ASME BPVC.XI.1-2025

SECTION XI

Rules for Inservice Inspection of
Nuclear Reactor Facility Components

2025 ASME Boiler and Pressure Vessel Code

An International Code

Division 1

Rules for Inservice Inspection of
Nuclear Power Plant Components

ASME
SETTING THE STANDARD

AN INTERNATIONAL CODE

2025 ASME Boiler & Pressure Vessel Code

2025 Edition July 1, 2025

XI

RULES FOR INSERVICE INSPECTION OF NUCLEAR REACTOR FACILITY COMPONENTS

Division 1

Rules for Inservice Inspection of Nuclear Power Plant Components

ASME Boiler and Pressure Vessel Committee
on Nuclear Inservice Inspection

The American Society of Mechanical Engineers
Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: July 1, 2025

This international code or standard was developed under procedures accredited as meeting the criteria for American National Standards and it is an American National Standard. The standards committee that approved the code or standard was balanced to ensure that individuals from competent and concerned interests had an opportunity to participate. The proposed code or standard was made available for public review and comment, which provided an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large.

ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity. ASME does not take any position with respect to the validity of any patent rights asserted in connection with any items mentioned in this document, and does not undertake to insure anyone utilizing a standard against liability for infringement of any applicable letters patent, nor does ASME assume any such liability. Users of a code or standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Participation by federal agency representatives or persons affiliated with industry is not to be interpreted as government or industry endorsement of this code or standard.

ASME accepts responsibility for only those interpretations of this document issued in accordance with the established ASME procedures and policies, which precludes the issuance of interpretations by individuals.

The endnotes and preamble in this document (if any) are part of this American National Standard.

ASME Collective Membership Mark

ASME Single Certification Mark

Library of Congress Catalog Card Number: 56-3934

Adopted by the Council of The American Society of Mechanical Engineers, 1914; latest edition 2025.

The American Society of Mechanical Engineers
Two Park Avenue, New York, NY 10016-5990

TABLE OF CONTENTS

FIGURES

TABLES

FORMS

(25)

LIST OF SECTIONS

SECTIONS

I Rules for Construction of Power Boilers

II Materials
- Part A — Ferrous Material Specifications
- Part B — Nonferrous Material Specifications
- Part C — Specifications for Welding Rods, Electrodes, and Filler Metals
- Part D — Properties (Customary)
- Part D — Properties (Metric)

III Rules for Construction of Nuclear Facility Components
- Subsection NCA — General Requirements for Division 1 and Division 2
- Appendices
- Division 1
  - Subsection NB — Class 1 Components
  - Subsection NCD — Class 2 and Class 3 Components
  - Subsection NE — Class MC Components
  - Subsection NF — Supports
  - Subsection NG — Core Support Structures
- Division 2 — Code for Concrete Containments
- Division 3 — Containment Systems for Transportation and Storage of Spent Nuclear Fuel and High-Level Radioactive Material
- Division 4 — Fusion Energy Devices
- Division 5 — High Temperature Reactors

IV Rules for Construction of Heating Boilers

V Nondestructive Examination

VI Recommended Rules for the Care and Operation of Heating Boilers

VII Recommended Guidelines for the Care of Power Boilers

VIII Rules for Construction of Pressure Vessels
- Division 1
- Division 2 — Alternative Rules
- Division 3 — Alternative Rules for Construction of High Pressure Vessels

IX Welding, Brazing, and Fusing Qualifications

X Fiber-Reinforced Plastic Pressure Vessels

XI Rules for Inservice Inspection of Nuclear Reactor Facility Components
- Division 1 — Rules for Inservice Inspection of Nuclear Power Plant Components
- Division 2 — Requirements for Reliability and Integrity Management (RIM) Programs for Nuclear Reactor Facilities

XII Rules for Construction and Continued Service of Transport Tanks

XIII Rules for Overpressure Protection

FOREWORD[*]

(25)

In 1911, The American Society of Mechanical Engineers established the Boiler and Pressure Vessel Committee to formulate standard rules for the construction of steam boilers and other pressure vessels. In 2009, the Boiler and Pressure Vessel Committee was superseded by the following committees:

(a) Committee on Power Boilers (I)
(b) Committee on Materials (II)
(c) Committee on Construction of Nuclear Facility Components (III)
(d) Committee on Heating Boilers (IV)
(e) Committee on Nondestructive Examination (V)
(f) Committee on Pressure Vessels (VIII)
(g) Committee on Welding, Brazing, and Fusing (IX)
(h) Committee on Fiber-Reinforced Plastic Pressure Vessels (X)
(i) Committee on Nuclear Inservice Inspection (XI)
(j) Committee on Transport Tanks (XII)
(k) Committee on Overpressure Protection (XIII)
(l) Technical Oversight Management Committee (TOMC)

Where reference is made to "the Committee" in this Foreword, each of these committees is included individually and collectively.

The Committee's function is to establish rules of safety relating to pressure integrity. The rules govern the construction[**] of boilers, pressure vessels, transport tanks, and nuclear components, and the inservice inspection of nuclear components and transport tanks. For nuclear items other than pressure-retaining components, the Committee also establishes rules of safety related to structural integrity. The Committee also interprets these rules when questions arise regarding their intent. The technical consistency of the Sections of the Code and coordination of standards development activities of the Committees is supported and guided by the Technical Oversight Management Committee. The Code does not address other safety issues relating to the construction of boilers, pressure vessels, transport tanks, or nuclear components, or the inservice inspection of nuclear components or transport tanks. Users of the Code should refer to the pertinent codes, standards, laws, regulations, or other relevant documents for safety issues other than those relating to pressure integrity and, for nuclear items other than pressure-retaining components, structural integrity. Except for Sections XI and XII, and with a few other exceptions, the rules do not, of practical necessity, reflect the likelihood and consequences of deterioration in service related to specific service fluids or external operating environments. In formulating the rules, the Committee considers the needs of users, manufacturers, and inspectors of components addressed by the Code. The objective of the rules is to afford reasonably certain protection of life and property, and to provide a margin for deterioration in service to give a reasonably long, safe period of usefulness. Advancements in design and materials and evidence of experience have been recognized.

The Code contains mandatory requirements, specific prohibitions, and nonmandatory guidance for construction activities and inservice inspection and testing activities. The Code does not address all aspects of these activities and those aspects that are not specifically addressed should not be considered prohibited. The Code is not a handbook and cannot replace education, experience, and the use of engineering judgment. The phrase *engineering judgment* refers to technical judgments made by knowledgeable engineers experienced in the application of the Code. Engineering judgments must be consistent with Code philosophy, and such judgments must never be used to overrule mandatory requirements or specific prohibitions of the Code.

The Committee recognizes that tools and techniques used for design and analysis change as technology progresses and expects engineers to use good judgment in the application of these tools. The designer is responsible for complying with Code rules and demonstrating compliance with Code equations when such equations are mandatory. The Code

[*] The information contained in this Foreword is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. Therefore, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the Code.

