RDT F 9-4 T

Supersedes
RDT F 9-4T, January 1976

RDT Standard

REQUIREMENTS FOR CONSTRUCTION OF NUCLEAR SYSTEM COMPONENTS AT ELEVATED TEMPERATURES (SUPPLEMENT TO ASME CODE CASES 1592, 1593, 1594, 1595, AND 1596)[1]

APRIL 1977

[1]
* 1974 EDITION WITH CODE CASE SUPPLEMENTS THROUGH #9, DATED AUGUST 11, 1975

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
DIVISION OF REACTOR DEVELOPMENT AND DEMONSTRATION

*Cover amended Amendment 1 (7/18/77)

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SIGNATURE C. Roderick

C. Roderick, Manager
Materials and Process Control

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0. INTRODUCTION

0.1 Scope. This standard provides rules for the construction of Class 1 nuclear components, parts, and appurtenances for use at elevated temperatures. This standard is a complete set of requirements only when used in conjunction with Section III of the ASME Boiler and Pressure Vessel Code (ASME Code) and addenda, ASME Code Cases 1592, 1593, 1594, 1595, and 1596, and RDT E 15-2NB. Unmodified paragraphs of the referenced Code Cases are not repeated in this standard but are a part of the requirements of this standard.

0.1.1 Applicability. The requirements of Section III of the ASME Code as modified by Code Cases 1592, 1593, 1594, 1595 and 1596; the requirements of RDT E 15-2NB; and the requirements of RDT F 9-4 are applicable.

0.1.2 Definitions. The definitions of terms used in RDT F 9-4 are consistent with those employed by Section III of the ASME Code. Terms not now defined by the ASME Code, or defined herein differently from the ASME Code, are defined in N-1300 or where they are first used in this standard.

0.2 Organization of Standard. RDT F 9-4 contains requirements that are additional to those of Code Cases 1592, 1593, 1594, 1595 and 1596. The organization of RDT F 9-4 corresponds to the section, paragraph, figure and equation designations of the Code Cases.

Requirements which supplement or replace an existing Code Case paragraph or portion are designated in this standard by the Code Case paragraph number prefixed with an "A". For example, the addition to paragraph -3114 is designated "A-3114".

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RDT F 9-5 is a non-mandatory standard which supplements RDT F 9-4 and provides the manufacturer with general guidelines and procedures to satisfy the requirements of RDT F 9-4. It addresses guidelines for the stress analysis aspects of design and supplies procedures for consideration and use by the manufacturer.

0.3 Revisions. Revisions of this standard, or the referenced documents in 0.5, effective later than those specified in the procurement or design specification may be used only by mutual consent of the owner and the manufacturer.

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0.5.1 RDT Standards.

RDT E 15-2NB-T	Class 1 Nuclear Components (Supplements to ASME Boiler and Pressure Vessel Code, Section III, Subsections NA and NB)
RDT F 9-5T	Guidelines and Procedures for Design of Nuclear System Components at Elevated Temperature

0.5.2 American Society of Mechanical Engineers (ASME) Publications.

ASME Boiler and Pressure Vessel Code,

Section III	Rules for the Construction of Nuclear Power Plant Components
Code Case 1521-1	Use of H Grades of SA-240, SA-479, SA-336 and SA-358, Section III
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Code Case 1595-1	Testing of Elevated Temperature Components Section III, Class 1
Code Case 1596-1	Protection Against Overpressure of Elevated Temperature Components Section III, Class 1

C1

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TABLE OF CONTENTS

		Page	
0.	INTRODUCTION	1	
	0.1 Scope	1	
	0.2 Organization of Standard	1	
	0.3 Revisions	2	
	0.4 Conflicts	2	
	0.5 Applicable Documents	2	
1.	SUPPLEMENTS TO CODE CASE 1592	3	
	-1000 INTRODUCTION	3	
	N-1200 Structural Evaluation Program	3	
	N-1300 Supplemental Terms	4	
	-2000 MATERIALS	4	
	-2120 Pressure Retaining Materials	4	
	-2121 Permitted Materials Specifications	4	
	-3000 DESIGN	4	
	-3100 General Requirements for Design	4	
	-3110 Scope, Acceptability and Loading Conditions	4	
	N-3111.3 Functional Limits	4	
	A-3114 Load Histogram	4	
	-3200 Design by Analysis	4	
	-3210 Design Criteria	4	
	-3213 Terms Relating to Analysis	4	
	-3213.1 Stress Intensity	4	N
	A-3213.1 Elastic Stress Intensity	5	
	A-3213.9 Secondary Stress	5	C
	-3214 Stress Analysis	5	
	A-3214.3 Mechanical Properties	5	
	N-3214.4 Material Properties for Inelastic Analysis	5	
	N-3214.5 Fabrication and Environmental Effects	5	
	-3220 Design Rules and Limits for Load-Controlled Stresses in Structures Other Than Bolts	6	
	-3223 Normal and Upset Conditions	6	
	-3224 Emergency Conditions	6	
	-3225 Faulted Conditions	7	

		Page
-3230	Stress Limits for Load-Controlled Stresses on Bolts	7
-3300	Vessel Design	7
-3350	Design of Welded Construction	7
-3352	Permissible Types of Welded Joints	7
N-3352(k)	Special Joints	7
-3600	Piping Design	8
-3640	Pressure Design of Components	8
-3647	Flanged Joints	8
-3670	Special Piping Requirements	8
-3671	Nonwelded Piping Joint	8
-3671.7	Patented Joints	8
APPENDIX T		8
T-1300	DEFORMATION AND STRAIN LIMITS FOR STRUCTURAL INTEGRITY	8
T-1320	Satisfaction of Strain Limits for Elastic Analysis	8
AT-1321	General Requirements	8
T-1324	Test No. 3	9
T-1325	Test No. 4	9
AT-1325	Test No. 4, Option A	9
AT-1325	Test No. 4, Option B	9
NT-1326	Test No. 5	9
T-1400	CREEP-FATIGUE EVALUATION	9
T-1410	General Requirements	9
AT-1411	Damage Equation	9
AT-1413	Equivalent Strain Range	10
AT-1414	Alternate Calculation Method - Equivalent Strain Range	10
T-1420	Limits Using Inelastic Analysis	10
T-1430	Limits Using Elastic Analysis	10
AT-1435	Alternate Creep-Fatigue Evaluation	10
T-1700	SPECIAL REQUIREMENTS	11
T-1710	Special Strain Requirements at Welds	11
AT-1714	Analysis of Geometry	11

