch (MTEB) 5-2 (currently Branch Technical Position (BTP) 5-3) resolution to the N16 water level instrumentation (WLI) forging material

3.1 Chemistry

The vessel beltline copper and nickel values were obtained from Fermi 2 plant-specific vessel purchase order records, Certified Material Test Reports (CMTR), or are values previously approved by the NRC, and remain unchanged from previous submittals (Reference 5). Surveillance materials are evaluated using the adjusted chemistry factors obtained from BWRVIP-135 (Reference 3). Best estimate chemistries for other beltline materials were also considered from Reference 3 and however, none were applicable to Fermi 2.

The chemistry factors (CF) for all materials are calculated based upon the requirements of Regulatory Guide 1.99, Revision 2 (RG 1.99, Reference 10).

3.2 Fluence

The peak RPV inside diameter (ID) fluence at metal interface between the cladding and the RPV base metal used in the P-T curve evaluation for Fermi 2 at 52 EFPY is 9.92e17 n/cm^2. This value was calculated using methods that comply with the guidelines of Regulatory Guide 1.190 (RG 1.190) (Reference 11) as discussed in Reference 1. This fluence applies to the lower-intermediate shell (Shell #2) plates and longitudinal axial (vertical) welds. The fluence at the elevation of girth weld between the lower shell (Shell #1) plate and lower-intermediate shell (Shell #2) is 5.74e17 n/cm^2. This fluence also applies to the lower shell plates and longitudinal axial welds. The peak fluence at the bottom of N16 WLI nozzle is 3.59e17 n/cm^2.

3.3 Initial Reference Temperature of Nil Ductility Transition (RT_{NDT})

The method for determining the Initial Reference Temperature of Nil-Ductility Transition (RT_{NDT}) for all vessel materials is that defined in Section 4.1.2 of Reference 2. Initial RT_{NDT} values for all vessel materials considered in developing the P-T curves are presented in tables in Appendix B.

The N16 WLI nozzle is evaluated for ART. As the WLI weld material is Inconel, for which fracture toughness evaluations are not required, only the WLI forging material is evaluated. The determination of initial RT_{NDT} for WLI forging material which was already submitted

to NRC is summarized as follows. The Combustion Engineering (CE) purchase specification for this material demonstrates a required test temperature of [[ ]], consistent with the N16 Certified Material Test Reports (CMTR). However, insufficient information is available to determine the initial RT_{NDT}. NRC MTEB 5-2, paragraph B.1.1(4) defines the method for determining initial RT_{NDT} where limited Charpy V-Notch tests were performed at a single temperature, as is the case for the N16 WLI forging material. Testing for one N16 WLI forging material was performed at [[ ]], with a minimum result of [[ ]] and where the maximum results is [[ ]] 45 ft-lbs. Therefore MTEB 5-2 states that the RT_{NDT} may be calculated as 20°F above the test temperature; hence, the initial RT_{NDT} is determined to be [[ ]]. Testing for the second N16 material was performed at [[ ]], but dropweight was not reported. The dropweight was considered to be [[ ]], consistent with MTEB 5-2 guidance. Therefore, the initial RT_{NDT} for this heat is the greater of the dropweight ([[ ]]) and [[ ]], shown in Table B-2. The resulting initial RT_{NDT} for this material is [[ ]].

3.4 Adjusted Reference Temperature (ART)

The ART values for 52 EFPY included in Appendix B are developed considering the latest BWRVIP Integrated Surveillance Program (ISP) published surveillance data available that is representative of the applicable materials in the Fermi 2 RPV (Reference 3). As the ISP plate material, heat C4114-2, is not identical to the target vessel material, the ISP data is not considered in the development of P-T curves. The ISP weld material, heat CE-2 (WM) (Heat 13253/12008), is identical to the target vessel material (13253/12008). Therefore, the ISP weld data is considered in the development of P-T curves. The CF value for weld is updated with ISP data and used for the determination of ART. This ART is not limiting with respect to the ART.

3.5 Surveillance Program

As discussed in Appendix A, Fermi 2 participates in the ISP. Two of the surveillance capsules, installed at plant startup, remain in the vessel, while the third capsule was removed at approximately 8 EFPY, but was not tested. As Fermi 2 is not a host plant, the three (3) surveillance capsules have an ISP status designation of deferred (standby) per Reference 4.

BWRVIP-135 (Reference 3) provides the representative surveillance data considered in determining the chemistry and any fitted or adjusted CFs for the beltline materials for Fermi 2.

Excerpt from Reference 3:

Target Vessel Materials and ISP Representative Materials for Fermi

Target Vessel Materials		ISP Representative Materials
Weld	13253/12008	CE-2(WM) [Heat 13253/12008]
Plate	C4554-1, C4568-2	C4114-2

T_{30} Shift Results for Weld Heat CE-2(WM)

Capsule	Cu (wt%)	Ni (wt%)	Fluence (10^{17} n/cm^2, E > 1 MeV)	ΔT_{30} (°F)
SSP E	0.21	0.86	17.572	192.7
SSP G			19.503	164.9

As seen above, the ISP representative plate, heat C4114-2, is not identical to any Fermi 2 vessel beltline plate. Therefore, this ISP data is not used in the development of P-T curves.

For Fermi 2, the ISP representative weld, heat CE-2 (WM) (13253/12008), is the identical heat as the Fermi 2 lower shell axial weld heat (13253/12008). This heat was contained in two (2) BWR Supplemental Surveillance Program (SSP) capsules that have been tested and analyzed. It is noted that the maximum scatter in the fitted data falls within the 1-sigma value of 28°F from RG 1.99. BWRVIP-135 also provides best estimate chemistries that are used in the ART evaluation. The best estimate chemistry for ISP weld heat is defined as 0.21% Cu and 0.86% Ni. The CF from RG 1.99 is 206.6°F (‘$Table\ CF_{SurvChem}$’ in Equation 1) and the fitted CF is [[ ]] (‘$CF_{FittedData}$’ in Equation 1). The Fermi 2 limiting vessel chemistry for this material is 0.26% Cu and 0.87% Ni, from plant-specific CMTRs. Using RG 1.99, the CF is 224.0°F (‘$Table\ CF_{VesselChem}$’ in Equation 1). As the ISP weld material is identical to the vessel target material, the ART table evaluates the ISP weld material using an adjusted CF and is therefore permitted to reduce the margin term as defined in RG 1.99, Position 2.1.

The CF for a weld material that has more than two (2) data points is determined by calculating an adjusted CF in accordance with RG 1.99. The adjusted CF is determined using the following equation:

$$Adjusted\ Surv.CF = \left(\frac{Table\ CF_{VesselChem}}{Table\ CF_{SurvChem}}\right) \times CF_{FittedData} \qquad (1)$$

For Fermi 2, the adjusted CF = (224.0°F / 206.6°F) * [[ ]].

As [[ ]]is greater than 224°F, and the surveillance data is credible, the adjusted CF of [[ ]]is used in the ART evaluation. This material was considered in determining the limiting ART for the P-T curves.

Should actual surveillance capsules be withdrawn and tested from the Fermi 2 RPV (e.g., status change to be an ISP host plant under the BWRVIP ISP), compliance with 10 CFR 50 Appendix H requirements on reporting test results and evaluations on the effects to plant operations parameters (e.g., P-T limits, hydrostatic and leak test conditions) will be in accordance with Section 3 of Reference3.

3.6 Beltline Weld Flaw Indications

Three (3) flaw indications have been evaluated for the Fermi 2 vessel, occurring at weld 15-308 (axial weld) in the lower-intermediate shell (Shell #2). Flaw #124 requirements bound those of Flaw #127 and Flaw #128. In addition, two (2) welding flaws were detected at weld 1-308 (axial weld) of upper shell (Shell #4) and were determined acceptable as they met the construction code acceptance criteria of ASME Code Section III NB-2500 and NB-5300.

A fracture mechanics evaluation was conducted using techniques consistent with the philosophy of Section XI of the ASME Code. The indication, Flaw #124, was modeled with length equal to 4.24 inches (along the weld thickness direction) and width equal to 2 inches. The long end of the indication is located 0.7 inches from the inside diameter (ID) surface, which includes a clad thickness of 0.3125 inches.

At 52 EFPY, the leak test temperature is calculated to be [[ ]] at [[ ]] from Table 1. For these conditions, the allowable fracture toughness (K_{Ir}) is [[ ]] and [[ ]] the calculated value of stress intensity factor (K_I), which is [[ ]]. For the [[ ]], K_{Ir} is [[ ]] and [[ ]] the calculated value of K_I, which is [[ ]]. Therefore, the P-T curves bound the calculated values of K_I; so, no additional shift of P-T curves is required. Because the calculated values of K_I are less than the allowable fracture toughness (K_{Ir}), the indication is not expected to become a surface indication during future operation and the indication is acceptable in the as-is condition for operation over 52 EFPY (60 years) considering GNF3 NFI and 24-month cycle extension operating conditions.

3.7 Thickness Discontinuities

For Fermi 2, there are four (4) thickness discontinuities in the RPV as follows:

- between the bottom head upper and lower torus
- between the bottom head torus and the support skirt attachment
- between the bottom head torus and Shell #1
- between Shell #1 and Shell #2.

There is also a thickness discontinuity between the top head dollar plate and torus; the P-T limits for the top head are determined considering this continuity in order to ensure that the vessel is adequately protected, or “bounded”.

An evaluation was performed for the vessel wall thickness transition discontinuities identified above. The Fermi 2 P-T curves bound the requirements due to the flaws discussed in Section 3.6, and the beltline thickness discontinuities discussed in this Section.

3.8 Pressure-Temperature (P-T) Curves

The Fermi 2 P-T curves presented in this PTLR are based upon the GEH methodology accepted by the NRC in Reference 2. Selected explanations are presented below, and Appendix D includes sample calculations demonstrating P-T curve methodology.

The pressure head for the beltline hydrostatic test curve (Curve A) for Fermi 2 is [[ ]]. This is determined using the height of the vessel and the elevation of the bottom of active fuel. The full vessel pressure head is [[ ]]. The pressure combining the internal pressure and pressure head is used for determining K_I for the bottom head curve as discussed in Sections 4.3.2.1.1 and 4.3.2.1.2 of Reference 2.

In Reference 2, the P-T curves for the non-beltline region were developed for a [[ ]] vessel with a nominal inside diameter of [[ ]]. Because the Fermi 2 RPV bottom head geometry is different from a [[ ]], it is necessary to confirm that the generic analysis of the [[ ]] applies to Fermi 2. The applicability of generic analysis data to Fermi 2 is shown as follows.