[**] *Construction*, as used in this Foreword, is an all-inclusive term comprising materials, design, fabrication, examination, inspection, testing, certification, and overpressure protection.

neither requires nor prohibits the use of computers for the design or analysis of components constructed to the requirements of the Code. However, designers and engineers using computer programs for design or analysis are cautioned that they are responsible for all technical assumptions inherent in the programs they use and the application of these programs to their design.

The rules established by the Committee are not to be interpreted as approving, recommending, or endorsing any proprietary or specific design, or as limiting in any way the manufacturer's freedom to choose any method of design or any form of construction that conforms to the Code rules.

The Committee meets regularly to consider revisions of the rules, new rules as dictated by technological development, Code cases, and requests for interpretations. Only the Committee has the authority to provide official interpretations of the Code. Requests for revisions, new rules, Code cases, or interpretations shall be addressed to the staff secretary in writing and shall give full particulars in order to receive consideration and action (see the Correspondence With the Committee page). Proposed revisions to the Code resulting from inquiries will be presented to the Committee for appropriate action. The action of the Committee becomes effective only after confirmation by ballot of the Committee and approval by ASME. Proposed revisions to the Code approved by the Committee are submitted to the American National Standards Institute (ANSI) and published at http://go.asme.org/BPVCPublicReview to invite comments from all interested persons. After public review and final approval by ASME, revisions are published at regular intervals in Editions of the Code.

The Committee does not rule on whether a component shall or shall not be constructed to the provisions of the Code. The scope of each Section has been established to identify the components and parameters considered by the Committee in formulating the Code rules.

Questions or issues regarding compliance of a specific component with the Code rules are to be directed to the ASME Certificate Holder (Manufacturer). Inquiries concerning the interpretation of the Code are to be directed to the Committee. ASME is to be notified should questions arise concerning improper use of the ASME Single Certification Mark.

When required by context in the Code, the singular shall be interpreted as the plural, and vice versa.

The words "shall," "should," and "may" are used in the Code as follows:

- *Shall* is used to denote a requirement.
- *Should* is used to denote a recommendation.
- *May* is used to denote permission, neither a requirement nor a recommendation.

STATEMENT OF POLICY ON THE USE OF THE ASME SINGLE CERTIFICATION MARK AND CODE AUTHORIZATION IN ADVERTISING

ASME has established procedures to authorize qualified organizations to perform various activities in accordance with the requirements of the ASME Boiler and Pressure Vessel Code. It is the aim of the Society to provide recognition of organizations so authorized. An organization holding authorization to perform various activities in accordance with the requirements of the Code may state this capability in its advertising literature.

Organizations that are authorized to use the ASME Single Certification Mark for marking items or constructions that have been constructed and inspected in compliance with the ASME Boiler and Pressure Vessel Code are issued Certificates of Authorization. It is the aim of the Society to maintain the standing of the ASME Single Certification Mark for the benefit of the users, the enforcement jurisdictions, and the holders of the ASME Single Certification Mark who comply with all requirements.

Based on these objectives, the following policy has been established on the usage in advertising of facsimiles of the ASME Single Certification Mark, Certificates of Authorization, and reference to Code construction. The American Society of Mechanical Engineers does not "approve," "certify," "rate," or "endorse" any item, construction, or activity and there shall be no statements or implications that might so indicate. An organization holding the ASME Single Certification Mark and/or a Certificate of Authorization may state in advertising literature that items, constructions, or activities "are built (produced or performed) or activities conducted in accordance with the requirements of the ASME Boiler and Pressure Vessel Code," or "meet the requirements of the ASME Boiler and Pressure Vessel Code." An ASME corporate logo shall not be used by any organization other than ASME.

The ASME Single Certification Mark shall be used only for stamping and nameplates as specifically provided in the Code. However, facsimiles may be used for the purpose of fostering the use of such construction. Such usage may be by an association or a society, or by a holder of the ASME Single Certification Mark who may also use the facsimile in advertising to show that clearly specified items will carry the ASME Single Certification Mark.

STATEMENT OF POLICY ON THE USE OF ASME MARKING TO IDENTIFY MANUFACTURED ITEMS

The ASME Boiler and Pressure Vessel Code provides rules for the construction of boilers, pressure vessels, and nuclear components. This includes requirements for materials, design, fabrication, examination, inspection, and stamping. Items constructed in accordance with all of the applicable rules of the Code are identified with the ASME Single Certification Mark described in the governing Section of the Code.

Markings such as "ASME," "ASME Standard," or any other marking including "ASME" or the ASME Single Certification Mark shall not be used on any item that is not constructed in accordance with all of the applicable requirements of the Code.

Items shall not be described on ASME Data Report Forms nor on similar forms referring to ASME that tend to imply that all Code requirements have been met when, in fact, they have not been. Data Report Forms covering items not fully complying with ASME requirements should not refer to ASME or they should clearly identify all exceptions to the ASME requirements.

CORRESPONDENCE WITH THE COMMITTEE

General

ASME codes and standards are developed and maintained by committees with the intent to represent the consensus of concerned interests. Users of ASME codes and standards may correspond with the committees to propose revisions or cases, report errata, or request interpretations. Correspondence for this Section of the ASME Boiler and Pressure Vessel Code (BPVC) should be sent to the staff secretary noted on the Section's committee web page, accessible at https://go.asme.org/CSCommittees.

NOTE: See ASME BPVC Section II, Part D for guidelines on requesting approval of new materials. See Section II, Part C for guidelines on requesting approval of new welding and brazing materials ("consumables").

Revisions and Errata

The committee processes revisions to this Code on a continuous basis to incorporate changes that appear necessary or desirable as demonstrated by the experience gained from the application of the Code. Approved revisions will be published in the next edition of the Code.

In addition, the committee may post errata and Special Notices at http://go.asme.org/BPVCerrata. Errata and Special Notices become effective on the date posted. Users can register on the committee web page to receive email notifications of posted errata and Special Notices.

This Code is always open for comment, and the committee welcomes proposals for revisions. Such proposals should be as specific as possible, citing the paragraph number, the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent background information and supporting documentation.

Cases

(a) The most common applications for cases are

(1) to permit early implementation of a revision based on an urgent need

(2) to provide alternative requirements

(3) to allow users to gain experience with alternative or potential additional requirements prior to incorporation directly into the Code

(4) to permit use of a new material or process

(b) Users are cautioned that not all jurisdictions or owners automatically accept cases. Cases are not to be considered as approving, recommending, certifying, or endorsing any proprietary or specific design, or as limiting in any way the freedom of manufacturers, constructors, or owners to choose any method of design or any form of construction that conforms to the Code.