D2

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|C2

A-3213.1 Elastic Stress Intensity. |N

A-3213.9 Secondary Stress. Add after the third sentence:

However, if a condition of elastic followup exists as defined in -3138, net bending stress which cannot be reduced by small deformation shall be considered as primary bending stresses, P_b, in the portion of the system so affected.

-3214 Stress Analysis.

A-3214.3 Mechanical Properties. Add: Material properties from the following sources may be used without the prior approval of the owner:

(1) Code Case 1592, and Section III, ASME Code.

(2) TID-26666, (for data not contained in the above).

If the necessary data are not available from the above sources or if the values given therein are not appropriate for specific use, the specific values judged by the manufacturer to accurately represent the subject material shall be approved by the owner prior to use. Recommendations, technical bases, and design implications of the proposed material properties shall be provided for the owner's consideration.

N-3214.4 Material Properties for Inelastic Analysis. The use of inelastic analysis is permitted for the purpose of determining the structural response of a component as an initial step in evaluating the creep-fatigue damage, the accumulated inelastic strain, the functional integrity, or the potential for buckling. When inelastic analysis is used in preparation for a creep-fatigue or inelastic strain evaluation, the plasticity and thermal creep properties used in the analysis shall be average (or representative). It is intended that the results of analysis based on "average" properties be compared to the Code supplied stress-rupture and fatigue limits.

N-3214.5 Fabrication and Environmental Effects. The limits of Code Case 1592 are based on tensile, creep, stress-rupture, and fatigue tests performed in air. The effects of other environments and fabrication processes on materials behavior, when significant, shall be accounted for in all structural and functional evaluations.

(a) The environmental factors which may modify material behavior include:

(1) The environmental fluid (e.g., sodium, inert gas, air and vacuum).

(2) The exposure to elevated temperature for long-time durations.

(3) Irradiation.

(b) Possible effects of these factors include:

(1) Aging.

(2) Irradiation-induced loss of ductility.

(3) Loss of alloying elements (including N, C, B, Mn) on both local and an overall basis.

(4) Loss of surface material due to erosion, corrosion, or oxidation.

(5) Alteration of the microstructure, especially at the surface of the component.

As an aid to the manufacturer, RDT F 9-5 contains some information on the effects of environment upon structural integrity. The SEP shall describe the degree and scope of the fabrication and environmental effect considerations which will be implemented in each stage of the design analysis.

-3220 Design Rules and Limits for Load-Controlled Stresses in Structures Other Than Bolts.

-3223 Normal and Upset Conditions. Add:

A-3223(c) The following additional limit shall apply: |E2

$$P_L + P_b \leq K S_m \qquad \text{(A-5)}$$

|D2

-3224 Emergency Conditions. Add:

A-3224(c) The following additional limit shall apply: |E2

$$P_L + P_b \leq 1.2K S_m \qquad \text{(A-11a)}$$

|D2

D2

-3225 Faulted Conditions. Add:

A-3225(c) Change to read: C2

In addition, the use-fraction rule of -3224(b) shall be satisfied for all loadings with the following modification: use a stress value of $P_{mi}/1.2$ (instead of P_{mi}) for all (Operation Condition) loadings in obtaining the t_{im} values from the curves of Fig. 1-14.4, as shown in Fig. -3224-1.

D2

A-3225(e) Change to read: C2

In addition, the use-fraction rule of -3224(d) shall be satisfied for all loadings with the following modification: use a stress value of $((P_L + P_b)/1.2\ K_t)_i$ instead of $(P_L + P_b)/K_t$ for all (Operating Conditions) loadings in obtaining the t_{ib} values from the curves of Fig. I-14.4 as shown in Fig. -3224-2.

-3230 Stress Limits for Load-Controlled Stresses on Bolts. Add:

N-3230(a) When criteria alternate to those of Appendix E are used, the criteria shall be approved by the owner prior to use.

-3300 Vessel Design.

-3350 Design of Welded Construction.

-3352 Permissible Types of Welded Joints. Add:

N-3352(h) Joint designs having internal crevices, such as backing strips which are not removed or socket welds, shall not be used for components intended for liquid metal service unless the prior written approval of the owner is obtained for each application.

N-3352(i) Welded joints shall be designed to permit required physical and visual accessibility for welding and nondestructive examination personnel and equipment. The weld joint designs shall make allowance for welder environment, position, and comfort due to the potential necessity to weld in close quarters while the part is under a high degree of preheat and due to location and orientation of the weld joint.

N-3352(j) Joints of Category C and D for which the Code requires ultrasonic examination in addition to radiographic examination shall be permitted only if the manufacturer demonstrates that meaningful ultrasonic examination can be performed.

N-3352(k) Special Joints. The requirements of NNB-3352.5 and NNB-3352.6 of RDT E 15-2NB shall apply.

-3600 Piping Design.

-3640 Pressure Design of Components. N

-3647 Flanged Joints. Change to read:

A-3647(c) Flanged joints exposed to elevated temperature service shall comply with analyses requirements of -3200.

-3670 Special Piping Requirements.

-3671 Nonwelded Piping Joints.