The P-T curve is dependent on the calculated K_I value which is proportional to the stress (σ) and the crack depth (a) as shown below:

$$K_I \propto \sigma\sqrt{\pi a} \qquad (2)$$

The stress is proportional to R/t (R = bottom head radius and t = bottom head thickness) and, for the P-T curves, crack depth, a, is t/4. Thus, K_I is proportional to $R/\sqrt{t}$. The generic curve value of $R/\sqrt{t}$, based on the generic BWR/6 bottom head dimensions, is:

Generic: [[ ]]

The Fermi 2-specific bottom head dimensions are R = 127.38 inches and t = 7.38 inches minimum, resulting in:

Fermi 2-specific: $R/\sqrt{t} = 127.38/\sqrt{7.38} = 47\sqrt{in}$

Because the generic value of $R/\sqrt{t}$ is [[ ]], the generic P-T curve [[ ]] when applied to the Fermi 2 bottom head.

The P-T curves for the heatup and cooldown operating conditions at a given EFPY apply for both the 1/4T and 3/4T locations. When combining pressure and thermal stresses, it is usually necessary to evaluate stresses at the 1/4T location (inside surface flaw) and the 3/4T location (outside surface flaw). This is because the thermal gradient tensile stress of interest is in the inner wall during cooldown and the outer wall during heatup. However, as a conservative simplification, the thermal gradient stress at the 1/4T location is assumed to be tensile for both heatup and cooldown. This results in the approach of applying the

maximum tensile stress at the 1/4T location. This approach is conservative because irradiation effects cause the allowable toughness, K_{Ir}, at 1/4T to be less than at 3/4T for a given metal temperature. This approach causes no operational difficulties, because the BWR is at steam saturation conditions during normal operation, well above the heatup/cooldown temperature curve limits.

For the core not critical curve (Curve B) and the core critical curve (Curve C), the P-T curves specify a coolant heatup and cooldown temperature rate of ≤ 100°F/hr for which the curves are applicable. However, the core not critical and the core critical curves were also developed to bound transients defined on the RPV thermal cycle diagram and the nozzle thermal cycle diagrams. The P-T limits and corresponding heatup/cooldown rates of either Curve A or Curve B may be applied while achieving or recovering from hydrostatic pressure and leak test conditions. Curve A may be used for the hydrostatic pressure and leak test if a coolant heatup and cooldown rate of ≤ 20°F/hr is maintained. Otherwise, the limits of Curve B apply when performing the hydrostatic pressure and leak test.

The Fermi 2 P-T curves are based upon an initial RT_{NDT} of [[ ]] for the bottom head, [[ ]] for the upper vessel, an ART of [[ ]] for the plates and welds, and [[ ]] for the N16 WLI nozzle. For Curve B, the N16 WLI nozzle requirements [[ ]] on the beltline limited curves.

For Fermi 2, the N16 WLI nozzle is [[ ]] for the beltline region for 52 EFPY. The WLI nozzle is evaluated using the appropriate stresses for the nozzle and shifting the baseline curve by the ART. Using the fluence discussed earlier, the P-T curves are beltline weld limited at all pressures [[ ]] for Curve A. For Curve B, the N16 nozzle requirements are bounding [[ ]].

In order to ensure that the limiting vessel discontinuity has been considered in the development of the P-T curves, the methods in Sections 4.3.2.1 and 4.3.2.2 of Reference 2 for the non-beltline and beltline regions, respectively, are applied.

In order to determine how much to shift the baseline non-beltline P-T curves, an evaluation is performed using Tables 4-4a and 4-5a from Reference 2. These tables define [[ ]]. Each component listed in these tables is evaluated using its plant-specific initial RT_{NDT}. The required temperature is then determined by [[ ]], thereby resulting in the required T for the curve. As the upper vessel curve is initially based on the non-shifted [[ ]], all resulting T values are compared to the [[ ]]. The difference between the maximum T and [[ ]] is used to shift the [[ ]]. The same method is applied for the [[ ]]. In this manner, it is assured that each curve bounds the maximum discontinuity that is represented.

For the Fermi 2 upper vessel curve, the maximum T value for pressure equal to [[ ]] from the method described above is [[ ]]. The initial required T-RT_{NDT} for the [[ ]]; this is then adjusted by the Fermi 2 specific maximum FW nozzle initial RT_{NDT} of [[ ]], resulting in [[ ]]. Comparing this to the other components bounded by the upper vessel curve, the limiting value is for the [[ ]]. The required T-RT_{NDT} for the [[ ]], which is added to the limiting [[ ]]. It is seen that the resulting T required for the [[ ]]. As [[ ]]is limiting, the Fermi 2 upper vessel curve is based on an RT_{NDT} of [[ ]]. As noted above, this calculation was performed for each component shown in Table 4-4a of the Reference 2; only the limiting cases are discussed here.

For the Fermi 2 bottom head or CRD hydrotest and core critical curves (Curves A and C, respectively), the maximum T value from the method described above is [[ ]]. The required T-RT_{NDT} for the [[ ]]; this is adjusted by the Fermi 2 specific maximum [[ ]], resulting in [[ ]]. Comparing this to the remaining components represented by the bottom head curve, the required T-RT_{NDT} is [[ ]], which is added to the [[ ]]. It is seen that the resulting T required for the [[ ]]. As [[ ]], the Fermi 2 bottom head (CRD) curve is based on an [[ ]]. As noted above, this calculation was performed for each component shown in Table 4-5a of Reference 2; only the limiting case is presented here.

Appendix H of Reference 2 contains the details of an analysis performed to determine the baseline requirement (non-shifted) for the [[ ]]. It can be seen in Section H.5 of Appendix H of Reference 2 that the stresses developed in this finite element analysis demonstrated that the [[ ]], resulting in a baseline non-shifted required T-RT_{NDT} of [[ ]]. Therefore, considering the determination of the required shift from the paragraph above for [[ ]], calculations for all components listed in Table 4-5a of Reference 2 were compared to the CRD T, which is [[ ]] (where [[ ]] materials). Therefore, the shift for the bottom head [[ ]]

The ART of the limiting beltline material is used to adjust the beltline P-T curves to account for the effects of irradiation. RG 1.99 provides the methods for determining the ART.

Appendix J of Reference 2 provides detailed results of an analysis performed for the WLI nozzle that provides the required stresses for the drill hole in the shell plate. These stresses were used to generate a specific curve applicable for the WLI nozzle to ensure that this location is bounded in the P-T curves. For Fermi 2, the N16 WLI nozzle is the [[ ]] for the beltline region for 52 EFPY. The Fermi 2 P-T curves are N16 WLI nozzle requirements are bounding Curve A [[ ]] and Curve B above [[ ]].

The Fermi 2 N16 WLI nozzle is a partial penetration design similar to that shown in Figure 1 in Appendix J of Reference 2, fabricated with a [[ ]]. Therefore, the evaluation is performed, consistent with the statement in Appendix J, by using the material properties and ART of the limiting forging material.

3.9 Reactor Coolant Pressure Boundary (RCPB)

ASME Code Section III, NB-2332(b) states:

> "Pressure retaining material, other than bolting, with nominal wall thickness over 2-1/2 in. for piping (pipe and tubes) and material for pumps, valves, and fittings with any pipe connections of nominal wall thickness greater than 2-1/2 in. shall meet the requirements of NB-2331. The lowest service temperature shall not be lower than RT_{NDT} + 100°F unless a lower temperature is justified by following methods similar to those contained in Appendix G."

All Fermi 2 ferritic reactor coolant pressure boundary (RCPB) piping have wall thicknesses less than 2.5 inches. The lowest service temperature may be less than RT_{NDT} + 100°F, however the methods of Appendix G have been followed to justify lower temperatures. Therefore, the requirements of NB-2332 have been met, and there are no ferritic RCPB piping components that require consideration in the Fermi 2 P-T curves.

With respect to the concern regarding irradiation effects on RCPB piping, the N16 WLI beltline nozzles were assessed. As can be seen in Table B-5, the WLI nozzle exceeds 1.0e17 n/cm^2 at the 1/4T location. It is further noted that the WLI piping have a thickness less than 2.5 inches and are fabricated from [[ ]]. Therefore, this piping meets the conditions identified in ASME NB-2332(b) and does not require evaluation for fracture toughness.

3.10 Future Changes

Changes to the curves, limits, or parameters within this PTLR, based upon new irradiation fluence data of the RPV, or other plant design assumptions in the Updated Final Safety Analysis Report (UFSAR), can be made pursuant to 10 CFR 50.59, provided the above

methodologies are utilized. The revised PTLR shall be submitted to the NRC upon issuance (Reference 2).

4.0 Operating Limits

The pressure-temperature (P-T) curves provided in this PTLR represent steam dome pressure versus minimum vessel metal temperature and incorporate the appropriate non-beltline limits and irradiation embrittlement effects in the beltline region. Note that the P-T curves were developed without allowance or margin for instrument uncertainty or errors.

The operating limits for pressure and temperature are required for three categories of operation:

1. Curve A: Pressure Test (Hydrostatic Pressure Tests and Leak Tests)

   Curve A may be used during pressure tests at times when the coolant temperature heatup or cooldown rate is ≤ 20°F/hr during a hydrotest and when the core is not critical.

2. Curve B: Non-Nuclear Heatup/Cooldown

   Curve B must be used whenever Curve A or Curve C do not apply. In other words, this curve must be followed during times when the coolant heatup or cooldown rate is greater than 20°F/hr during a pressure test and when the core is not critical. Additionally, when performing low-power physics testing, Curve B must be followed. The heatup and cooldown rate is limited to ≤ 100°F/hr when using Curve B.

3. Curve C: Core Critical Operation

   This curve must be used when the core is critical with the exception as noted in Item 2 above, during low-power physics testing activities. The heatup and cooldown rate is limited to ≤ 100°F/hr when using Curve C.

Complete P-T curves were developed for 52 EFPY. The P-T curves are provided in Figures 1 through 3, and a tabulation of the curves is included in Table 1.

Other temperature limits applicable to the RPV and controlled by the Technical Specification are:

- Heatup and Cooldown rate limit during Hydrostatic and Class 1 Leak Testing: ≤ 20°F/hour.
- Normal Operating Heatup and Cooldown rate limit: ≤ 100 °F/hour.
- RPV bottom head coolant temperature to RPV coolant temperature ΔT limit during Recirculation Pump startup: ≤ 145 °F.
- Recirculation loop coolant temperature to RPV coolant temperature ΔT limit during Recirculation Pump startup: ≤ 50 °F.

- RPV flange and adjacent shell temperature limit: ≥ 72 °F.

5.0 Discussion

The procedures described in References 1 and 2 were used in the development of the P-T curves for Fermi 2.

The method for determining the initial Reference Temperature of Nil-Ductility Transition (RT_{NDT}) for all vessel materials is defined in Section 4.1.2 of Reference 2. Initial RT_{NDT} values for all vessel materials considered are presented in tables in Appendix B.

For Fermi 2, the surveillance material, weld heat CE-2 (WM) (13253/12008), was considered using Procedure 1 as defined in Appendix I of Reference 2. This procedure was used because the target vessel material and the surveillance material are identical heats. However, from Table B-5, the limiting material is N16 WLI nozzle forging whose ART is [[ ]]. This ART was used for the generation of P-T curves.