(c) The committee will consider proposed cases concerning the following topics only:

(1) equipment to be marked with the ASME Single Certification Mark, or

(2) equipment to be constructed as a repair/replacement activity under the requirements of Section XI

(d) A proposed case shall be written as a question and reply in the same format as existing cases. The proposal shall also include the following information:

(1) a statement of need and background information

(2) the urgency of the case (e.g., the case concerns a project that is underway or imminent)

(3) the Code Section and the paragraph, figure, or table number to which the proposed case applies

(4) the editions of the Code to which the proposed case applies

(e) A case is effective for use when the public review process has been completed and it is approved by the cognizant supervisory board. Cases that have been approved will appear in the next edition or supplement of the Code Cases books, "Boilers and Pressure Vessels" or "Nuclear Components." Each Code Cases book is updated with seven Supplements. Supplements will be sent or made available automatically to the purchasers of the Code Cases books until the next edition of the Code. Annulments of Code Cases become effective six months after the first announcement of the annulment in a Code Case Supplement or Edition of the appropriate Code Case book. The status of any case is available at http://go.asme.org/BPVCCDatabase. An index of the complete list of Boiler and Pressure Vessel Code Cases and Nuclear Code Cases is available at http://go.asme.org/BPVCC.

Interpretations

(a) Interpretations clarify existing Code requirements and are written as a question and reply. Interpretations do not introduce new requirements. If a revision to resolve conflicting or incorrect wording is required to support the interpretation, the committee will issue an intent interpretation in parallel with a revision to the Code.

(b) Upon request, the committee will render an interpretation of any requirement of the Code. An interpretation can be rendered only in response to a request submitted through the online Inquiry Submittal Form at http://go.asme.org/InterpretationRequest. Upon submitting the form, the inquirer will receive an automatic email confirming receipt.

(c) ASME does not act as a consultant for specific engineering problems or for the general application or understanding of the Code requirements. If, based on the information submitted, it is the opinion of the committee that the inquirer should seek assistance, the request will be returned with the recommendation that such assistance be obtained. Inquirers may track the status of their requests at http://go.asme.org/Interpretations.

(d) ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME committee or subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

(e) Interpretations are published in the ASME Interpretations Database at http://go.asme.org/Interpretations as they are issued.

Committee Meetings

The ASME BPVC committees regularly hold meetings that are open to the public. Persons wishing to attend any meeting should contact the secretary of the applicable committee. Information on future committee meetings can be found at http://go.asme.org/BCW.

(25)

PERSONNEL
ASME Boiler and Pressure Vessel Standards Committees, Subgroups, and Working Groups

January 1, 2025

TECHNICAL OVERSIGHT MANAGEMENT COMMITTEE (TOMC)

R. E. McLaughlin, *Chair*
N. A. Finney, *Vice Chair*
S. J. Rossi, *Staff Secretary*
R. W. Barnes
T. L. Bedeaux
C. T. Brown
R. P. Deubler
G. W. Galanes
J. A. Hall
T. E. Hansen
G. W. Hembree
R. B. Keating
B. Linnemann
W. M. Lundy
D. I. Morris
M. D. Rana
S. C. Roberts
F. J. Schaaf, Jr.
G. Scribner
W. J. Sperko
D. Srnic
R. W. Swayne
J. Vattappilly
M. Wadkinson
D. W. Lamond, *Ex-Officio Member*
B. K. Nutter, *Ex-Officio Member*
E. M. Ortman, *Ex-Officio Member*
M. J. Pischke, *Ex-Officio Member*
J. F. Henry, *Honorary Member*

Subgroup on Research and Development (TOMC)

S. C. Roberts, *Chair*
S. J. Rossi, *Staff Secretary*
R. W. Barnes
N. A. Finney
G. W. Galanes
R. B. Keating
R. E. McLaughlin
E. M. Ortman
D. Andrei, *Contributing Member*

Subgroup on Strategic Initiatives (TOMC)

N. A. Finney, *Chair*
S. J. Rossi, *Staff Secretary*
R. W. Barnes
G. W. Galanes
G. W. Hembree
R. B. Keating
R. E. McLaughlin
E. M. Ortman
S. C. Roberts
M. Wadkinson

Task Group on Field Sites (TOMC)

R. V. Wielgoszinski, *Chair*
M. Vazquez, *Staff Secretary*
P. Becker
T. Bedeaux
J. Hoskinson
D. T. Peters
G. Scribner

Task Group on Remote Inspection and Examination (SI-TOMC)

S. C. Roberts, *Chair*
M. Frediani, *Staff Secretary*
P. J. Coco
N. A. Finney
S. A. Marks
R. Rockwood
C. Stevens
M. Tannenbaum
J. Cameron, *Alternate*
A. Byk, *Contributing Member*
S. J. Rossi, *Contributing Member*
C. A. Sanna, *Contributing Member*

Special Working Group on High Temperature Technology (TOMC)

D. Dewees, *Chair*
F. W. Brust
T. D. Burchell
P. R. Donavin
B. F. Hantz
R. I. Jetter
P. Smith

Honors and Awards Committee (TOMC)

E. M. Ortman,
G. W. Galanes
D. W. Lamond
B. K. Nutter
R. E. McLaughlin

ADMINISTRATIVE COMMITTEE

R. E. McLaughlin, *Chair*
N. A. Finney, *Vice Chair*
S. J. Rossi, *Staff Secretary*
G. W. Galanes
R. B. Keating
D. W. Lamond
B. Linnemann
B. K. Nutter
E. M. Ortman
M. J. Pischke
M. D. Rana
S. C. Roberts
R. R. Stevenson
M. Wadkinson

MARINE CONFERENCE GROUP

J. Oh, *Staff Secretary*
J. G. Hungerbuhler, Jr.
G. Nair
H. N. Patel
N. Prokopuk
J. D. Reynolds

CONFERENCE COMMITTEE

R. D. Troutt — Texas, *Chair*
J. T. Amato — Ohio, *Secretary*
M. O. Amuzie — New Jersey
R. Becker — Colorado
H. Berny — Minnesota
T. D. Boggs — Missouri
R. A. Boillard — Indiana
D. P. Brockerville — Newfoundland and Labrador, Canada
R. J. Bunte — Iowa
A. Buquis — Arizona
J. H. Burpee — Maine
M. Carlson — Washington
T. Carter — Mississippi
N. Chiasson — Prince Edward Island, Canada
T. G. Clark — Oregon
B. J. Crawford — Georgia
E. L. Creaser — New Brunswick, Canada
J. J. Dacanay — Hawaii
M. Davidian — California
R. DeLury — Manitoba, Canada
A. Denham — Michigan
C. Derks — Wisconsin
C. Dinic — Ontario, Canada
D. A. Ehler — Nova Scotia, Canada
S. D. Frazier — Washington
A. Gibbs — Wisconsin
T. J. Granneman II — Oklahoma
M. L. Jordan — Kentucky
R. Kamboj — British Columbia, Canada
E. Kawa — Massachusetts
A. Khssassi — Quebec, Canada
D. Kinney — North Carolina
K. S. Lane — Alaska
A. M. Lorimor — South Dakota
T. Maher — Illinois
M. Mailman — Northwest Territories, Canada
W. McGivney — City of New York, New York
S. F. Noonan — Maryland
B. S. Oliver — New Hampshire
J. L. Oliver — Nevada
P. B. Polick — Illinois
B. Ricks — Montana
W. J. Ross — Pennsylvania
M. H. Sansone — New York
T. S. Seime — North Dakota
C. S. Selinger — Saskatchewan, Canada
J. E. Sharier — Ohio
R. Spiker — North Carolina
D. Srnic — Alberta, Canada
D. J. Stenrose — Michigan
R. J. Stimson II — Kansas
R. K. Sturm — Utah
D. K. Sullivan — Arkansas
J. Taveras — Rhode Island
R. Termini — Louisiana
S. Van Slavens — Delaware
D. M. Warburton — Florida
E. Wiggins — Alabama