-3671.7 Patented Joints. Add:

N-3671.7(d) The use of these types of joints shall require prior approval of the owner.

APPENDIX T

T-1300 DEFORMATION AND STRAIN LIMITS FOR STRUCTURAL INTEGRITY

T-1320 Satisfaction of Strain Limits Using Elastic Analysis. Add:

AT-1321. General Requirements. Modify the fourth line to read, "...1322, T-1323, T-1324, NT-1325, or NT-1326 is satisfied. The ..."

Also, modify the last sentence of the first paragraph to read, "... be evaluated in T-1322, T-1323, T-1324, NT-1325, and NT-1326."

AT-1321(c) Modify the first sentence to read, "... of T-1322, T-1323, T-1324, NT-1325, or NT-1326, whichever ..."

Modify the second sentence to read, "Note that T-1324, NT-1325, and NT-1326 provide for ..."

AT-1321(d) Modify the second line to read, "... satisfy the conditions of T-1322, T-1323, or NT-1325 then ..."

Modify the second sentence to read, "T-1324 and NT-1326 provide methods for ..."

Modify the last sentence to read, "... of T-1322, T-1323, and NT-1325. "

AT-1321(e) Modify to read: The time and temperature conditions used in selecting the isochronous curves in T-1324 or NT-1326 shall always sum to the entire life regardless of whether all or only part of the cycles are evaluated under the procedures of T-1324 or NT-1326.

(e) Following the second sentence in NB-3222.4(e) add: The S_a value at $N < 10^6$ cycles shall be justified by the manufacturer. |D2

T-1700 SPECIAL REQUIREMENTS

T-1710 Special Strain Requirements at Welds. Add:

AT-1714 Analysis of Geometry. Among the factors to be considered are overall (as well as local) geometry distortions due to weld shrinkage, weld reinforcement, mismatch, and transitions between regions containing different types of weld-induced distortions. The manner in which these distortions are accounted for in the structural evaluation shall be included in the stress report (see NA-3350).

T-1800 ISOCHRONOUS STRESS-STRAIN RELATIONS

Fig. AT-1800-C-11. In Fig. T-1800-C-11 change the parameter list to read:

MATERIAL - SOLUTION ANNEALED Ni-Fe-Cr (Alloy 800H)
TEMPERATURE - 1300°F

Fig. AT-1800-C-10. In Fig. T-1800-C-10 change the parameter list to read:

MATERIAL - SOLUTION ANNEALED Ni-Fe-Cr (Alloy 800H)
TEMPERATURE - 1350°F

2. SUPPLEMENTS TO CODE CASE 1593

For RDT F 9-4 applications, any reference in Code Case 1593 to the rules of Subsection NB shall mean the rules as supplemented by RDT E 15-2NB.

(End of Amendment Page)

3. SUPPLEMENTS TO CODE CASE 1594

For RDT F 9-4 applications, any reference in Code Case 1594 to the rules of Subsection NB shall mean the rules as supplemented by RDT E 15-2NB. Where the Code Case provides rules in lieu of those contained in Subsection NB, the following supplemental requirements shall apply.

2.0 Examination of Weld-Edge Preparation Surfaces N

Change the last sentence to read:

A-2.0 This requirement shall apply to welds having a nominal thickness greater than 3/8 inch.

Change NB-5130(b) to read:

(b) Laminar type discontinuities are acceptable without repair if they do not exceed the lesser of 1/2 T or 1 in. in length. The extent of all laminar type indications exceeding the lesser of 1/2 T or 1 in. in length shall be determined by ultrasonic examination. Indications exceeding the lesser of 1/2 T or 1 in. in length shall be repaired by welding to a depth of 3/8 in. or the depth of the indication, whichever is less, unless the ultrasonic examination reveals that additional depth of repair is required to meet the ultrasonic examination requirement for the product form.

And add a closing paragraph:

Regardless of material thickness, weld edge preparation surfaces for joint Categories A, B, C and D, and similar pressure boundary joints, and for tube-to-tubesheet joints and seal welded joints (see NNB-3352.6 of RDT E 15-2NB) joints of -3227.7 and N-3352(k), shall be examined visually in accordance with NNB-5290 of RDT E 15-2NB.

D N

6.0 Category D Vessel Welds and Similar Nozzle Welds That Are Applicable to Piping, Pumps, and Valves

A-6.4 Partial-Penetration Welds. Change to read:

Partial-penetration welds shall be used only for the small-diameter applications allowed by the rules for design of Class 1 components operating at elevated temperatures. Partial-penetration welds as shown in Figs. NB-4244(d)-1 and NB-4244(d)-2 shall be examined progressively using either the magnetic particle or the liquid penetrant method. The increments of examination shall be the root-layer and the lesser of each one-third of the maximum weld dimension measured parallel to the centerline of the connections, or 1/2 in. In addition, each completed weld shall undergo surface examination in accordance with the requirements of Paragraph 3.0(a) of this Case.

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C. Roderick, Manager
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APRIL 1977

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1 and 2	1* and 2
5 and 6	5* and 6
7 and 8	7 and 8*
11 and 12	11 and 12*

Amendment 3(11-15-77) replaces pages of the April 1977 issue to reflect changes in ASME Code Case 1592-7 as follows:

Old Pages	New Pages
Cover Page	Cover Page
i and ii	i and ii
iii	iii
1 and 2	1 and 2
3 and 4	3* and 4
5 and 6	5 and 6
7 and 8	7 and 8
9 and 10	9* and 10
11 and 12	11 and 12*

*This page not amended.

Amendment 4(11-15-78) replaces pages of the April 1977 issue to reflect changes in ASME Code Case 1592-8 through -10 as follows:

Old Pages	New Pages
Cover Page	Cover Page
i and ii	i and ii
1 and 2	1* and 2
3 and 4	3*, 4, and 4A
-	6A and 6B
7 and 8	7, 7A, 7B, and 8
9 and 10	9, 9A, and 10
11 and 12	11 and 12*

*This page not amended.