The ART of the limiting beltline material is used to adjust the beltline P-T curves to account for irradiation effects. Regulatory Guide 1.99, Revision 2 (RG 1.99) provides the methods for determining the ART.

The P-T curves for the non-beltline region were conservatively developed for [[ ]] vessel with nominal inside diameter of [[ ]]. The analysis is considered appropriate for Fermi 2 because the plant-specific geometric values [[ ]] by the generic analysis for the large [[ ]]. The generic value [[ ]] to the conditions at Fermi 2 using plant-specific RT_{NDT} values for the reactor pressure vessel.

For Fermi 2, the N16 WLI nozzle forging material is the limiting material for the beltline region for 52 EFPY whose initial RT_{NDT} and ART are 30°F and [[ ]], respectively. The generic pressure test P-T curve is applied to the Fermi 2 beltline curve by shifting the P vs. (T - RT_{NDT}) values to reflect the ART value of [[ ]] for 52 EFPY. Using the fluence discussed above, the P-T curves are [[ ]] for Curves A, B, and C. Curve A is [[ ]]; Curve B and Curve C are [[ ]].

In order to ensure that the limiting vessel discontinuity has been considered in the development of the P-T curves, the methods in Sections 4.3.2.1 and 4.3.2.2 of Reference 2 for the non-beltline and beltline regions, respectively, are applied.

6.0 References

1. Final Safety Evaluation Regarding Removal of Methodology Limitations for NEDC-32983P-A, General Electric Methodology for Reactor Pressure Vessel Fast Neutron Flux Evaluation (TAC NO. MC3788), November 17, 2005.
2. Final Safety Evaluation for Boiling Water Reactors Owners' Group Licensing Topical Report NEDC-33178P, General Electric Methodology for Development of Reactor Pressure Vessel Pressure-Temperature Curves (TAC NO. MD2693), April 27, 2009.
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5. DTE Energy/Enrico Fermi Power Plant 2 Pressure and Temperature Limits Report Up to 24 And 32 Effective Full-Power Years, NEDC-33785P, Revision 1, June 2013. (GEH Proprietary Information)
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7. Not used.
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9. Mehta, H.S., Stevens, G.L., Sommerville, D.V., Benson, M., Kirk, M., Griesbach, T.J., and Kusnick, J., Treatment of Stresses Exceeding Material Yield Strength in ASME Code Section XI Appendix G Fracture Toughness Evaluations, 2014 ASME Pressure Vessels and Piping Conference, PVP2014-28397, July 2014.
10. Radiation Embrittlement of Reactor Vessel Materials, USNRC Regulatory Guide 1.99, Revision 2, May 1988.
11. Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence, USNRC Regulatory Guide 1.190, March 2001.

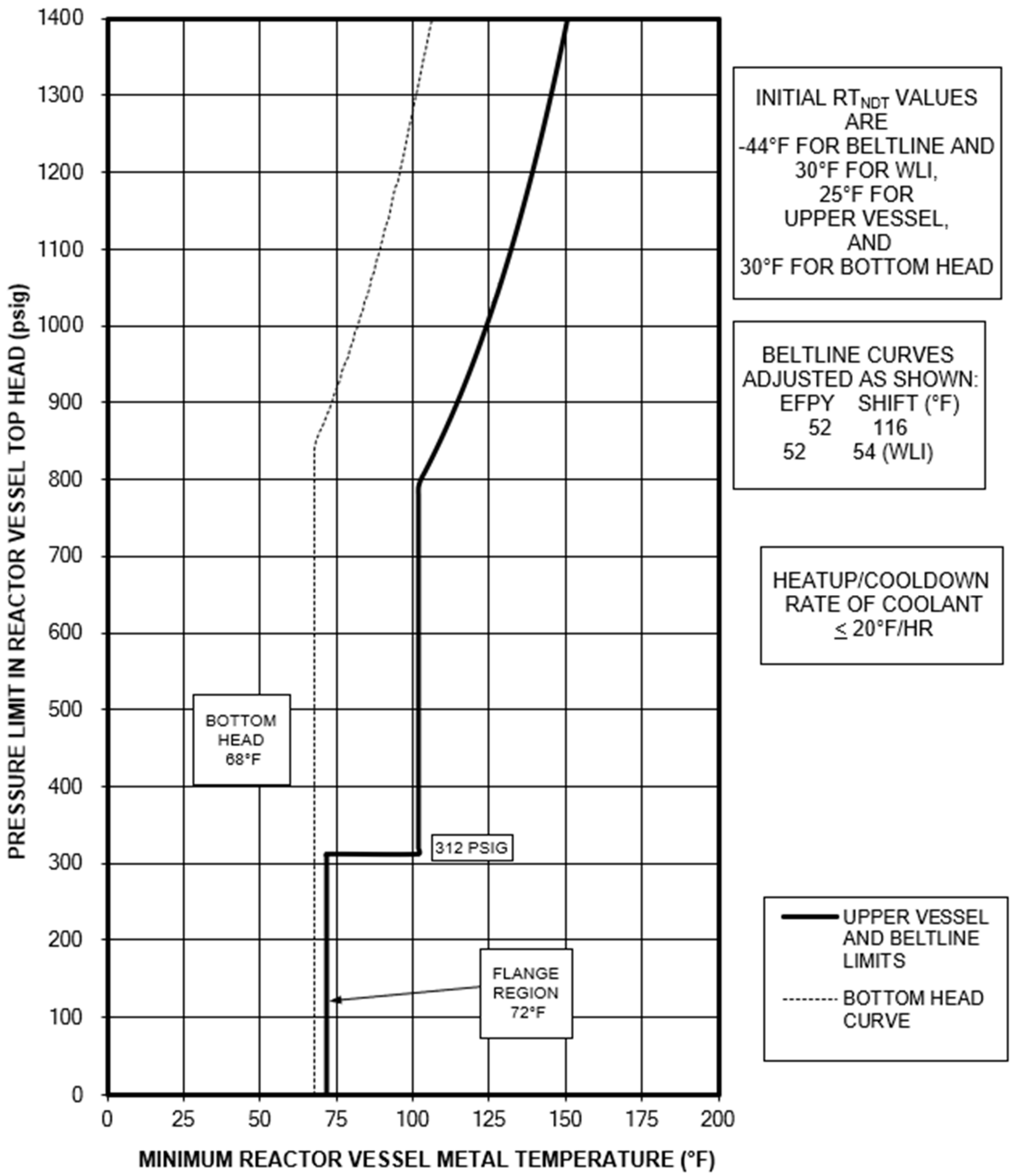

Figure 1 – Fermi 2 Composite Curve A (Pressure Test P-T Curves) Effective for up to 52 EFPY

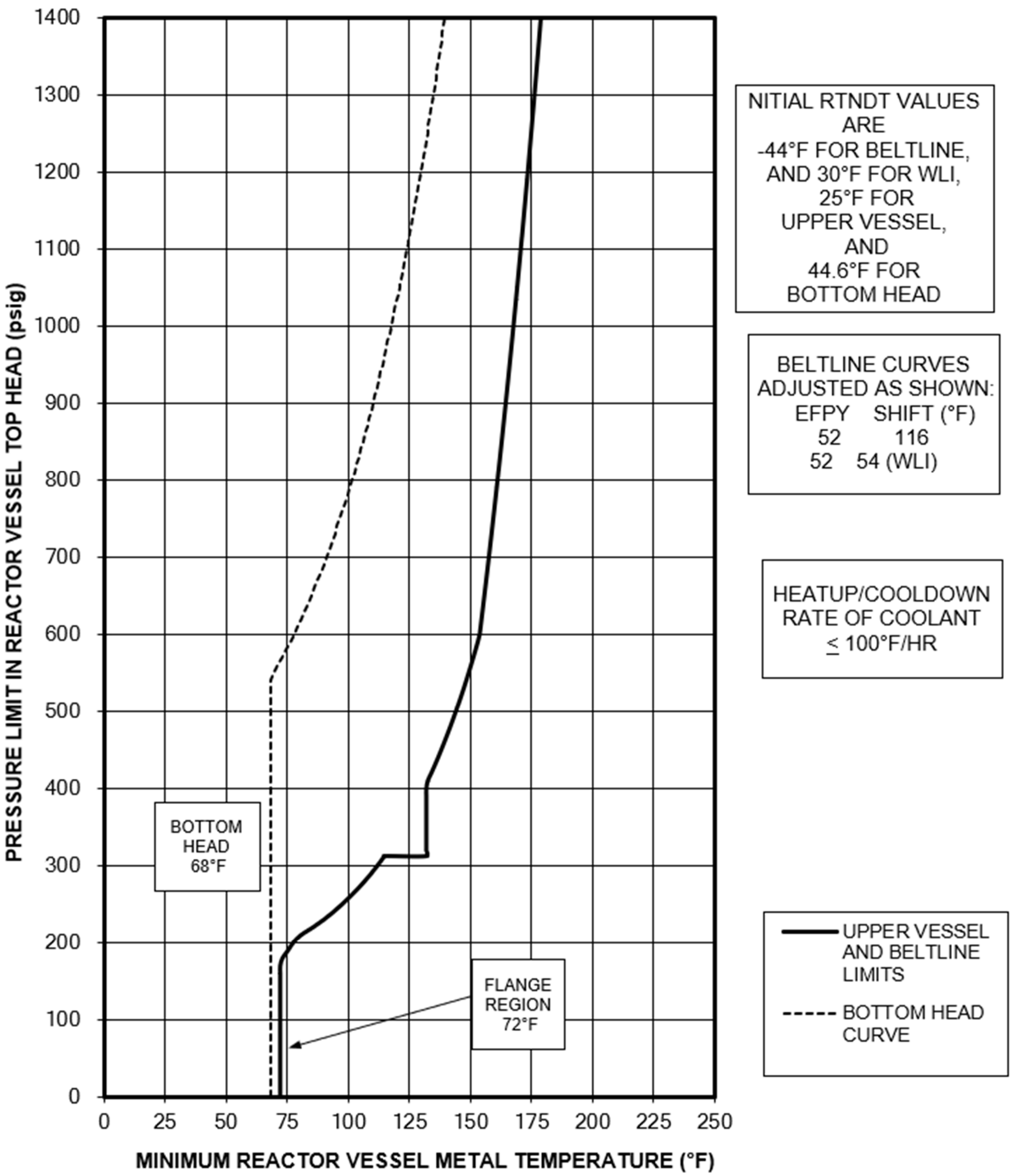

Figure 2 – Fermi 2 Composite Curve B (Core Not Critical P-T Curves) Effective for up to 52 EFPY