INTERNATIONAL INTEREST REVIEW GROUP

V. Felix
Y.-G. Kim
S. H. Leong
W. Lin
O. F. Manafa
C. Minu
Y.-W. Park
A. R. Reynaga Nogales
P. Williamson

COMMITTEE ON POWER BOILERS (BPV I)

E. M. Ortman, *Chair*
D. E. Tompkins, *Vice Chair*
U. D'Urso, *Staff Secretary*
D. I. Anderson
R. Antoniuk
J. L. Arnold
K. K. Coleman
S. Fincher
G. W. Galanes
P. F. Gilston
T. E. Hansen
J. S. Hunter
M. Ishikawa
M. Lemmons
M. Lewis
C. T. McDaris
R. E. McLaughlin
L. Moedinger
Y. Oishi
M. Ortolani
A. Spangenberg
D. E. Tuttle
J. Vattappilly
M. Wadkinson
F. Zeller
H. Michael, *Contributing Member*
D. Berger, *Honorary Member*
P. D. Edwards, *Honorary Member*
J. G. Feldstein, *Honorary Member*
D. N. French, *Honorary Member*
J. Hainsworth, *Honorary Member*
J. F. Henry, *Honorary Member*
P. A. Molvie, *Honorary Member*
J. T. Pillow, *Honorary Member*
B. W. Roberts, *Honorary Member*
J. M. Tanzosh, *Honorary Member*
R. V. Wielgoszinski, *Honorary Member*
R. L. Williams, *Honorary Member*

Executive Committee (BPV I)

D. E. Tompkins, *Chair*
E. M. Ortman, *Vice Chair*
P. Becker
J. R. Braun
P. F. Gilston
A. Hantodkar
M. Lewis
C. T. McDaris
L. S. Nicol
A. Spangenberg
K. Thanupillai
M. Wadkinson

Subgroup on Design (BPV I)

C. T. McDaris, *Chair*
L. S. Tsai, *Secretary*
T. K. Acharya
D. I. Anderson
P. Becker
T. Huynh
L. Krupp
N. S. Ranck
J. Vattappilly
M. Wadkinson
C. Welles

Subgroup on Fabrication and Examination (BPV I)

P. F. Gilston, *Chair*
P. Becker, *Vice Chair*
J. L. Arnold
K. K. Coleman
S. Fincher
G. W. Galanes
T. E. Hansen
M. Lewis
S. J. Lombardo
C. T. McDaris
R. E. McLaughlin
Y. Oishi

Subgroup on General Requirements and Piping (BPV I)

D. E. Tompkins, *Chair*
M. Wadkinson, *Vice Chair*
M. Lemmons, *Secretary*
R. Antoniuk
T. E. Hansen
M. Ishikawa
S. J. Lombardo
R. E. McLaughlin
L. Moedinger
E. M. Ortman
D. E. Tuttle
J. Vattappilly

Subgroup on Locomotive Boilers (BPV I)

J. R. Braun, *Chair*
S. M. Butler, *Secretary*
G. W. Galanes
S. A. Lee
L. Moedinger
G. M. Ray
M. W. Westland

Subgroup on Materials (BPV I)

M. Lewis, *Chair*
L. S. Nicol, *Vice Chair*
S. H. Bowes
K. K. Coleman
G. W. Galanes
P. F. Gilston
K. Hayes
J. S. Hunter
E. Liebl
F. Masuyama
M. Ortolani
D. W. Rahoi
F. Zeller
B. W. Roberts, *Contributing Member*
J. M. Tanzosh, *Contributing Member*

Subgroup on Solar Boilers (BPV I)

R. E. Hearne, *Secretary*
S. Fincher
J. S. Hunter
P. Swarnkar

Task Group on Additive Manufacturing (BPV I)

K. K. Coleman, *Chair*
P. Becker, *Secretary*
J. L. Arnold
G. W. Galanes
P. F. Gilston
L. Moedinger
J. Vattappilly

Task Group on Modernization (BPV I)

S. J. Lombardo, *Chair*
U. D'Urso, *Staff Secretary*
D. I. Anderson
J. L. Arnold
G. W. Galanes
R. E. McLaughlin
E. M. Ortman
D. E. Tuttle

European International Working Group (BPV I)

A. Spangenberg, *Chair*
B. Daume
J. Fleischfresser
C. Jaekel
R. Kauer
D. Koelbl
S. Krebs
T. Ludwig
R. A. Meyers
H. Michael
F. Miunske
M. Sykora
P. Chavdarov, *Contributing Member*
J. Henrichsmeyer, *Contributing Member*
B. Müller, *Contributing Member*

India International Working Group (BPV I)

K. Thanupillai, *Chair*
A. Hantodkar, *Vice Chair*
A. Ghosh, *Secretary*
P. Brahma
H. Dalal
T. Dhanraj
A. S. Ganeth
S. Gopalakrishnan
A. Jain
R. Madnani
S. Purkait
A. Relekar
M. Shiroya
D. K. Shrivastava
K. Singha
R. Sundararaj
S. Velu
S. Venkataramana

COMMITTEE ON MATERIALS (BPV II)

G. W. Galanes, *Chair*
M. Ortolani, *Vice Chair*
C. E. Rodrigues, *Staff Secretary*
A. Appleton
P. Chavdarov
J. F. Grubb
J. A. Hall
D. O. Henry
K. M. Hottle
M. Ishikawa
M. Kowalczyk
D. L. Kurle
F. Masuyama
S. Neilsen
L. S. Nicol
D. W. Rahoi
W. Ren
E. Shapiro
R. C. Sutherlin
F. Zeller
J. Cameron, *Contributing Member*
A. Chaudouet, *Contributing Member*
K. K. Coleman, *Contributing Member*
D. W. Gandy, *Contributing Member*
K. L. Hayes, *Contributing Member*
W. Hoffelner, *Contributing Member*
K. E. Orie, *Contributing Member*
D. T. Peters, *Contributing Member*
B. W. Roberts, *Contributing Member*
J. M. Tanzosh, *Contributing Member*
E. Upitis, *Contributing Member*
T. M. Cullen, *Honorary Member*
G. C. Hsu, *Honorary Member*

Executive Committee (BPV II)

G. W. Galanes, *Chair*
C. E. Rodrigues, *Staff Secretary*
E. Alexis
A. Appleton
J. Cameron
P. Chavdarov
J. F. Grubb
S. Guzey
K. L. Hayes
K. M. Hottle
W. MacDonald
M. Ortolani
P. K. Rai
J. Robertson
E. Shapiro