REQUIREMENTS FOR CONSTRUCTION OF CLASS 1 ELEVATED TEMPERATURE NUCLEAR SYSTEM COMPONENTS (SUPPLEMENT TO ASME CODE CASES 1592, 1593, 1594, 1595, AND 1596) |E3

TABLE OF CONTENTS

		Page	
0.	INTRODUCTION	1	
	0.1 Scope	1	
	0.2 Organization of Standard	1	
	0.3 Revisions	2	
	0.4 Conflicts	2	
	0.5 Applicable Documents	2	
1.	SUPPLEMENTS TO CODE CASE 1592	3	
	-1000 INTRODUCTION	3	|E4
	N-1200 Structural Evaluation Program	3	
	N-1300 Supplemental Terms	4	
	-2000 MATERIALS	4	|E4
	-2120 Pressure Retaining Materials	4	
	-2121 Permitted Materials Specifications	4	
	-3000 DESIGN	4	
	-3100 General Requirements for Design	4	
	-3110 Scope, Acceptability and Loading Conditions	4	
	-3111.1 Acceptability	4	|N4
	N-3111.3 Functional Limits	4	
	A-3114 Load Histogram	4	
	-3200 Design by Analysis	4A	|C4
	-3210 Design Criteria	4A	
	-3213 Terms Relating to Analysis	4A	
	A-3213.8 Primary Stress	5	|N3 |D3
	A-3213.9 Secondary Stress	5	
	-3214 Stress Analysis	5	
	A-3214.3 Mechanical Properties	5	
	N-3214.4 Material Properties for Inelastic Analysis	5	
	N-3214.5 Fabrication and Environmental Effects	5	
	-3220 Design Rules and Limits for Load-Controlled Stresses in Structures Other Than Bolts	6	
	-3223 Normal and Upset Conditions	6	
	-3224 Emergency Conditions	6	
	-3225 Faulted Conditions	7	

		Page	
-3230	Stress Limits for Load-Controlled Stresses on Bolts	7A	C4
-3300	Vessel Design	7B	
-3350	Design of Welded Construction	7B	
-3352	Permissible Types of Welded Joints	7B	
N-3352(k)	Special Joints	7B	
-3600	Piping Design	8	D3
-3670	Special Piping Requirements	8	
-3671	Nonwelded Piping Joint	8	
-3671.7	Patented Joints	8	
APPENDIX I-14		8	
APPENDIX T		8	
T-1300	DEFORMATION AND STRAIN LIMITS FOR STRUCTURAL INTEGRITY	8	
T-1320	Satisfaction of Strain Limits for Elastic Analysis	8	
AT-1321	General Requirements	8	
T-1324	Test No. 3	9	
T-1325	Test No. 4	9	
AT-1325	Test No. 4, Option A	9	
AT-1325	Test No. 4, Option B	9	
NT-1326	Test No. 5	9	
T-1400	CREEP-FATIGUE EVALUATION	9A	C4
T-1410	General Requirements	9A	
AT-1411	Damage Equation	9A	D3
T-1420	Limits Using Inelastic Analysis	10	
T-1430	Limits Using Elastic Analysis	10	
AT-1435	Alternate Creep-Fatigue Evaluation	10	
T-1500	BUCKLING AND INSTABILITY	11	N4
T-1510	General Requirements	11	
T-1700	SPECIAL REQUIREMENTS	11	D2
T-1710	Special Strain Requirements at Welds	11	
AT-1714	Analysis of Geometry	11	

REQUIREMENTS FOR CONSTRUCTION OF NUCLEAR SYSTEM COMPONENTS AT ELEVATED TEMPERATURES (SUPPLEMENT TO ASME CODE CASES 1592, 1593, 1594, 1595, AND 1596) E3

0. INTRODUCTION

0.1 Scope. This standard provides rules for the construction of Class 1 nuclear components, parts, and appurtenances for use at elevated temperatures. This standard is a complete set of requirements only when used in conjunction with Section III of the ASME Boiler and Pressure Vessel Code (ASME Code) and addenda, ASME Code Cases 1592, 1593, 1594, 1595, and 1596, and RDT E 15-2NB. Unmodified paragraphs of the referenced Code Cases are not repeated in this standard but are a part of the requirements of this standard.

0.1.1 Applicability. The requirements of Section III of the ASME Code as modified by Code Cases 1592, 1593, 1594, 1595 and 1596; the requirements of RDT E 15-2NB; and the requirements of RDT F 9-4 are applicable.

0.1.2 Definitions. The definitions of terms used in RDT F 9-4 are consistent with those employed by Section III of the ASME Code. Terms not now defined by the ASME Code, or defined herein differently from the ASME Code, are defined in N-1300 or where they are first used in this standard.

0.2 Organization of Standard. RDT F 9-4 contains requirements that are additional to those of Code Cases 1592, 1593, 1594, 1595 and 1596. The organization of RDT F 9-4 corresponds to the section, paragraph, figure and equation designations of the Code Cases.

Requirements which supplement or replace an existing Code Case paragraph or portion are designated in this standard by the Code Case paragraph number prefixed with an "A". For example, the addition to paragraph -3114 is designated "A-3114".

The requirements of this standard that are not designated as additions to existing Code Case paragraphs are designated as new Code Case paragraphs at the location of similar requirements. These paragraphs are numbered using the next sequential Code Case paragraph number and prefixing it with an "N". For example, the new paragraph of this standard that is to be added to 6100 is designated as "N-6127".

RDT F 9-5 is a non-mandatory standard which supplements RDT F 9-4 and provides the manufacturer with general guidelines and procedures to satisfy the requirements of RDT F 9-4. It addresses guidelines for the stress analysis aspects of design and supplies procedures for consideration and use by the manufacturer.