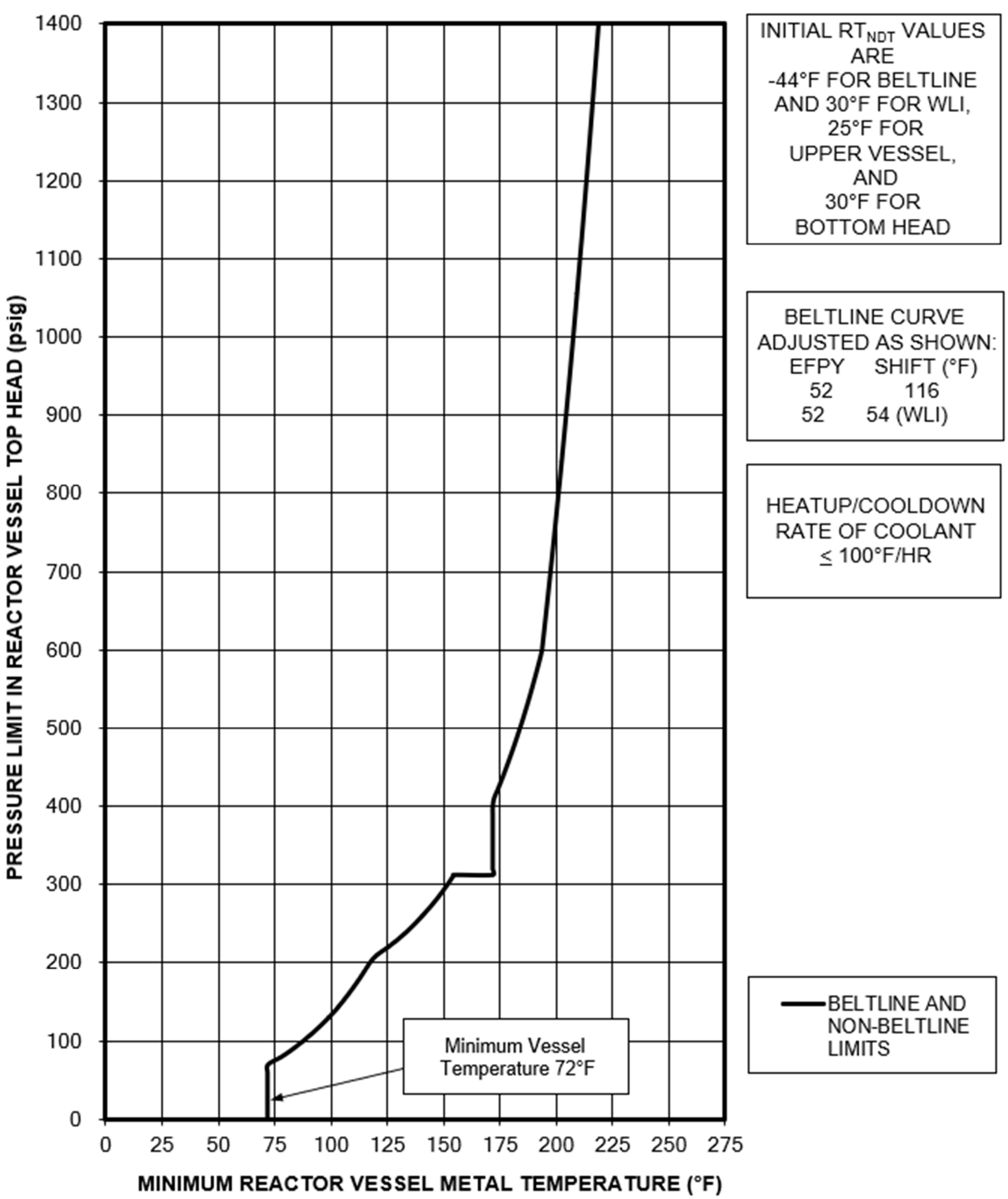

Figure 3 – Fermi 2 Limiting Curve C (Core Critical P-T Curve) Effective for up to 52 EFPY

Table 1 Fermi 2 Tabulation of Curves – 52 EFPY

PRESSURE (PSIG)	BOTTOM HEAD CURVE A (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE A (°F)	BOTTOM HEAD CURVE B (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE B (°F)	LIMITING 52 EFPY CURVE C (°F)
0	68.0	72.0	68.0	72.0	72.0
10	68.0	72.0	68.0	72.0	72.0
20	68.0	72.0	68.0	72.0	72.0
30	68.0	72.0	68.0	72.0	72.0
40	68.0	72.0	68.0	72.0	72.0
50	68.0	72.0	68.0	72.0	72.0
60	68.0	72.0	68.0	72.0	72.0
70	68.0	72.0	68.0	72.0	72.2
80	68.0	72.0	68.0	72.0	78.2
90	68.0	72.0	68.0	72.0	83.3
100	68.0	72.0	68.0	72.0	87.8
110	68.0	72.0	68.0	72.0	91.9
120	68.0	72.0	68.0	72.0	95.7
130	68.0	72.0	68.0	72.0	99.2
140	68.0	72.0	68.0	72.0	102.4
150	68.0	72.0	68.0	72.0	105.2
160	68.0	72.0	68.0	72.0	107.9
170	68.0	72.0	68.0	72.0	110.5
180	68.0	72.0	68.0	72.9	112.9

PRESSURE (PSIG)	BOTTOM HEAD CURVE A (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE A (°F)	BOTTOM HEAD CURVE B (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE B (°F)	LIMITING 52 EFPY CURVE C (°F)
190	68.0	72.0	68.0	75.2	115.2
200	68.0	72.0	68.0	77.3	117.3.0
210	68.0	72.0	68.0	80.4	120.4
220	68.0	72.0	68.0	85.5	125.3
230	68.0	72.0	68.0	89.8	129.8
240	68.0	72.0	68.0	93.8	133.8
250	68.0	72.0	68.0	97.3	137.3
260	68.0	72.0	68.0	100.7	140.7
270	68.0	72.0	68.0	103.8	143.8
280	68.0	72.0	68.0	106.7	146.7
290	68.0	72.0	68.0	109.4	149.4
300	68.0	72.0	68.0	111.9	151.9
310	68.0	72.0	68.0	114.2	154.2
312.5	68.0	72.0	68.0	114.8	154.8
312.5	68.0	102.0	68.0	132.0	172.0
320	68.0	102.0	68.0	132.0	172.0
330	68.0	102.0	68.0	132.0	172.0
340	68.0	102.0	68.0	132.0	172.0
350	68.0	102.0	68.0	132.0	172.0
360	68.0	102.0	68.0	132.0	172.0

PRESSURE (PSIG)	BOTTOM HEAD CURVE A (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE A (°F)	BOTTOM HEAD CURVE B (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE B (°F)	LIMITING 52 EFPY CURVE C (°F)
370	68.0	102.0	68.0	132.0	172.0
380	68.0	102.0	68.0	132.0	172.0
390	68.0	102.0	68.0	132.0	172.0
400	68.0	102.0	68.0	132.0	172.0
410	68.0	102.0	68.0	132.6	172.6
420	68.0	102.0	68.0	134.0	174.0
430	68.0	102.0	68.0	135.5	175.5
440	68.0	102.0	68.0	136.8	176.8
450	68.0	102.0	68.0	138.1	178.1
460	68.0	102.0	68.0	139.4	179.4
470	68.0	102.0	68.0	140.6	180.6
480	68.0	102.0	68.0	141.8	181.8
490	68.0	102.0	68.0	143.0	183.0
500	68.0	102.0	68.0	144.1	184.1
510	68.0	102.0	68.0	145.2	185.2
520	68.0	102.0	68.0	146.3	186.3
530	68.0	102.0	68.0	147.3	187.3
540	68.0	102.0	68.0	148.4	188.4
550	68.0	102.0	69.5	149.3	189.3
560	68.0	102.0	71.3	150.3	190.3

PRESSURE (PSIG)	BOTTOM HEAD CURVE A (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE A (°F)	BOTTOM HEAD CURVE B (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE B (°F)	LIMITING 52 EFPY CURVE C (°F)
570	68.0	102.0	73.0	151.3	191.3
580	68.0	102.0	74.6	152.2	192.2
590	68.0	102.0	76.2	153.1	193.1
600	68.0	102.0	77.8	153.9	193.9
610	68.0	102.0	79.3	154.3	194.3
620	68.0	102.0	80.7	154.7	194.7
630	68.0	102.0	82.1	155.1	195.1
640	68.0	102.0	83.5	155.4	195.4
650	68.0	102.0	84.8	155.8	195.8
660	68.0	102.0	86.1	156.2	196.2
670	68.0	102.0	87.4	156.6	196.6
680	68.0	102.0	88.7	156.9	196.9
690	68.0	102.0	89.9	157.3	197.3
700	68.0	102.0	91.0	157.7	197.7
710	68.0	102.0	92.2	158.0	198.0
720	68.0	102.0	93.3	158.4	198.4
730	68.0	102.0	94.4	158.8	198.8
740	68.0	102.0	95.5	159.1	199.1
750	68.0	102.0	96.6	159.5	199.5
760	68.0	102.0	97.6	159.8	199.8

PRESSURE (PSIG)	BOTTOM HEAD CURVE A (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE A (°F)	BOTTOM HEAD CURVE B (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE B (°F)	LIMITING 52 EFPY CURVE C (°F)
770	68.0	102.0	98.6	160.2	200.2
780	68.0	102.0	99.6	160.5	200.5
790	68.0	102.0	100.6	160.9	200.9
800	68.0	102.8	101.5	161.2	201.2
810	68.0	104.1	102.5	161.6	201.6
820	68.0	105.4	103.4	161.9	201.9
830	68.0	106.6	104.3	162.3	202.3
840	68.0	107.9	105.2	162.6	202.6
850	68.6	109.0	106.0	162.9	202.9
860	69.6	110.2	106.9	163.3	203.3
870	70.6	111.4	107.7	163.6	203.6
880	71.5	112.5	108.6	163.9	203.9
890	72.5	113.6	109.4	164.3	204.3
900	73.4	114.6	110.2	164.6	204.6
910	74.4	115.7	111.0	164.9	204.9
920	75.3	116.7	111.7	165.2	205.2
930	76.1	117.7	112.5	165.6	205.6
940	77.0	118.7	113.3	165.9	205.9
950	77.9	119.7	114.0	166.2	206.2
960	78.7	120.6	114.7	166.5	206.5

PRESSURE (PSIG)	BOTTOM HEAD CURVE A (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE A (°F)	BOTTOM HEAD CURVE B (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE B (°F)	LIMITING 52 EFPY CURVE C (°F)
970	79.6	121.5	115.5	166.8	206.8
980	80.4	122.4	116.2	167.1	207.1
990	81.2	123.3	116.9	167.5	207.5
1000	82.0	124.2	117.6	167.8	207.8
1010	82.7	125.1	118.2	168.1	208.1
1020	83.5	125.9	118.9	168.4	208.4
1030	84.3	126.8	119.6	168.7	208.7
1035	84.6	127.2	119.9	168.8	208.8
1040	85.0	127.6	120.2	169.0	209.0
1050	85.7	128.4	120.9	169.3	209.3
1055	86.1	128.8	121.2	169.4	209.4
1060	86.4	129.2	121.5	169.6	209.6
1070	87.2	130.0	122.1	169.9	209.9
1080	87.9	130.8	122.8	170.2	210.2
1090	88.6	131.5	123.4	170.5	210.5
1100	89.2	132.3	124.0	170.8	210.8
1105	89.6	132.6	124.3	170.9	210.9
1110	89.9	133.0	124.6	171.1	211.1
1120	90.6	133.7	125.2	171.4	211.4
1130	91.2	134.5	125.8	171.6	211.6