Subgroup on External Pressure (BPV II)

E. Alexis, *Chair*
S. Guzey, *Vice Chair*
J. A. A. Morrow, *Secretary*
L. F. Campbell
H. Chen
M. Ghorashi
D. S. Griffin
J. F. Grubb
S. Krishnamurthy
D. L. Kurle
R. W. Mikitka
P. K. Rai
M. Wadkinson

Subgroup on Ferrous Specifications (BPV II)

K. M. Hottle, *Chair*
A. Appleton, *Vice Chair*
C. Hyde, *Secretary*
D. Amire-Brahimi
G. Cuccio
O. Elkadim
D. Fialkowski
J. Grimm
J. F. Grubb
D. S. Janikowski
Y.-J. Kim
W. C. Mack
J. Nickel
D. Poweleit
R. Rezaeifar
R. Schmidt
E. Upitis
L. Watzke
C. Meloy, *Contributing Member*

Subgroup on International Material Specifications (BPV II)

P. Chavdarov, *Chair*
M. Ishikawa, *Vice Chair*
C. Zhou, *Secretary*
A. Chaudouet
H. Chen
A. F. Garbolevsky
D. O. Henry
W. M. Lundy
F. Zeller
T. F. Miskell, *Contributing Member*
E. Upitis, *Contributing Member*

Subgroup on Nonferrous Alloys (BPV II)

J. Robertson, *Chair*
W. MacDonald, *Vice Chair*
R. M. Beldyk
J. M. Downs
H. Dutta
J. F. Grubb
J. A. Hall
D. Maitra
D. W. Rahoi
R. Rezaeifar
E. Shapiro
J. Shubilla
R. C. Sutherlin
R. Wright
S. Yem
D. B. Denis, *Contributing Member*
D. T. Peters, *Contributing Member*

Subgroup on Physical Properties (BPV II)

P. K. Rai, *Chair*
S. Neilsen, *Vice Chair*
D. Chandiramani
H. Eshraghi
J. F. Grubb
B. F. Hantz
R. D. Jones
P. K. Lam
D. W. Rahoi
E. Shapiro
D. K. Verma
S. Yem
D. B. Denis, *Contributing Member*

Subgroup on Strength, Ferrous Alloys (BPV II)

M. Ortolani, *Chair*
S. Rosinski, *Vice Chair*
L. S. Nicol, *Secretary*
G. W. Galanes
J. A. Hall
M. Ishikawa
S. W. Knowles
F. Masuyama
M. Osterfoss
D. W. Rahoi
M. Ueyama
F. Zeller
F. Abe, *Contributing Member*

Subgroup on Strength of Weldments (BPV II & BPV IX)

K. L. Hayes, *Chair*
G. W. Galanes, *Vice Chair*
S. H. Bowes, *Secretary*
K. K. Coleman, *Chair*
M. Denault
D. W. Gandy
M. Ghahremani
W. F. Newell, Jr.
J. A. Penso
D. W. Rahoi
W. J. Sperko
J. P. Swezy, Jr.
B. W. Roberts, *Contributing Member*

China International Working Group (BPV II)

Sanjiang Liu, *Chair*
H. Zhang, *Vice Chair*
T. Xu, *Secretary*
W. Cai
W. Fang
F. Kong
H. Li
J. Li
Z. Rongcan
S. Tan
C. Wang
Jinguang Wang
Jiongxiang Wang
Q.-J. Wang
H.-C. Yang
J. Yang
L. Yin
X.-H. Zhang
Y. Zhang

Working Group on Creep Strength Enhanced Ferritic Steels (BPV II)

M. Ortolani, *Chair*
G. W. Galanes, *Vice Chair*
P. Becker, *Secretary*
S. H. Bowes
K. Kimura
M. Lang
S. Luke
F. Masuyama
T. Melfi
W. F. Newell, Jr.
J. J. Sanchez-Hanton
J. A. Siefert
W. J. Sperko
F. Zeller
F. Abe, *Contributing Member*
K. K. Coleman, *Contributing Member*
J. M. Tanzosh, *Contributing Member*

COMMITTEE ON CONSTRUCTION OF NUCLEAR FACILITY COMPONENTS (BPV III)

R. B. Keating, *Chair*
T. M. Adams, *Vice Chair*
D. E. Matthews, *Vice Chair*
A. Maslowski, *Staff Secretary*
A. Appleton
S. Asada
R. W. Barnes
W. H. Borter
M. E. Cohen
R. P. Deubler
P. R. Donavin
A. C. Eberhardt
J. V. Gardiner
W. J. Geringer
J. Grimm
S. Hunter
R. I. Jetter
J. I. Kim
G. H. Koo
D. W. Lewis
M. A. Lockwood
D. W. Mann
K. A. Manoly
K. Matsunaga
B. McGlone
S. McKillop
J. B. McLean
J. C. Minichiello
M. N. Mitchell
T. Nagata
J. B. Ossmann
S. Pellet
E. L. Pleins
W. J. Sperko
Y. J. Wang
W. Windes
C. Basavaraju, *Alternate*
T. P. Davis, *Contributing Member*
T.-L. Sham, *Contributing Member*
C. T. Smith, *Contributing Member*
R. M. Jessee, *Honorary Member*
E. B. Branch, *Honorary Member*
M. N. Bressler, *Honorary Member*
G. D. Cooper, *Honorary Member*
D. F. Landers, *Honorary Member*
C. Pieper, *Honorary Member*

Working Group on Data Analysis and the Materials Properties Database (BPV II)

W. MacDonald, *Chair*
C. E. Rodrigues, *Staff Secretary*
J. F. Grubb
F. Masuyama
S. Neilsen
M. Ortolani
R. C. Sutherlin
M. J. Swindeman
F. Abe, *Contributing Member*
D. Andrei, *Contributing Member*
J. Cameron, *Contributing Member*
G. W. Galanes, *Contributing Member*
W. C. Mack, *Contributing Member*
D. T. Peters, *Contributing Member*
W. Ren, *Contributing Member*
E. Shapiro, *Contributing Member*

Executive Committee (BPV III)

R. B. Keating, *Chair*
A. Maslowski, *Secretary*
T. M. Adams
T. P. Davis
P. R. Donavin
D. W. Lewis
D. Mann
K. A. Manoly
D. E. Matthews
B. McGlone
S. McKillop
J. B. McLean
Yanli Wang
K. A. Kavanagh, *Alternate*

Task Group on Modernization of Materials Data (BPV II)

C. E. Rodrigues, *Staff Secretary*
E. Alexis
M. Brijlani
D. B. Denis
G. W. Galanes
J. A. Hall
B. F. Hantz
A. Hassan
W. MacDonald
S. Neilsen
L. S. Nicol
W. Ren
J. C. Sowinski
M. Wadkinson
J. Cameron, *Contributing Member*
J. F. Grubb, *Contributing Member*
W. Hoffelner, *Contributing Member*

Latin America International Working Group (BPV III)