0.3 Revisions. Revisions of this standard, or the referenced documents in 0.5, effective later than those specified in the Procurement or Design Specification may be used only by mutual consent of the Owner and the Manufacturer.

0.4 Conflicts. The requirements of this standard shall in no way be construed to relieve any ASME Code designated party of his responsibility for meeting the requirements of the ASME Code. Where this standard appears to conflict with the requirements of a referenced document, this shall be immediately brought to the attention of the owner for resolution.

0.5 Applicable Documents. The following documents are a part of this standard to the extent specified herein.

0.5.1 RDT Standards.

RDT E 15-2NB-T	Class 1 Nuclear Components (Supplement to ASME Boiler and Pressure Vessel Code, Section III, Subsections NA and NB)
RDT F 9-5T	Guidelines and Procedures for Design of Nuclear System Components at Elevated Temperature

0.5.2 American Society of Mechanical Engineers (ASME) Publications.

ASME Boiler and Pressure Vessel Code,

Section III	Rules for the Construction of Nuclear Power Plant Components
Code Case 1521-1	Use of H Grades of SA-240, SA-479, SA-336 and SA-358, Section III
Code Case 1592-8 through 1592-10	Class 1 Components in Elevated Temperature Service, Section III, Division 1
Code Case 1593-1	Fabrication and Installation of Elevated Temperature Components Section III, Class 1
Code Case 1594-1	Examination of Elevated Temperature Components Section III, Class 1
Code Case 1595-1	Testing of Elevated Temperature Components Section III, Class 1
Code Case 1596-1	Protection Against Overpressure of Elevated Temperature Components Section III, Class 1

C3 C4

0.5.3 Other Documents.

TID-26666 Nuclear Systems Materials Handbook*

0.5.4 Applicable Version of ASME Code. RDT F 9-4, in referring to sections of the ASME Code, refers specifically to the 1974 Edition, including all applicable addenda. The term "Code Case 1592" (or 1593, 1594, 1595, 1596)refers specifically to the revision identified in 0.5.2.

1. SUPPLEMENTS TO CODE CASE 1592

For RDT F 9-4 applications, any reference in Code Case 1592 to the rules of Subsections NA and NB shall mean the rules as supplemented by RDT E 15-2NB.

-1000 INTRODUCTION

Add:

N-1200 Structural Evaluation Program. To facilitate the orderly review and certification of the stress report to be provided to the owner by the manufacturer, a structural evaluation program shall be provided to the owner as part of the manufacturer's proposal. A structural evaluation plan (SEP) is one part of the structural evaluation program. The SEP shall provide a description of the methods of analysis which the manufacturer contemplates using in various phases of the structural analysis. The plan shall indicate the degree to which the manufacturer anticipates using elastic, simplified inelastic and more detailed inelastic methods of analysis in design iterations and for demonstrating compliance with the requirements of RDT F 9-4. The manufacturer shall identify any computer programs to be used and shall describe, or provide the basic theory of the programs, and identify the assumptions involved in their use. The manufacturer shall also describe the extent to which the computer programs have been verified for applications comparable to those involved in the proposed project.

As the design analysis progresses, the manufacturer shall provide the owner with an updated SEP and interim design analysis reports which document stress calculations in support of conclusions that the design shown by drawings used, or to be used, complies with the requirements of RDT F 9-4 and the ASME Code; or, when it is concluded that the requirements have not been met by the design analyzed, the manufacturer shall provide data concerning any redesign proposed, the additional analysis methods proposed for use in further analysis, or both. RDT F 9-5 provides a complete description of the contents and use of the SEP.

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*May be obtained from the Nuclear Systems Materials Handbook Advisory Group, Hanford Engineering Development Laboratory, Westinghouse Hanford Company, P.O. Box 1970, Richland, Washington 99352.

N-1300 Supplemental Terms.

(a) Owner. As used in RDT F 9-4, "Owner" shall mean the owner or his designated agent.

(b) Procurement Specification. As used in RDT F 9-4, "Procurement Specification" shall mean the document or documents which contain all of the information required by the ASME Code for a design specification, plus any additional requirements which have to be satisfied to ensure adequacy of the component for the intended application. E4

-2000 MATERIALS (As in NB-2000 Except for the Following Paragraphs)

-2120 Pressure Retaining Materials.

-2121 Permitted Material Specifications. Add:

N-2121(e) Permitted materials shall also meet the requirements of RDT E 15-2NB. The H Grades of Types 304 and 316 stainless steel may be used as permitted by Code Case 1521 if they also are permitted by Table I-14.4 of Code Case 1592.

-3000 DESIGN

-3100 General Requirements for Design.

-3110 Scope, Acceptability and Loading Conditions. Add:

-3111.1 Acceptability. Change: N4

A-3111.1(c) For Code Case issues 1592 through 1592-8 change the first sentence to read: "...Which apply to a vessel (-3300), pump (-3400), valve (-3500), or piping (-3600)."

And add:

N-3111.3 Functional Limits. The functional aspects of the design of a component, part, or appurtenance may in some cases require more restrictive limits on stress or total accumulated deformation (See Appendix T-1300) than those imposed by RDT F 9-4 for the purpose of structural integrity. Functional aspects shall be carefully considered, especially those that may impact safety capabilities of the plant.

A-3114 Load Histogram. In the event the design specification does not include the time sequence and duration of each operation cycle, agreement shall be established between the owner and manufacturer on the time sequence and duration; this agreement shall be documented in a revised Design Specification.

-3200 Design by Analysis.

-3210 Design Criteria.