PRESSURE (PSIG)	BOTTOM HEAD CURVE A (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE A (°F)	BOTTOM HEAD CURVE B (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE B (°F)	LIMITING 52 EFPY CURVE C (°F)
1140	91.9	135.2	126.3	171.9	211.9
1150	92.5	135.9	126.9	172.2	212.2
1160	93.1	136.5	127.5	172.5	212.5
1170	93.8	137.2	128.0	172.8	212.8
1180	94.4	137.9	128.6	173.1	213.1
1190	95.0	138.5	129.1	173.4	213.4
1200	95.6	139.2	129.7	173.6	213.6
1210	96.2	139.8	130.2	173.9	213.9
1220	96.8	140.5	130.8	174.2	214.2
1230	97.3	141.1	131.3	174.5	214.5
1240	97.9	141.7	131.8	174.8	214.8
1250	98.5	142.3	132.3	175.0	215.0
1260	99.0	142.9	132.8	175.3	215.3
1270	99.6	143.5	133.3	175.6	215.6
1280	100.1	144.1	133.8	175.8	215.8
1290	100.7	144.7	134.3	176.1	216.1
1300	101.2	145.3	134.8	176.4	216.4
1310	101.7	145.8	135.3	176.7	216.7
1320	102.3	146.4	135.8	176.9	216.9
1330	102.8	147.0	136.2	177.2	217.2

PRESSURE (PSIG)	BOTTOM HEAD CURVE A (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE A (°F)	BOTTOM HEAD CURVE B (°F)	UPPER RPV & BELTLINE AT 52 EFPY CURVE B (°F)	LIMITING 52 EFPY CURVE C (°F)
1340	103.3	147.5	136.7	177.5	217.5
1350	103.8	148.1	137.2	177.7	217.7
1360	104.3	148.6	137.6	178.0	218.0
1370	104.8	149.1	138.1	178.2	218.2
1380	105.3	149.7	138.5	178.5	218.5
1390	105.8	150.2	139.0	178.8	218.8
1400	106.3	150.7	139.4	179.0	219.0

Appendix A Reactor Vessel Material Surveillance Program

In accordance with 10 CFR 50, Appendix H, Reactor Vessel Material Surveillance Program Requirements, the first surveillance capsule was removed from the Fermi 2 reactor vessel after Cycle 7, during refueling outage (RFO) 7 in April 2000. This capsule was placed in the Spent Fuel Pool and has not been tested. The surveillance capsule contains flux wires for neutron fluence measurement, Charpy V-Notch impact test specimens and uniaxial tensile test specimens fabricated using materials from the vessel materials within the core beltline region.

As described in the Fermi 2 Updated Final Safety Analysis Report (UFSAR) Section 5.2.4.4, Surveillance Programs for the Reactor Pressure Vessel, the BWR Vessel and Internals Project (BWRVIP) Integrated Surveillance Program (ISP) will determine the removal schedule for the remaining Fermi 2 surveillance capsules. The Fermi 2 material surveillance program is administered in accordance with the BWRVIP ISP. The ISP combines the US BWR surveillance programs into a single integrated program. This program uses similar heats of materials in the surveillance programs of BWRs to represent the limiting materials in other vessels. It also adds data from the [[ ]]. Per the BWRVIP ISP, Fermi 2 [[ ]]; all surveillance capsules are classified as "Deferred".

Appendix B Fermi 2 Reactor Pressure Vessel P-T Curve Supporting Plant-Specific Information

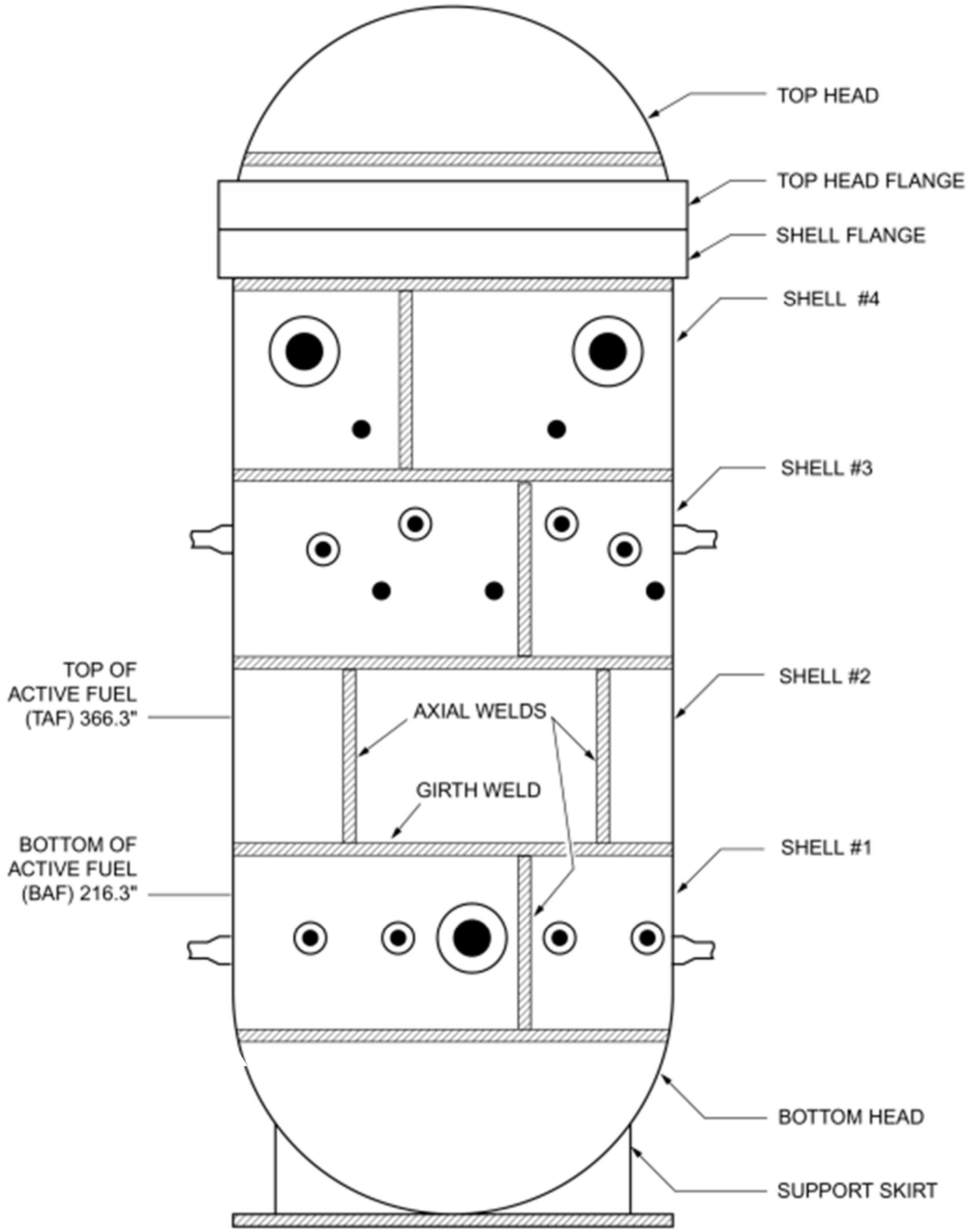

Figure B-1 - Schematic of the Fermi 2 RPV Showing Arrangement of Vessel Plates and Welds

Table B-1 Fermi 2 Initial RTNDT Values for RPV Plate and Flange Materials

Component	Heat	Test Temp (°F)	Charpy Energy (ft-lb)			(T_{50T}-60) (°F)	Drop Weight NDT (°F)	RT_{NDT} (°F)
Top Head & Flange								
Shell Flange G3701	AWH 113 2V-708	10	89	89	90	-20	10	10
Top Head Flange G3702	ACR 108	10	196	191	101	-20	10	10
Top Head Dollar C3732	C5445-1	10	79	86	79	-20	-10	-10
Top Head Lower Torus Plates								
G3731-1	C5445-2	10	95	91	97	-20	-10	-10
G3731-2	C5445-2	10	97	96	101	-20	-10	-10
Top Head Upper Torus Plates G3730	C5445-1	10	107	85	102	-20	-10	-10
Shell Courses								
Upper Shell Plates								
G3703-1	C4568-1	40	68	65	56	10	-10	10
G3703-2	C4564-2	40	64	49	54	12	-10	12
G3703-3	C4560-2	10	53	63	52	-20	-10	-10
G3703-4	C4554-2	40	74	75	87	10	-10	10
Upper Intermediate Plates								
G3704-1	C4574-1	10	70	68	66	-20	-10	-10
G3704-2	C4578-2	10	59	45	52	-10	-10	-10
G3704-3	C4578-1	10	44	56	68	-8	-10	-8
Lower-Intermediate Plates								
G3703-5	C4564-1	10	60	45	59	-10	-20	-10
G3705-1	B8614-1	10	62	64	56	-20	-20	-20
G3705-2	C4574-2	10	48	49	60	-16	-30	-16
G3705-3	C4568-2	10	46	67	63	-12	-30	-12
Lower Shell Plates								
G3706-1	C4540-2	10	64	76	74	-20	-10	-10
G3706-2	C4560-1	10	85	79	99	-20	-10	-10
G3706-3	C4554-1	10	59	65	68	-20	-10	-10
Bottom Head								
Bottom Head Dollar G3708	C3424-1	10	41	48	57	-2	-10	-2
Bottom Head Upper Torus Plates								
G3711-1	C4526-1	-40	57	60	55	-70	-10	-10
G3712-1	C4504-3	-40	70	64	56	-70	-10	-10
Bottom Head Lower Torus Plates								
C3709-1	C5050-2	10	58	70	83	-20	-10	-10
C3710-1	C4504-1	10	74	70	74	-20	-10	-10
C3710-2	C4504-2	40	40	48	42	30	10	30

Note: Minimum Charpy values are provided for all materials.