M. F. Liendo, *Chair*
J. Fernández, *Vice Chair*
O. Martinez, *Staff Secretary*
P. Yamamoto, *Secretary*
E. H. Aldaz
G. O. Anteri
A. P. Antipasti
D. O. Bordato
G. Bourguigne
M. Brusa
A. Claus
R. G. Cocco
A. J. Dall'Osto
J. I. Duo
M. M. Gamizo
I. M. Guerreiro
I. A. Knorr
D. E. Matthews
A. E. Pastor
M. Rivero
R. Taboada
O. A. Verastegui
M. D. Vigliano
M. Zunino

China International Working Group (BPV III)

Yong Wang, *Chair*
J. Gu, *Vice Chair*
C. Jiang, *Vice Chair*
H. Yu, *Secretary*
L. Feng
L. Guo
D. Kang
Y. Li
H. Lin
Shenghua Liu
W. Liu
J. Ma
K. Mao
D. E. Matthews
J. Ming
W. Pei
C. Peiyin
Z. Sun
G. Tang
L. Ting
J. Wen
F. Wu
C. Yang
P. Yang
W. Yang
H. Yin
D. Yuangang
D. Zhao
Z. Zhong
Q. Zhou
H. Zhu

European International Working Group (BPV III)

J. Wendt, *Chair*
D. Koelbl, *Vice Chair*
R. Gersinska, *Secretary*
P. Ancion
P. R. Donavin
R. Döring
C. G. Frantescu
T. Hantzka
A. Huber
R. E. Hueggenberg
E. Iacopetta
A. Juengert
F. Juettemann
M. H. Koeppen
C. Kuschke
H.-W. Lange
T. Ludwig
M. Reichert
G. Roos
J. Rudolph
L. Sybertz
I. Tewes
R. Tiete
F. Wille

India International Working Group (BPV III)

S. B. Parkash, *Chair*
V. Sehgal, *Vice Chair*
M. Brijlani, *Secretary*
S. Aithal
A. D. Bagdare
H. Dalal
S. K. Goyal
D. Kulkarni
Raj Kumar
Ritesh Kumar
S. Kumar
T. Mukherjee
D. Narain
A. D. Paranjpe
J. R. Patel
E. L. Pleins
S. Ponnappan
T. J. P. Rao
S. Singh
B. K. Sreedhar
N. Mistry, *Alternate*

Korea International Working Group (BPV III)

G. H. Koo, *Chair*
O.-S. Kim, *Secretary*
H. Ahn
S. Cho
G.-S. Choi
M. Choi
M.-J. Choi
S. Choi
J. Y. Hong
N.-S. Huh
S. S. Hwang
C. Jang
I.-S. Jeong
S. H. Kang
J. Kim
J. I. Kim
J.-S. Kim
M.-W. Kim
S.-S. Kim
Y.-B. Kim
Y.-S. Kim
D. Kwon
B. Lee
D. Lee
D. W. Lee
Sanghoon Lee
Sungjae Lee
S.-G. Lee
H. Lim
I.-K. Nam
C.-K. Oh
C.-Y. Oh
E.-J. Oh
C. Park
H. Park
Y.-H. Park
Y. S. Pyun
J. H. Seo
T. Shin
S. Song
T.-K. Song
W. J. Sperko
J. S. Yang
O. Yoo

Seismic Design Steering Committee (BPV III)

T. M. Adams, *Chair*
K. Gresh, *Secretary*
C. Basavaraju
D. Chowdhury
R. Döring
G. H. Koo
A. Maekawa
J. B. McLean
R. M. Pace
M. Pérès
K. Shibukuwa
F. G. Abatt, *Contributing Member*
M. Arcaro, *Contributing Member*
P. R. Donavin, *Contributing Member*
R. W. Haupt, *Contributing Member*

Task Group on Alternate Requirements (BPV III)

J. Wen, *Chair*
R. R. Romano, *Secretary*
T. Basso
P. J. Coco
P. R. Donavin
J. V. Gardiner
F. Grant
J. Grimm
R. S. Hill III
M. Kris
M. A. Lockwood
K. A. Manoly
D. E. Matthews
S. McKillop
B. P. Nolan
J. B. Ossmann
E. C. Renaud
M. A. Richter
R. Summitt
K. Voelsing
Yanli Wang
I. H. Tseng, *Alternate*

United Kingdom International Working Group (BPV III)

P. M. James, *Chair*
J. Emslie, *Vice Chair*
C. B. Carpenter, *Secretary*
T. Bann
M. J. Chevalier
A. J. Cole-Baker
M. Consonni
M. J. Crathorne
P. Gill
G. Innes
S. A. Jones
B. McGlone
B. Pellereau
E. I. S. Pendry
J. Randles
C. R. Schneider
J. W. Stairmand
J. Sulley
J. Talamantes-Silva
A. J. Holt, *Contributing Member*

Special Working Group on New Plant Construction Issues (BPV III)

J. B. Ossmann, *Chair*
A. Maslowski, *Staff Secretary*
M. C. Buckley, *Secretary*
M. Arcaro
K. Burnett
A. Cardillo
P. J. Coco
K. Harris
E. Henry
J. Honcharik
M. Kris
R. E. McLaughlin
A. McLendon
Z. McLucas
N. J. McTiernan
K. Pigg
E. L. Pleins
J. Pollak
D. W. Sandusky
M. C. Scott
R. R. Stevenson
H. Xu
J. Yan
J. C. Minichiello, *Contributing Member*

Special Working Group on Editing and Review (BPV III)

D. E. Matthews, *Chair*
R. P. Deubler
A. C. Eberhardt
S. Hunter
B. McGlone
J. C. Minichiello
J. F. Strunk
Yanli Wang
C. Wilson

Special Working Group on HDPE Stakeholders (BPV III)

S. Patterson, *Secretary*
M. Kuntz
J. E. O'Sullivan

Special Working Group on Honors and Awards (BPV III)

R. W. Barnes, *Chair*
A. Appleton
R. M. Jessee
D. E. Matthews
J. C. Minichiello

Special Working Group on International Meetings and IWG Liaisons (BPV III)

D. E. Matthews, *Chair*
A. Maslowski, *Staff Secretary*
R. W. Barnes
P. R. Donavin
E. L. Pleins
W. J. Sperko

Joint ACI-ASME Committee on Concrete Components for Nuclear Service (BPV III)

J. B. McLean, *Chair*
L. J. Colarusso, *Vice Chair*
A. Dinizulu, *Staff Secretary*
S. Bae
C. J. Bang
A. C. Eberhardt
B. D. Hovis
T. C. Inman
C. Jones
T. Kang
N.-H. Lee
S. Malushte
J. A. Munshi
T. Muraki
J. S. Saini
J. F. Strunk
G. Thomas
A. Varma
S. Wang
A. Istar, *Alternate*
A. Adediran, *Contributing Member*
J.-B. Domage, *Contributing Member*
P. S. Ghosal, *Contributing Member*
M. R. Senecal, *Contributing Member*
Z. Shang, *Contributing Member*
M. Sircar, *Contributing Member*
C. T. Smith, *Contributing Member*