-3213 Terms Relating to Analysis. | D3

(End of Amendment Page)

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Fig. -3224-1 Use-fraction for Membrane Stress. Delete and add: N4

Figure A-3224-1

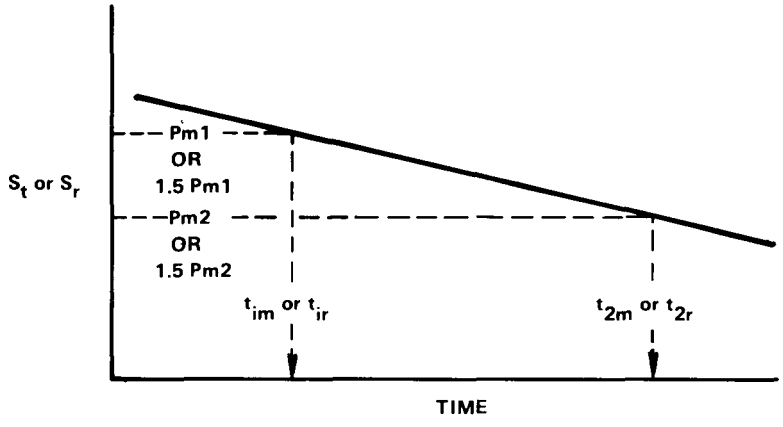

Fig. A-3224-1 Use-fractions for Membrane Stress

Fig. -3224-2 Use-fractions for Membrane-plus-bending Stress. Delete and add:

Fig. A-3224-2

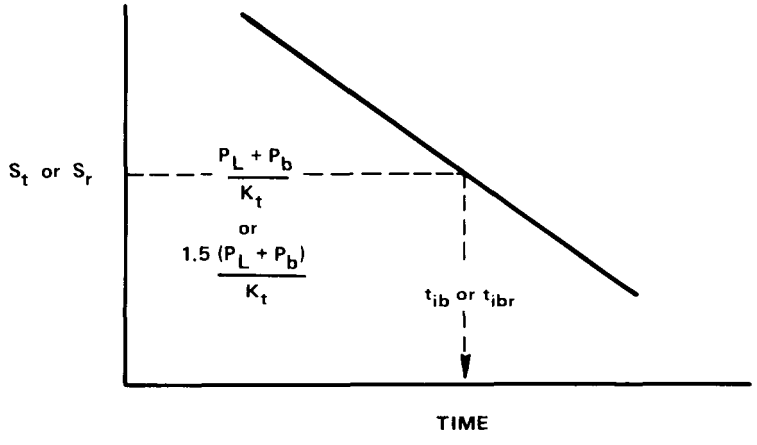

Fig. A-3224-2 Use-fractions for Membrane-plus-bending Stress

(End of Amendment Page)

D2
N4

A-3225 Faulted Conditions. Add to the introductory paragraph: As an alternative to the requirements of (a) through (e), the rules of (g) through (k) may be used.

D2 D3

And add:

A-3225(e) Change to read:

In addition, the use-fraction rule of -3224(d) shall be satisfied for all loadings with the following modification: use a stress value of $((P_L + P_b)/1.2\ K_t)_i$ instead of $(P_L + P_b)/K_t$ for all (Operating Conditions) loadings in obtaining the t_{ib} values from the curves of Fig. I-14.4 as shown in Fig. -3224-2. C2

N-3225(f) When the stress ratio methods of Appendix F are utilized the designer shall consider any significant distortion, warping or ovalization, of the cross-section. In materials which have a low yield to ultimate strength ratio, and also high elongation, the effects of cross-sectional distortion may significantly reduce the load carrying capacity below the values predicted by the stress ratio method. N3

N-3225(g) The rules in -3225 (and in Appendix F) shall be applied in all instances unless alternative or supplementary criteria, as required by public health and safety considerations for specific components or systems, are defined in, and made applicable by the Owner's Design Specifications (NA-3250). The type of analysis (elastic or inelastic) used by the system designer shall be indicated in the Design Specifications (see F-1322.1). N4

N-3225(h) The general primary-membrane stress intensity, derived from P_m for the Faulted Condition loadings, shall not exceed the smaller of 0.67 S_r and one of the Faulted Condition limits in Appendix F.

$$P_m \leq \begin{matrix}\text{Limit in Appendix F for } P_m \\ 0.67\ S_r\end{matrix}$$

where S_r is the stress-to-rupture in time t taken from Fig. I-14.6.

N-3225(i) In addition, the use-fraction sum associated with the general primary membrane stresses that arise from all Operating Condition loadings, shall satisfy the requirement:

$$\sum_i (t_i/t_{ir}) \leq B_r$$

where, N4

t_i = the total duration of a specific loading P_{mi} at elevated temperature T_i during the entire service life of the component. Note that $\sum_i (t_i)$ is that part of the component service life at elevated temperatures (i.e., temperatures above values governed by the rules of subsection NB, as explained in -3211).

t_{ir} = maximum allowed time under the load stress intensity, 1.5 P_{mi}, as determined from a graph of minimum stress-to-rupture vs. time (see Fig. I-14.6).

B_r = use fraction factor and is equal to 1.0 (or less if so specified in the Design Specifications (NA-3250)).

The use of Fig. I-14.6 for determining t_{ir} for two loading conditions at two different temperatures is shown schematically in Fig. -3224-1. In Fig. -3224-1, 1.5 P_{mi} (i=1, 2, 3, etc.) represents 1.5 times the calculated membrane stress intensity for the loading condition and temperature in question; and T_i represents the maximum local wall-averaged temperature during t_i. Note that it may be desirable to consider that a given stress intensity acts during several time periods, t_i, in order to take credit to the variation of temperature with time.