Table B-2 Fermi 2 Initial RTNDT Values for RPV Nozzle Materials

Component	Heat or Heat / Flux / Lot	Test Temp (°F)	Charpy Energy (ft-lb)			$(T_{50T}-60)$ (°F)	Drop Weight NDT (°F)	RT_{NDT} (°F)
Recirculation Outlet Nozzle								
G3717-1	AJF 181	10	77	96	59	-20	-20	-20
G3717-2	AJF 193	10	91.5	89	85	-20	-30	-20
Recirculation Inlet Nozzle								
G3718-1	AV3505 9A-9239	10	54	45	38	4	0	4
G3718-2	AV3505 9A-9240	10	34	32	36	16	-10	16
G3718-3	AV3502 9A-9365	10	35	32	36	16	20	20
G3718-5	AV3503 9A-9368	10	42	36	60	8	-30	8
G3718-6	AV3503 9A-9369	10	49	40	49	0	-30	0
G3718-7	AV3504 9A-9371	10	58	28	37	24	-40	24
G3718-8	AV3857 9D-9407	10	48	32	46	16	20	20
G3718-9	AV3857 9D-9406	10	47	64	58	-14	10	10
G3718-10	AV3857 9D-9408	10	82	46	55	-12	10	10
G5218-4	AV3934 9E-9011	10	47	60	88	-14	40	40
Steam Outlet Nozzle								
G3714-1	AV3496 9A-9234	10	66	36	85	8	10	10
G3714-2	AV3507 9A-9235	10	74	75	36	8	0	8
G3714-3	AV3510 9A-9236	10	36	34	32	16	10	16
G3714-4	AV3511 9A-9237	10	52	32	42	16	10	16
Feedwater Nozzle								
G3715-1	AV3508 9A-9228	10	82	91	58	-20	0	0
G3715-2	AV3508 9A-9229	10	68	58	50	-20	0	0
G3715-3	AV3508 9A-9230	10	62	67	76	-20	-30	-20
G3715-4	AV3509 9A-9232	10	60	42	64	-4	-10	-4
G3715-5	AV3509 9A-9231	10	38	54	50	4	0	4
G3715-6	AV3504 9B-9202	10	39	46	34	12	-10	12
Core Spray Nozzle								
G3720-1	AV2997 9A-9363	10	67	52	96	-20	-10	-10
G3720-2	AV2997 9A-9364	10	70	99	84	-20	-10	-10
Instrumentation Nozzle								
G3811-1	Q2Q14W 969C-1	10	54	59	73	-20	10	10
G3811-2	Q2Q14W 969C-2	10	54	59	73	-20	10	10
Top Head Vent Nozzle								
G3810	Q2Q6W 986C	10	92	95	88	-20	10	10
Jet Pump Nozzle								
G3719-1	EV-9806 8L-9211A	10	99	124	105	-20	-20	-20
G3719-2	EV-9806 8L-9211B	10	99	124	105	-20	-20	-20
CRD HYD Return Nozzle								
G3716	AV3138 8L-9104	10	42	40	48	0	10	10
Core ΔP Nozzle	Alloy 600							
G3738	NX9492							[2]
Replacement Instrument Nozzle [3]								
G3806	2127273	10	36	43	30	20	30	30
G3806R	6397860	10	250	230	247	-20	30	30
High Pressure Leak Detector Nozzle								
G4546								10 [1]
Drain Nozzle								
G3739	Q1Q1VW 738T	10	39	25	32	30	40	40
CRD Stub Tubes								
G3736-1 through -5	Alloy 600							[2]

(1) Information for this heat is not available; the purchase specification requirements are used for evaluation of this component.
(2) Alloy 600 components do not require fracture toughness evaluation.
(3) Dropweight data was not available; therefore NRC MTEB 5-2 was applied for the determination of dropweight.

Notes: Minimum Charpy values are provided for all materials.

The Replacement Instrument nozzle material data was reviewed; it was found that the previously reported value of 40°F was unnecessarily conservative, and has been reduced to a maximum of 30°F.

Table B-3 Fermi 2 Initial RT_{NDT} Values for RPV Weld Materials

Component	Heat or Heat / Flux / Lot	Test Temp (°F)	Charpy Energy (ft-lb)			$(T_{50T}$-60) (°F)	Drop Weight NDT (°F)	RT_{NDT} (°F)
Beltline - Axial								
Lower Shell								
2-307 A, B, C	13253 Linde 1092 Lot 3833	10	79	79	82	-50	-	-50
	12008 Linde 1092 Lot 3833	10	62	47	62	-44	-	-44
Lower-Intermediate Shell								
15-308 A, B, C, D	33A277 Linde 124 Lot 3878	10	83	94	87	-50	-	-50
Beltline - Girth								
Lower-Intermediate Shell to Lower Shell								
1-313	10137 Linde 0091 Lot 3999	10	101	108	107	-50	-	-50
Non-Beltline - Axial								
Upper-Intermediate Shell								
2-308 A through C	20291 & 12008 Linde 1092 Lot 3833	10	62	47	62	-44	-	-44
	HADH	10	112	110	114	-50	-	-50
	EOAG	10	173	133	135	-50	-	-50
Upper Shell								
1-308 A through D	34B009 Linde 124 Lot 3687	10	55	65	57	-50	-	-50
	34B009 Linde 124 Lot 3688	10	69	70	63	-50	-	-50
Bottom Head Upper Torus Meridional Welds								
1-306 A through K	HADH	10	112	110	114	-50	-	-50
Bottom Head Lower Torus Meridional Welds								
2-306 A through G	LACH-2	10	125	119	119	-50	-	-50
	HADH	10	112	110	114	-50	-	-50
Top Head Upper Torus Meridional Welds								
2-319 A through E	EOEJ	10	136	170	150	-50	-	-50
Top Head Lower Torus Meridional Welds								
1-319 A through H	DOAJ	10	166	146	158	-50	-	-50
	AOFJ	10	112	105	115	-50	-	-50
	EOEJ	10	136	170	150	-50	-	-50
Non-Beltline - Girth								
Top Head Assembly								
3-319, 4-319, 5-319	33A277 Linde 0091 Lot 3977	10	111	106	113	-50	-	-50
	90099 Linde 0091 Lot 3977	10	56	30	52	-10	-	-10
Shell Flange to Upper Shell								
13-308	21935 Linde 1092 Lot 3889	10	51	70	74	-50	-	-50
Upper Shell to Upper-Intermediate Shell								
4-308-A	305424 Linde 1092 Lot 3889	10	82	87	92	-50	-	-50
Upper-Intermediate Shell to Lower-Intermediate Shell								
4-308-B	1P3571 Linde 1092 Lot 3958 Tandem	10	79	68	64	-50	-	-50
	1P3571 Linde 1092 Lot 3958 Single	10	40	46	46	-30	-	-30
Lower Shell to Bottom Head								
9-307	90099 Linde 0091 Lot 3977	10	56	30	52	-10	-	-10
	90136 Linde 0091 Lot 3998	10	110	109	107	-50	-	-50
Bottom Head Assembly								
3-306, 5-306, 6-306	1P2809 Linde 1092 Lot 3854	10	102	102	103	-50	-	-50
Support Skirt to Bottom Head								
4-309	21935 Linde 1092 Lot 3869	10	62	59	60	-50	-	-50

Table B-3: Fermi 2 Initial RT_{NDT} Values for RPV Weld Materials (continued)

Component	Heat or Heat / Flux / Lot	Test Temp (°F)	Charpy Energy (ft-lb)			(T_{50T}-60) (°F)	Drop Weight NDT (°F)	RT_{NDT} (°F)
Nozzle Welds								
Recirculation Outlet	LOBI	10	123	104	115	-50	-	-50
5-314 A & B	CBAI							10
	GBAI	10	120	105	128	-50	-	-50
Recirculation Inlet								
13-314 A through K	LOEH	10	113	123	140	-50	-	-50
13-314D (Replacement)	BBAI	10	97	100	77	-50	-	-50
	LACH	10	125	119	119	-50	-	-50
	HOGI	10	91	93	94	-50	-	-50
	IAGI	10	142	157	170	-50	-	-50
Steam Outlet	FAGI	10	135	121	136	-50	-	-50
8-316 A through D	LACH	10	125	119	119	-50	-	-50
Feedwater Nozzle	FACI							10
4-316 A through F	HOGI	10	91	93	94	-50	-	-50
	LOEH	10	113	123	140	-50	-	-50
	COFI	10	96	97	89	-50	-	-50
Core Spray Nozzles	IAGI	10	142	157	170	-50	-	-50
14-316 A & B	BBAI	10	97	100	77	-50	-	-50
Top Head Instrument Nozzle								
14-318 A & B	ABEA							10
	BOIA	10	99	110	113	-50	-	-50
Top Head Vent Nozzle	ABEA							10
2-318	BOIA	10	99	110	113	-50	-	-50
Jet Pump Nozzle	LACH	10	125	119	119	-50	-	-50
19-314 A & B	LOEH	10	113	123	140	-50	-	-50
CRD HYD Return Nozzle								
15-315	IAGI	10	142	157	170	-50	-	-50
Core ΔP Nozzle								
9-315	Inconel 182							
Instrument Nozzles								
4-315 A through F	Inconel 182							
Drain Nozzle								
17-315	CAFJ	10	85	101	108	-50	-	-50
Stub Tubes								
1-310	Inconel 182							
Appurtenance Welds								
Stabilizer Brackets	ICJJ	10	121	120	128	-50	-	-50
10-324 A through H	DBIJ	10	129	117	122	-50	-	-50
	HOCJ	10	165	174	140	-50	-	-50
	GBCJ	10	126	143	121	-50	-	-50
Steam Dryer Hold Down Brackets to Top Head								
10-319	KAHJ	10	108	116	107	-50	-	-50
Basin Seal Skirt								
6-324 A through D	IBEJ	10	160	151	145	-50	-	-50
	LOAJ	10	152	125	104	-50	-	-50
7-324 A through D; 8-324	HOKJ	10	110	177	154	-50	-	-50
	KACJ	10	102	81	108	-50	-	-50
Thermocouple Pads								
1-325	GBJJ	10	203	160	239	-50	-	-50
2-325	COEJ	10	129	95	81	-50	-	-50
3-325; 4-325; 6-325	FCJJ	10	180	224	171	-50	-	-50
	BBJJ	10	107	102	53	-50	-	-50
	COCA	10	120	139	137	-50	-	-50
	HOKJ	10	110	177	154	-50	-	-50
	FOIA	10	182	224	218	-50	-	-50
7-325; 8-325	BOLH	10	159	138	123	-50	-	-50
Top Head Lifting Lugs	GBCJ	10	126	143	121	-50	-	-50
8-319 A through D	DBIJ	10	129	117	122	-50	-	-50

Note: Minimum Charpy values are provided for all materials.