Special Working Group on Modernization (SG Div 2) (BPV III)

A. Varma, *Chair*
J. B. McLean, *Vice Chair*
J. S. Saini, *Vice Chair*
A. Adediran
S. Malushte
S. Wang
I. Zivanovic
R. Janowiak, *Contributing Member*
F. Lin, *Contributing Member*
J. A. Pires, *Contributing Member*

Task Group on Steel-Concrete Composite Containments (SG Div 2) (BPV III)

A. Varma, *Chair*
R. Janowiak
S. Malushte
J. B. McLean
J. A. Pires
J. S. Saini

Working Group on Design (SG Div 2) (BPV III)

N.-H. Lee, *Chair*
S. Bae
L. J. Colarusso
A. C. Eberhardt
B. D. Hovis
T. C. Inman
C. Jones
J. A. Munshi
T. Muraki
J. S. Saini
G. Thomas
S. Wang
A. Istar, *Alternate*
P. S. Ghosal, *Contributing Member*
S.-Y. Kim, *Contributing Member*
J. Kwon, *Contributing Member*
S. E. Ohler-Schmitz, *Contributing Member*
B. B. Scott, *Contributing Member*
Z. Shang, *Contributing Member*
M. Shin, *Contributing Member*
M. Sircar, *Contributing Member*

Working Group on Materials, Fabrication, and Examination (SG Div 2) (BPV III)

C. Jones, *Chair*
A. Eberhardt, *Vice Chair*
C. J. Bang
B. Birch
J.-B. Domage
T. Kang
N.-H. Lee
Z. Shang
J. F. Strunk
I. Zivanovic
A. A. Aboelmagd, *Contributing Member*
P. S. Ghosal, *Contributing Member*

Subcommittee on Design (BPV III)

P. R. Donavin, *Chair*
S. McKillop, *Vice Chair*
R. P. Deubler, *Secretary*
T. P. Davis
M. A. Gray
R. I. Jetter
R. B. Keating
J. I. Kim
K. A. Manoly
D. E. Matthews
M. N. Mitchell
B. Pellereau
Yanli Wang
W. F. Weitze
C. Basavaraju, *Alternate*
G. L. Hollinger, *Contributing Member*
W. J. O'Donnell, Sr., *Contributing Member*
K. Wright, *Contributing Member*

Subgroup on Component Design (SC-D) (BPV III)

D. E. Matthews, *Chair*
P. Vock, *Vice Chair*
D. Chowdhury, *Secretary*
D. J. Ammerman
G. A. Antaki
J. J. Arthur
S. Asada
C. Basavaraju
N. A. Costanzo
R. P. Deubler
P. Hirschberg
M. Kassar
D. Keck
T. R. Liszkai
K. A. Manoly
R. Martin
K. R. May
J. C. Minichiello
T. Mitsuhashi
D. Murphy
T. M. Musto
T. Nagata
S. Pellet
S. Willoughby-Braun
C. Wilson
T. M. Adams, *Contributing Member*
R. B. Keating, *Contributing Member*
O.-S. Kim, *Contributing Member*
R. J. Masterson, *Contributing Member*
H. S. Mehta, *Contributing Member*
G. Z. Tokarski, *Contributing Member*
J. P. Tucker, *Contributing Member*

Task Group on Pressurized Heavy Water Reactor (SG-CD) (BPV III)

R. W. Barnes, *Chair*
M. Brijlani
D. E. Matthews
B. McGlone
J. B. Ossmann
S. B. Parkash
E. L. Pleins
W. D. Reinhardt
C. A. Sanna
V. Sehgal
S. Singh

Task Group to Improve Section III/XI Interface (SG-CD) (BPV III)

P. Vock, *Chair*
E. Henry, *Secretary*
G. A. Antaki
A. Cardillo
D. Chowdhury
J. Honcharik
J. Hurst
J. Lambin
C. A. Nove
T. Nuoffer
J. B. Ossmann
A. T. Roberts III
J. Sciulli
A. Udyawar
S. Willoughby-Braun

Working Group on Core Support Structures (SG-CD) (BPV III)

R. Martin, *Chair*
R. Z. Ziegler, *Secretary*
G. W. Delport
L. C. Hartless
D. Keck
T. R. Liszkai
M. Nakajima
M. D. Snyder
R. O. Vollmer
T. M. Wiger
C. Wilson
Y. Wong
K. Hsu, *Alternate*
H. S. Mehta, *Contributing Member*

Working Group on Design of Division 3 Containment Systems (SG-CD) (BPV III)

D. J. Ammerman, *Chair*
S. Klein, *Secretary*
J. Bignell
G. Bjorkman
V. Broz
D. D. Imholte
D. W. Lewis
A. Rigato
P. Sakalaukus, Jr.
D. Siromani
C. R. Sydnor
R. Sypulski
R. Williamson
X. Zhai
X. Zhang
J. Smith, *Alternate*
J. C. Minichiello, *Contributing Member*

Working Group on HDPE Design of Components (SG-CD) (BPV III)

M. Brandes
J. R. Hebeisen
P. Krishnaswamy
M. Kuntz
K. A. Manoly
D. P. Munson
R. Stakenborghs
B. Lin, *Alternate*

Working Group on Piping (SG-CD) (BPV III)

G. A. Antaki, *Chair*
S. Weindorf, *Secretary*
C. Basavaraju
J. Catalano
C. M. Faidy
R. G. Gilada
M. A. Gray
R. J. Gurdal
R. W. Haupt
A. Hirano
P. Hirschberg
M. Kassar
D. Lieb
M. Moenssens
I.-K. Nam
K. E. Reid II
B. Still
D. Vlaicu
W. F. Weitze
K. Hsu, *Alternate*
R. B. Keating, *Contributing Member*
T. B. Littleton, *Contributing Member*
Y. Liu, *Contributing Member*
J. F. McCabe, *Contributing Member*
J. C. Minichiello, *Contributing Member*
A. N. Nguyen, *Contributing Member*
M. S. Sills, *Contributing Member*
N. C. Sutherland, *Contributing Member*
G. Z. Tokarski, *Contributing Member*
E. A. Wais, *Contributing Member*
C.-I. Wu, *Contributing Member*

Working Group on Pressure Relief (SG-CD) (BPV III)

K. R. May, *Chair*
J. F. Ball, *Vice Chair*
R. Krithivasan, *Secretary*
J. W. Dickson
N. Hansing
S. Jones
D. Miller
T. Patel
B. J. Yonsky
Y. Wong, *Alternate*
J. Yu, *Alternate*
M. Brown, *Contributing Member*
S. T. French, *Contributing Member*
S. Ruesenberg, *Contributing Member*

Working Group on Pumps (SG-CD) (BPV III)

D. Chowdhury, *Chair*
J. V. Gregg, Jr., *Secretary*
B. Busse
R. Ibrahim
T. Johnson
K. J. Noel
D. Skidmore
J. Sulley
Y. Wong
N. Chandran, *Alternate*

Working Group on Supports (SG-CD) (BPV III)