N-3225(j) The combined primary-membrane-plus-bending stress intensities, derived from P_L and P_b, shall not exceed the smaller of 0.67 $K_t S_r$ and one of the Faulted Condition limits in Appendix F.

$$(P_L + P_b) \leq \begin{array}{l}\text{Limit in Appendix F for } (P_L + P_b) \\ 0.67\ K_t S_r\end{array}$$

N-3225(k) In addition, the sum of the use-fractions associated with the primary membrane-plus-bending stresses that arise from all Operating Condition loadings, shall not exceed the value of 1.00.

$$\sum_i (t_i/t_{ibr}) \leq 1.00$$

where t_i is the total duration of loading at temperature T_i, and t_{ibr} is the time value determined by entering Fig. I-14.6 at a value of stress equal to 1.5 $(P_L + P_b)/K_t$ as shown in Fig. -3224-2.

-3230 Stress Limits for Load-Controlled Stresses on Bolts. Add:

N-3230(a) When criteria alternate to those of Appendix E are used, the approval of the Owner shall be obtained prior to use. E4

-3300 Vessel Design.

-3350 Design of Welded Construction.

-3352 Permissible Types of Welded Joints. Add:

N-3352(h) Joint designs having internal crevices, such as backing strips which are not removed or socket welds, shall not be used for components intended for liquid metal service unless the prior written approval of the owner is obtained for each application.

N-3352(i) Welded joints shall be designed to permit required physical and visual accessibility for welding and nondestructive examination personnel and equipment. The weld joint designs shall make allowance for welder environment, position, and comfort due to the potential necessity to weld in close quarters while the part is under a high degree of preheat and due to location and orientation of the weld joint.

N-3352(j) Joints of Category C and D for which the Code requires ultrasonic examination in addition to radiographic examination shall be permitted only if the manufacturer demonstrates that meaningful ultrasonic examination can be performed.

N-3352(k) Special Joints. The requirements of NNB-3352.5 and NNB-3352.6 of RDT E 15-2NB shall apply.

(End of Amendment Page)

-3600 Piping Design. |D3

-3670 Special Piping Requirements.

-3671 Nonwelded Piping Joints.

-3671.7 Patented Joints. Add:

N-3671.7(d) The approval of the Owner to use these types of joints shall be obtained prior to use. |E4

APPENDIX I-14 |N4

TABLES I-14.0

Table AI-14.1 Permissible Materials for Structures Other than Bolting. For Code Case issues 1592 through 1592-9, delete: SA-409 Welded Pipe.

APPENDIX T

T-1300 DEFORMATION AND STRAIN LIMITS FOR STRUCTURAL INTEGRITY

T-1320 Satisfaction of Strain Limits Using Elastic Analysis. Add:

AT-1321. General Requirements. Modify the fourth line to read, "...1322, T-1323, T-1324, NT-1325, or NT-1326 is satisfied. The ..."

Also, modify the last sentence of the first paragraph to read, "... be evaluated in T-1322, T-1323, T-1324, NT-1325, and NT-1326."

AT-1321(c) Modify the first sentence to read, "... of T-1322, T-1323, T-1324, NT-1325, or NT-1326, whichever ..."

Modify the second sentence to read, "Note that T-1324, NT-1325, and NT-1326 provide for ..."

AT-1321(d) Modify the second line to read, "... satisfy the conditions of T-1322, T-1323, or NT-1325 then ..."

Modify the second sentence to read, "T-1324 and NT-1326 provide methods for ..."

Modify the last sentence to read, "... of T-1322, T-1323, and NT-1325. "

AT-1321(e) Modify to read: The time and temperature conditions used in selecting the isochronous curves in T-1324 or NT-1326 shall always sum to the entire life regardless of whether all or only part of the cycles are evaluated under the procedures of T-1324 or NT-1326.

T-1324 Test No. 3. Add:

AT-1324(a) Modify the first sentence to read, "... the criteria of T-1322, T-1323, and NT-1325 may be ..."

T-1325 Test No. 4. Add: C4

AT-1325 Test No. 4, Option A. Modify the first sentence to read, "... satisfied if the limits of NB-3222.2, NB-3222.3 and NB-3222.5 are met for Upset as well as for Normal Operating Conditions and, in addition ..." N4

AT-1325(d) Change the second paragraph to read: "3 $\bar{S}_m$ = (1.5 S_m + S_{rH}) ... Subsection NB rules (The value of 1.5 S_m should be evaluated at the cold extreme of the thermal stress cycle);"

And change the third paragraph to read: "3 $\bar{S}_m$ = (S_{rH} + S_{rC})...;"

And Add:

AT-1325 Test No. 4, Option B. If the rules of NT-1325, Option A, are satisfied using 1.5 times the average yield strength (instead of 1.5 times the minimum yield strength) in step (a), and using 1.00 times the average yield strength (instead of 1.25 times the minimum yield strength) in step (b), and if the range of the primary-plus-secondary stress intensity in NB-3222.2 and NB-3222.3 does not exceed the lower of 3 times the value of S_m and:

(a) $1.5S_m + S_{rH}$ when one end of the cycle is within the temperature limits of Section III, or

(b) $S_{rH} + S_{rC}$ when both ends of the cycle are above the temperature limits of Section III, whichever is applicable,

and if the limits of NT-1435, NB-3222.2, NB-3222.3, and NB-3222.5 are satisfied for normal, upset and emergency operating conditions, then the limits of T-1310 are considered to have been satisfied. In such cases the rules of NB-3228.3 may be used when the modified $3S_m$ value (defined immediately above) is used.

NT-1326 Test No. 5. For axisymmetric structures subject to axisymmetric loading away from local structural discontinuities (as defined in paragraph -3213.3) the procedure of 6.1.3.2.b of RDT F 9-5 may be used to bound the accumulated inelastic strains. When the resulting membrane and surface strains are shown, using Test No. 5, to be within the limits of T-1310 (a) and (b), respectively, the strain limits of T-1310 are considered satisfied.