Table B-4 Fermi 2 Initial RTNDT Values for RPV Appurtenance and Bolting Materials

Component	Heat	Test Temp (°F)	Charpy Energy (ft-lb)			(T_{50T}-60) (°F)	Drop Weight NDT (°F)	RT_{NDT} (°F)
Misc Appurtenances:								
Support Skirt Forging S8530	AHC 178	10	81	100	102	-20	30	30
Shroud Support G3726	Alloy 600 580608-1X							(1)
Stabilizer Brackets								
C-6-1	A4516-1	40	58	49	53	12	10	12
C-6-2	C5313-2	10	57	45	52	-10	-30	-10
Guide Rod Brackets G3772	Stainless Steel							(1)
Steam Dryer Support Lugs G3775	Stainless Steel							(1)
Steam Dryer Hold Down Brackets								
G4871	C2588-2D	10	122	129	107	-20	-	-20
D5591	C6195-4	10	83	69	61	-20	-	-20
Core Spray Brackets G3774	Stainless Steel							(1)
Basin Seal Skirt								
G3818	C2588-2B							10 (2)
G3819	22A459							10 (2)
Surveillance Specimen Brackets								
G3776	Stainless Steel							(1)
G3777	Stainless Steel							(1)
Feedwater Sparger Brackets G3773	Stainless Steel							(1)
Top Head Lifting Lugs G3732								40 (2)

Component	Heat	Test Temp (°F)	Charpy Energy (ft-lb)			Min Lat Exp (mils)	LST (°F)
Closure Studs							
G3778-1	14677	10	50	50	52	-	70
G3778-2	67156	10	55	54	55	-	70
G3778-3	-3	10	-	-	-	-	70
Closure Nuts							
G3779-1	48192	10	58	59	54	-	70
G3779-2	(3)	10	-	-	-	-	70
Closure Washers							
Closure Washers G5252	(3)	10	-	-	-	-	70
Bushings							
G4853	(3)	10	-	-	-	-	70

(1) Information for this heat is not available; the purchase specification requirements are used for evaluation of this component.
(2) Alloy 600 and Stainless Steel components do not require fracture toughness evaluation.
(3) Information for this component is not available; ASME Code requirements are applied.

Note: Minimum Charpy values are provided for all materials.

Table B-5 Fermi 2 Adjusted Reference Temperatures for up to 52 EFPY

Lower-Intermediate Shell Plates, Axial Welds

Thickness in inches = 6.125

52 EFPY Peak I.D. fluence = 9.92E+17 n/cm^2

52 EFPY Peak 1/4 T fluence = 6.87E+17 n/cm^2

Water Level Instrumentation Nozzle

Thickness in inches = 6.125

52 EFPY Peak I.D. fluence = 3.59E+17 n/cm^2

52 EFPY Peak 1/4 T fluence = 2.49E+17 n/cm^2

Lower Shell Plates and Axial Welds & Lower to Lower-Intermediate Girth Weld

Thickness in inches = 7.125

52 EFPY Peak I.D. fluence = 5.74E+17 n/cm^2

52 EFPY Peak 1/4 T fluence = 3.74E+17 n/cm^2

COMPONENT	HEAT OR HEAT/LOT	%Cu	%Ni	CF	Adjusted CF [1]	Initial RT_{NDT} °F	1/4 T Fluence n/cm^2	52 EFPY ΔRT_{NDT} °F	σ_I	σ_Δ	Margin °F	52 EFPY Shift °F	52 EFPY ART °F
PLANT SPECIFIC CHEMISTRIES													
PLATES:													
Lower Shell													
G3706-1	C4540-2	0.08	0.62	51		-10	3.74E+17	13	0	6	13	25	15
G3706-2	C4560-1	0.11	0.57	74		-10	3.74E+17	18	0	9	18	37	27
G3706-3	C4554-1	0.12	0.56	82		-10	3.74E+17	21	0	10	21	41	31
Lower-Intermediate Shell													
G3703-5	C4564-1	0.09	0.55	58		-10	6.87E+17	20	0	10	20	40	30
G3705-1	B8614-1	0.12	0.61	83		-20	6.87E+17	29	0	14	29	58	38
G3705-2	C4574-2	0.10	0.55	65		-16	6.87E+17	22	0	11	22	45	29
G3705-3	C4568-2	0.12	0.61	83		-12	6.87E+17	29	0	14	29	58	46

Table B-5 Fermi 2 Adjusted Reference Temperatures for up to 52 EFPY (continued)

COMPONENT	HEAT OR HEAT/LOT	%Cu	%Ni	CF	Adjusted CF (1)	Initial RT_{NDT} °F	1/4 T Fluence n/cm^2	52 EFPY ΔRT_{NDT}°F	σ_I	σ_Δ	Margin °F	52 EFPY Shift °F	52 EFPY ART °F
WELDS:													
Lower Shell Axial 2-307 A, B, C	Tandem 13253, 12008 1092 Lot 3833	0.26	0.87	224		-44	3.74E+17	56	0	28	56	112	68
Lower-Intermediate Shell Axial 15-308 A, B, C, D	33A277, 124 Lot 3878	0.32	0.50	188.5		-50	6.87E+17	65	0	28	56	121	71
Lower to Lower-Intermediate Girth 1-313	10137, 0091 Lot 3999	0.23	1.00	236		-50	3.74E+17	59	0	28	56	115	65
NOZZLES:													
N16 (Water Level Instrumentation)	2127273	0.272	0.214	136		30	2.49E+17	27	0	13	27	54	84
N16 (Water Level Instrumentation)	6397860	0.272	0.214	136		30	2.49E+17	27	0	13	27	54	84
N16 Weld	Inconel (2)												

Table B-5 Fermi 2 Adjusted Reference Temperatures for up to 52 EFPY (continued)

COMPONENT	HEAT OR HEAT/LOT	%Cu	%Ni	CF	Adjusted CF (1)	Initial RT_{NDT} °F	1/4 T Fluence n/cm^2	52 EFPY ΔRT_{NDT}°F	σ_I	σ_Δ	Margin °F	52 EFPY Shift °F	52 EFPY ART °F
Best Estimate Chemistries (6) None	None												
INTEGRATED SURVEILLANCE PROGRAM (3): BWRVIP-135 R3													
Plate (4)	C4114-2	0.12	0.70	84.5	[[ ]]	-12	6.87E+17	29	0	15	29	58	46
Weld (5)	CE-2 (WM) (13253,12008)	0.21	0.86	207		-44	3.74E+17	88	0	28	28	116	72

1. Adjusted CF calculated per RG 1.99 Position 2.1.
2. [[ ]].
3. Procedures defined in RG 1.99 are applied to determine the ART considering the Integrated Surveillance Program.
4. This ISP plate heat number is not identical to target (any plant specific) plate heat number. It is presented using the ISP chemistry, RG 1.99 R2 CF, the limiting Fermi 2 plate (Heat C4568-2) fluence and its initial $RT_{NDT.}$ This is not applicable to development of P-T curves and is provided for information only.
5. The ISP weld is the identical heat and is presented using the ISP chemistry and adjusted CF with the vessel weld Initial RT_{NDT} and fluence. σ_Δ is presented as calculated but is multiplied by 0.5 for the Margin calculation as defined in RG 1.99, Position 2.1.
6. None of the plate and weld heats had different best estimate chemistries.

Table B-6 Fermi 2 RPV Beltline P-T Curve Input Values for 52 EFPY

Adjusted RT_{NDT} = Initial RT_{NDT} + Shift	A = [[ ]] (limiting value for [[ ]]) A = [[ ]] (limiting value for [[ ]]) (Based on ART values in Table B-5; no additional adjustment is required to protect the existing flaw discussed in Section 3.5.)
Vessel Height	H = 861.6 inches
Bottom of Active Fuel Height	B = 216.3 inches
Vessel Radius (to base metal)	R = 127 inches
Minimum Vessel Thickness (without clad)	t = 6.125 inches

Table B-7 Fermi 2 Definition of RPV Beltline Region (1)

Component	Elevation (inches from RPV "0")
Shell # 2 - Top of Active Fuel (TAF)	366.3
Shell # 1 - Bottom of Active Fuel (BAF)	216.3
Shell # 2 – Top of Extended Beltline Region	381.6
Shell # 1 – Bottom of Extended Beltline Region	208.5
Circumferential Weld Between Shell #1 and Shell #2	244.6
Circumferential Weld Between Shell #2 and Shell #3	415.6
Centerline of Recirculation Outlet Nozzle N1 in Shell # 1	161.5
Top of Recirculation Outlet Nozzle N1 in Shell # 1	193.7
Centerline of Recirculation Inlet Nozzle N2 in Shell # 1	181.0
Top of Recirculation Inlet Nozzle N2 in Shell # 1	197.5
Centerline of Water Level Instrumentation Nozzle N16 in Shell # 2	366.0
Bottom of Water Level Instrumentation Nozzle N16 in Shell # 2 (2)	364.2

1. The extended beltline region is defined as any location where the peak neutron fluence is expected to exceed or equal 1.0e17 n/cm^2.
2. Elevation considering the WLI weld for the bounding fluence value at the WLI nozzle.

Based on the above, it is concluded that none of the Fermi 2 reactor vessel plates, nozzles, or welds, other than those included in the Adjusted Reference Temperature Table, are in the beltline region.

Appendix C Fermi 2 Reactor Pressure Vessel P-T Curve Checklist

Table C-1 provides a checklist that defines pertinent points of interest regarding the methods and information used in developing the Fermi 2 Pressure-Temperature Limits Report. This table demonstrates that all important parameters have been addressed in accordance with the P-T curve Licensing Topical Report (LTR) (Reference 2), and includes comments, resolutions, and clarifications as necessary.

Table C-1 Fermi 2 Checklist

Parameter	Completed	Comments/Resolutions/Clarifications
Initial RT_{NDT}		
Initial RT_{NDT} has been determined for Fermi 2 for all vessel materials including plates, flanges, forgings, studs, nuts, bolts, welds. Include explanation (including methods/sources) of any exceptions, resolution of discrepant data (e.g., deviation from originally reported values).	☒	The N16 water level instrumentation nozzle is considered within the beltline region. This forging was fabricated from [[ ]]. Additional details regarding this material and its properties are provided in Section 3.0 of this PTLR. All other information remains unchanged from previous submittals.
Appendix B contains tables of all Initial RT_{NDT} values for Fermi 2.	☒	
Has any non-Fermi 2 initial RT_{NDT} information (e.g., ISP, comparison to other plant) been used?	☒	Plate heat C4114-2 information was obtained from the ISP database. This material is not the identical heat to the target vessel plate material and, in accordance with the ISP guidance; this data was not used in determining the limiting ART.
If deviation from the P-T curve LTR process occurred, sufficient supporting information has been included (e.g., Charpy V-Notch data used to determine an Initial RT_{NDT}).	☒	Details regarding the determination of the initial RT_{NDT} of the N16 nozzle are provided in Section 3.0 of this PTLR. No other deviations from the P-T curve LTR process.
All previously published Initial RT_{NDT} values from sources such as the GL88-01, Reactor Vessel Integrity Database (RVID), UFSAR, etc., have been reviewed.	☒	RVID was reviewed for the beltline materials; all initial RT_{NDT} values agree; no further review was performed.

Table C-1: Fermi 2 Checklist (continued)

Parameter	Completed	Comments/Resolutions/Clarifications
Adjusted Reference Temperature (ART)		
Sigma I (σ_I, standard deviation for Initial RT_{NDT}) is 0°F unless the RT_{NDT} was obtained from a source other than CMTRs. If σ_I is not equal to 0, reference/basis has been provided.	☒	Sigma I is equal to 0 for all materials.
Sigma Δ (σ_Δ, standard deviation for ΔRT_{NDT}) is determined per RG 1.99, Revision 2.	☒	
Chemistry has been determined for all vessel beltline materials including plates, forgings (if applicable), and welds for Fermi 2. Include explanation (including methods/sources) of any exceptions, resolution of discrepant data (e.g., deviation from originally reported values).	☒	Sufficient information was not available to determine the chemistry content for the N16 water level instrumentation nozzle materials. [[ ]]. More information is provided in Section 3.0. No deviations from previously reported values.
Non-Fermi 2 chemistry information (e.g., ISP, comparison to other plant) used has been adequately defined and described.	☒	Plate heat C4114-2 and weld heat CE-2 (WM) 13253/12008 have been evaluated using best estimate chemistry from the ISP.
For any deviation from the P-T curve LTR process, sufficient information has been included.	☒	No deviations from the P-T curve LTR process.