T-1400 CREEP-FATIGUE EVALUATION

T-1410 General Requirements. Add:

AT-1411 Damage Equation. In the definition of "T_d" modify the first sentence to read: "=allowable time duration at a given peak stress intensity (for elastic analysis) or at a given peak effective stress (for inelastic analysis) of load condition k." And add:

(End of Amendment Page)

Peak stress effects (creep-rupture damage due to peak stresses) have been included in the Fig. T-1430 design fatigue curves. Thus, the primary-plus-secondary stress values (rather than the primary-plus-secondary plus peak values) may be used to determine the creep damage when Fig. T-1430 is used in the fatigue evaluation. |D3

T-1420 Limits Using Inelastic Analysis.

NT-1420(d) Where local discontinuities are analytically modeled, the analysis shall demonstrate the ability of the model to determine the local stress and strain. Otherwise, the fatigue damage sum shall be evaluated by using Eq 7 to obtain the strain range and by entering the fatigue design curve, Fig. T-1430.

T-1430 Limits Using Elastic Analysis. Add: |D3

Table AT-1430-1A, 1B Design Fatigue Strain Range, ε_t, for 304 SS and 316 SS (Elastic Analysis). In the first line of the fifth Column, change the value for ε_t to 0.0137 (i.e., for 950°F and for 10^1 cycles). |N4

T-1431 General Requirements. Add:

AT-1431(a) Modify the second sentence to read, "However, the secondary stress range due to through-the-thickness thermal gradients..."

AT-1432 Modify Eq 7 and definition of terms to read,

"$\varepsilon_t = (S^*/S)\ K^2$ ..."
"ε_t = the derived maximum ..."
"ε_c = the creep strain from ..."

T-1433 Creep Damage Evaluation. Add:

AT-1433(c) The value of S_k may be assumed to vary during the cycle, k, if the inequality $Sy|k \geq (P_L + P_b + Q)$ is satisfied.

AT-1435 Alternate Creep-Fatigue Evaluation. Modify to read, "... may be replaced (totally, or not at all) by ..."

(b) "... factor, U from NB-3222.4(e)(5) Step 6, ..."

(c) The rules of NB-3228.3 may be used for Types 304 and 316 stainless steels and Ni-Fe-Cr Alloy 800, Grade 2 with the temperature, limit of 800°F replaced by 1300°F. The rules of NB-3228.3 may not be used when Option A of NT-1325 is invoked. When using NB-3228.3, the quantity $3S_m$ shall be defined as in NT-1325 Option A(d). |E4

(d) The references to NB-3222 and NB-3227 in NB-3222.4(e) shall be replaced by references to -3222 and -3227, respectively.

(e) Following the second sentence in NB-3222.4(e) add: The S_a value at $N > 10^6$ cycles shall be justified by the Manufacturer. |E4

|D2

T-1500 BUCKLING AND INSTABILITY |N4

T-1510 General Requirements. Add:

AT-1510(a) The stability limits in NB-3133 of Section III do not protect against column mode buckling. Whenever column mode buckling is a potential failure mode, the Manufacturer shall demonstrate that the load factors meet or exceed the applicable values from Tables T-1521-1 and T-1522-1.

T-1700 SPECIAL REQUIREMENTS

T-1710 Special Strain Requirements at Welds. Add:

AT-1714 Analysis of Geometry. Among the factors to be considered are overall (as well as local) geometry distortions due to weld shrinkage, weld reinforcement, mismatch, and transitions between regions containing different types of weld-induced distortions. The manner in which these distortions are accounted for in the structural evaluation shall be included in the stress report (see NA-3350).

|D3

2. SUPPLEMENTS TO CODE CASE 1593

For RDT F 9-4 applications, any reference in Code Case 1593 to the rules of Subsection NB shall mean the rules as supplemented by RDT E 15-2NB.

(End of Amendment Page)

3. SUPPLEMENTS TO CODE CASE 1594

For RDT F 9-4 applications, any reference in Code Case 1594 to the rules of Subsection NB shall mean the rules as supplemented by RDT E 15-2NB. Where the Code Case provides rules in lieu of those contained in Subsection NB, the following supplemental requirements shall apply.

2.0 Examination of Weld-Edge Preparation Surfaces | N

Change the last sentence to read:

A-2.0 This requirement shall apply to welds having a nominal thickness greater than 3/8 inch.

Change NB-5130(b) to read:

(b) Laminar type discontinuities are acceptable without repair if they do not exceed the lesser of 1/2 T or 1 in. in length. The extent of all laminar type indications exceeding the lesser of 1/2 T or 1 in. in length shall be determined by ultrasonic examination. Indications exceeding the lesser of 1/2 T or 1 in. in length shall be repaired by welding to a depth of 3/8 in. or the depth of the indication, whichever is less, unless the ultrasonic examination reveals that additional depth of repair is required to meet the ultrasonic examination requirement for the product form.

And add a closing paragraph:

Regardless of material thickness, weld edge preparation surfaces for joint Categories A, B, C and D, and similar pressure boundary joints, and for tube-to-tubesheet joints and seal welded joints (see NNB-3352.6 of RDT E 15-2NB) joints of -3227.7 and N-3352(k), shall be examined visually in accordance with NNB-5290 of RDT E 15-2NB.

| D

6.0 Category D Vessel Welds and Similar Nozzle Welds That Are Applicable to Piping, Pumps, and Valves | N

A-6.4 Partial-Penetration Welds. Change to read:

Partial-penetration welds shall be used only for the small-diameter applications allowed by the rules for design of Class 1 components operating at elevated temperatures. Partial-penetration welds as shown in Figs. NB-4244(d)-1 and NB-4244(d)-2 shall be examined progressively using either the magnetic particle or the liquid penetrant method. The increments of examination shall be the root-layer and the lesser of each one-third of the maximum weld dimension measured parallel to the centerline of the connections, or 1/2 in. In addition, each completed weld shall undergo surface examination in accordance with the requirements of Paragraph 3.0(a) of this Case.