Table C-1: Fermi 2 Checklist (continued)

Parameter	Completed	Comments/Resolutions/Clarifications
All previously published chemistry values from sources such as the GL88-01, Reactor Vessel Integrity Database (RVID), UFSAR, etc., have been reviewed.	☒	RVID was reviewed; all initial RT_{NDT} values agree; no further review was performed
The fluence used for determination of ART and any extended beltline region was obtained using an NRC-approved methodology.	☒	One (1) NRC-approved methodology (Reference 1) was used for the entire plant license.
The fluence calculation provides an axial distribution to allow determination of the vessel elevations that experience fluence of 1.0e17 n/cm^2 both above and below active fuel.	☒	
The fluence calculation provides an axial distribution to allow determination of the fluence for intermediate locations such as the beltline girth weld (if applicable) or for any nozzles within the beltline region.	☒	
All materials within the elevation range where the vessel experiences a fluence ≥1.0e17 n/cm^2 have been included in the ART calculation. All initial RT_{NDT} and chemistry information is available or explained.	☒	
Discontinuities		
The discontinuity comparison has been performed as described in Section 4.3.2.1 of the P-T curve LTR. Any deviations have been explained.	☒	There are no deviations.

Table C-1: Fermi 2 Checklist (continued)

Parameter	Completed	Comments/Resolutions/Clarifications
Discontinuities requiring additional components (such as nozzles) to be considered part of the beltline have been adequately described. It is clear which curve is used to bound each discontinuity.	☒	
Appendix G of the P-T curve LTR describes the process for considering a thickness discontinuity, both beltline and non-beltline. If there is a discontinuity in the Fermi 2 vessel that requires such an evaluation, the evaluation was performed. The affected curve was adjusted to bound the discontinuity, if required.	☒	The thickness discontinuity evaluation demonstrated that [[ ]]; the curves [[ ]] the discontinuity stresses.
Appendix H of the P-T curve LTR defines the basis for the CRD Penetration curve discontinuity and the appropriate transient application. The Fermi 2 evaluation bounds the requirements of Appendix H.	☒	
Appendix J of the P-T curve defines the basis for the Water Level Instrumentation Nozzle curve discontinuity and the appropriate transient application. The Fermi 2 evaluation bounds the requirements of Appendix J.	☒	

Appendix D Sample P-T Curve Calculations

Beltline Water Level Instrumentation Nozzle

Pressure Test (Curve A) for 52 EFPY

K_I for the discontinuity is determined considering the K_I obtained from Table 7 of Appendix J of Reference .2 (for hydrotest). For 1055 psig, this K_I is scaled by pressure as follows:

[[ ]]

T-RT_{NDT} is calculated in the following manner:

[[ ]]

The ART is added to T-RT_{NDT} to obtain the required T:

[[ ]]

This temperature can be found from Table 1 as it bounds the temperature requirements for upper RPV and beltline region.

Core Not Critical (Curve B) for 52 EFPY

K_I for the discontinuity is determined considering the K_I obtained from Table 5 of Appendix J of Reference 2.

$K_{I(pressure)}$ = [[ ]]

$K_{I(thermal)}$ = [[ ]]

The transient used for the WLI nozzle, defined in Appendix J, is used in determination of K_I.

The total K_I is therefore:

[[

]]

T-RT_{NDT} is calculated in the following manner:

[[ ]]

The ART is added to T-RT_{NDT} to obtain the required T:

[[ ]]

This temperature can be found from Table 1 as it [[ ]] the temperature requirements for [[ ]].

Correction Factor

The total stress for the WLI nozzle exceeds the yield stress; therefore, the correction factor, R, is calculated to consider the nonlinear effects in the plastic region. The R factor adjustment for the WLI nozzle is based on the assumptions and recommendation of Welding Research Council (WRC) Bulletin 175 (Reference 8) that provides the technical background for Appendix G (Fracture Toughness Criteria for Protection Against Failure) of ASME Boiler & Pressure Vessel Code Section XI. WRC Bulletin 175 proposes the methodology how to estimate the stresses when the secondary and peak stresses calculated on an elastic basis exceed the yield stress. This is to consider the nonlinear effects in the local plastic region. However, for the application to WLI nozzle, [[

]] The technical detail for this method is described in Section 5.C.3 of WRC Bulletin 175. The applicability of this procedure to pressure vessel was studied in a Pressure Vessels & Piping (PVP) Conference paper (Reference 9). For example, the R factor under the pressure of 1055 psig is calculated below in accordance with the Equation 4-7 of Reference 2.

$R = [\sigma_{ys} - \sigma_{pm} + ((\sigma_{total} - \sigma_{ys})/30)]/(\sigma_{total} - \sigma_{pm})$

Applied to the WLI nozzle:

[[

]]

R factor values for WLI nozzle over the entire pressure range are shown as follows.

[[				

[[				

]]

Beltline Calculations Excluding Nozzles

Pressure Test (Curve A) at 1055 psig for 52 EFPY

A sample calculation for the beltline material, not including the N16 WLI nozzle, for Curve A is provided for 1055 psig as follows.

The ART applied to the beltline P-T curves is [[ ]], for [[ ]].

Pressure is calculated to include hydrostatic pressure for a full vessel:

P = 1055 psig + (H – B) * 0.0361 psi/inch

(H = vessel height; B = elevation of bottom of active fuel)

= 1055 + (861.6 – 216.3) * 0.0361

= 1078 psig

Pressure Stress:

σ = PR/t

(P = pressure; R = vessel radius; t = vessel thickness)

= 1.078 * 127 / 6.125

= 22.35 ksi

M_m = $0.926 * \sqrt{t}$ (for $2 \leq \sqrt{t} \leq 3.464$)
= $0.926 * \sqrt{6.125}$
= 2.29

The stress intensity factor, K_{It}, is calculated as described in Section 4.3.2.2.4 of Reference 2, except that "G" is 20°F/hr instead of 100°F/hr.

M_t = 0.2942, from ASME Appendix G, Figure G-2214-1

ΔT = $GC^2 / 2\beta$

G = coolant heatup/cooldown rate of 20°F/hr

C = minimum vessel thickness including clad = 6.4375" = 0.5365 ft

β = thermal diffusivity at 550°F = 0.354 ft^2/hr

= $(20 * (0.5365)^2) / (2 * 0.354)$
= 8.13°F

K_{It} = $M_t * \Delta T$
= 0.2942 * 8.13
= 2.39

K_{Im} = $\sigma * M_m$
= 22.35 * 2.29
= 51.2

$T\text{-}RT_{NDT}$ = $\ln[(1.5 * K_{Im} + K_{It} - 33.2) / 20.734] / 0.02$
= $\ln[(1.5 * 51.2 + 2.39 - 33.2) / 20.734] / 0.02$
= 39.8°F

T is calculated by adding the ART:

T = [[ ]]
= [[ ]] for P = 1055 psig at 52 EFPY

This temperature is not obvious from the P-T curves as it [[
]].

Core Not Critical (Curve B) at 1055 psig for 52 EFPY

As discussed above and shown in Table B-5, the ART applied to the beltline Curve B is [[
]] for the lower shell axial weld.

The ΔT term is calculated as shown above for the Pressure Test case, but the temperature rate change is 100°F/hr instead of 20°F/hr. Therefore, ΔT equals 40.65°F.

P = 1055 psig + (H – B) * 0.0361 psi/inch

(H = vessel height; B = elevation of bottom of active fuel)

= 1055 + (861.6 – 216.3) * 0.0361

= 1078 psig

Pressure Stress:

σ = PR/t

(P = pressure; R = vessel radius; t = vessel thickness)

= 1.078 * 127 / 6.125

= 22.35 ksi

K_{Im} = $\sigma * M_m$

= 22.35 * 2.29

= 51.2

K_{It} = $M_t * \Delta T$ (for the 100°F/hr case)

= 0.2942 * 40.65

= 11.96

$T-RT_{NDT}$ = $\ln [(2.0 * K_{Im} + K_{It} - 33.2) / 20.734] / 0.02$

= $\ln [(2.0 * 51.2 + 11.96 - 33.2) / 20.734] / 0.02$

= 68.2°F

T is calculated by adding the ART:

T = [[ ]]

= [[ ]] for P = 1055 psig at 52 EFPY

This temperature is not obvious from the P-T curves as it [[ ]].

Feedwater Nozzle Calculations

An evaluation was performed for the feedwater nozzle as described in Section 4.3.2.1.3 of the Reference 2. The first part of the evaluation is as described earlier, where it is assured that the limiting component that is represented by the upper vessel curve is bounded by the [[ ]]. A second evaluation was performed using the Fermi 2-specific feedwater nozzle dimensions; this evaluation is shown below to demonstrate that the baseline curve is applicable to Fermi 2:

Vessel radius to base metal, R_v	[[
Vessel thickness, t_v	
Vessel pressure, P_v	
Pressure stress = PR/t = [[ ]]	
Dead Weight + Thermal Restricted Free End stress	
Total Stress = [[ ]]	]]

The factor $F(a/r_n)$ from Figure A5-1 of *PVRC Recommendations on Toughness Requirements for Ferritic Materials*, WRC-175 is determined where:

$a = ¼ * (t_n^2 + t_v^2)^{½}$	[[
t_n = thickness of nozzle	
t_v = thickness of vessel	
r_n = apparent radius of nozzle = $r_i + 0.29*r_c$	
r_i = actual inner radius of nozzle	
r_c = nozzle radius (nozzle corner radius)	]]

Therefore, a/r_n = [[ ]]. The value $F(a/r_n)$, taken from Figure A5-1 of WRC-175 for an [[ ]]. Including the safety factor of 1.5, the stress intensity factor, K_I, is $1.5\ \sigma\ (\pi a)^{1/2} * F(a/r_n)$:

Fermi 2 Plant-Specific Nominal K_I = 1.5 * [[ ]]

A detailed upper vessel example calculation for core not critical conditions is provided in Section 4.3.2.1.4 of the Reference 2. Section 4.3.2.1.3 of the Reference 2 defines the baseline nominal K_I to be [[ ]] for the FW nozzle evaluation upon which the baseline non-shifted upper vessel P-T curve is based. It can be seen that the nominal K_I from this Fermi 2 evaluation is [[ ]]. Therefore, it has been shown that the nominal K_I for the Fermi 2-specific FW nozzle is less than the baseline K_I, demonstrating applicability of the FW nozzle curve for Fermi 2.