N. A. Costanzo, *Chair*
U. S. Bandyopadhyay, *Secretary*
K. Avrithi
N. M. Bisceglia
R. P. Deubler
N. M. Graham
Y. Matsubara
S. Pellet
G. Thomas
G. Z. Tokarski
L. Vandersip
P. Wiseman
J. Bozga, *Alternate*
R. J. Masterson, *Contributing Member*
R. Roche-Rivera, *Contributing Member*
J. R. Stinson, *Contributing Member*

Working Group on Valves (SG-CD) (BPV III)

P. Vock, *Chair*
S. Jones, *Secretary*
M. C. Buckley
N. Hansing
G. A. Jolly
J. Lambin
T. Lippucci
C. A. Mizer
H. O'Brien
J. O'Callaghan
M. Rain
K. E. Reid II
J. Sulley
Y. Wong, *Alternate*

Working Group on Vessels (SG-CD) (BPV III)

D. Murphy, *Chair*
S. Willoughby-Braun, *Secretary*
J. J. Arthur
C. Basavaraju
M. Brijlani
L. Constantinescu
J. I. Kim
D. E. Matthews
T. Mitsuhashi
T. J. Schriefer
M. C. Scott
J. Shupert
D. Vlaicu
C. Wilson
R. Z. Ziegler
M. R. Breach, *Alternate*
B. Basu, *Contributing Member*
R. B. Keating, *Contributing Member*
W. F. Weitze, *Contributing Member*

Subgroup on Design Methods (SC-D) (BPV III)

S. McKillop, *Chair*
P. R. Donavin, *Vice Chair*
J. Wen, *Secretary*
K. Avrithi
M. A. Gray
J. V. Gregg, Jr.
K. Hsu
E. Isom
R. Kalnas
D. Keck
J. I. Kim
B. Pellereau
W. D. Reinhardt
P. Smith
R. O. Vollmer
W. F. Weitze
Y. Wong, *Alternate*
S. R. Gosselin, *Contributing Member*
H. T. Harrison III, *Contributing Member*
W. J. O'Donnell, Sr., *Contributing Member*
K. Wright, *Contributing Member*

Special Working Group on Computational Modeling for Explicit Dynamics (SG-DM) (BPV III)

G. Bjorkman, *Chair*
D. J. Ammerman, *Vice Chair*
V. Broz, *Secretary*
J. Bignell
S. Kuehner
D. Molitoris
W. D. Reinhardt
E. Rosvall
P. Sakalaukus, Jr.
D. Siromani
C.-F. Tso
M. C. Yaksh
U. Zencker
X. Zhang
M. R. Breach, *Contributing Member*
Y. Wong, *Contributing Member*

Working Group on Design Methodology (SG-DM) (BPV III)

B. Pellereau, *Chair*
R. O. Vollmer, *Secretary*
K. Avrithi
C. Basavaraju
F. Berkepile
M. Cho
D. Clarkson
C. M. Faidy
Y.-J. Gao
M. Kassar
J. I. Kim
T. R. Liszkai
D. Lytle
K. Matsunaga
S. Ranganath
W. D. Reinhardt
S. Wang
W. F. Weitze
J. Wen
T. M. Wiger
J. Wu
K. Hsu, *Alternate*
G. Banyay, *Contributing Member*
D. S. Bartran, *Contributing Member*
R. D. Blevins, *Contributing Member*
M. R. Breach, *Contributing Member*
H. T. Harrison III, *Contributing Member*
P. Hirschberg, *Contributing Member*
S. McKillop, *Contributing Member*
A. Walker, *Contributing Member*
K. Wright, *Contributing Member*

Working Group on Environmental Fatigue Evaluation Methods (SG-DM) (BPV III)

M. A. Gray, *Chair*
W. F. Weitze, *Secretary*
S. Asada
K. Avrithi
R. C. Cipolla
T. M. Damiani
C. M. Faidy
A. Hirano
P. Hirschberg
K. Hsu
A. Morley
J.-S. Park
B. Pellereau
T. Seppanen
D. Vlaicu
K. Wang
K. A. Manoly, *Alternate*
S. Cuvilliez, *Contributing Member*
T. D. Gilman, *Contributing Member*
S. R. Gosselin, *Contributing Member*
Y. He, *Contributing Member*
H. S. Mehta, *Contributing Member*
K. Wright, *Contributing Member*

Working Group on Fatigue Strength (SG-DM) (BPV III)

P. R. Donavin, *Chair*
T. M. Damiani
D. W. DeJohn
C. M. Faidy
P. Gill
R. J. Gurdal
K. Hsu
J. I. Kim
A. Morley
B. Pellereau
M. S. Shelton
I. Viscarra
Yanli Wang
W. F. Weitze
Y. Zou
C. E. Hinnant, *Contributing Member*
P. Hirschberg, *Contributing Member*
S. H. Kleinsmith, *Contributing Member*
S. Majumdar, *Contributing Member*
H. S. Mehta, *Contributing Member*
W. J. O'Donnell, Sr., *Contributing Member*
S. Ranganath, *Contributing Member*
K. Wright, *Contributing Member*

Working Group on Probabilistic Methods in Design (SG-DM) (BPV III)

M. Golliet, *Chair*
R. Kalnas, *Vice Chair*
G. Brouette
R. Fougerousse
J. Hakii
E. Hanson
D. O. Henry
A. Hirano
K. A. Manoly
A. Morley
B. Pellereau
A. Weaver
M. Yagodich
I. H. Tseng, *Alternate*
K. Avrithi, *Contributing Member*
R. S. Hill III, *Contributing Member*

Subgroup on Containment Systems for Spent Nuclear Fuel and High-Level Radioactive Material (BPV III)

D. W. Lewis, *Chair*
D. J. Ammerman, *Vice Chair*
S. Klein, *Secretary*
J. Bignell
G. Bjorkman
V. Broz
D. D. Imholte
A. Rigato
P. Sakalaukus, Jr.
D. Siromani
C. R. Sydnor
R. Sypulski
J. Wellwood
X. J. Zhai
X. Zhang
J. Smith, *Alternate*
W. H. Borter, *Contributing Member*
E. L. Pleins, *Contributing Member*
N. M. Simpson, *Contributing Member*

Subgroup on Fusion Energy Devices (BPV III)

T. P. Davis, *Chair*
A. Maslowski, *Staff Secretary*
M. Ellis, *Secretary*
L. Babu
M. Bashir
J. P. Blanchard
B. R. Doshi
L. El-Guebaly
R. Holmes
D. Johnson
I. Kimihiro
P. Mokaria
F. J. Schaaf, Jr.
P. Smith
Y. Song
D. White
R. W. Barnes, *Contributing Member*
W. K. Sowder, Jr., *Contributing Member*

Special Working Group on Fusion Stakeholders (SG-FED) (BPV III)

R. Holmes, *Chair*
C. Barnes
R. W. Barnes
J. Brister
A. A. Campbell
V. Chugh
T. P. Davis
S. S. Desai
F. Deschamps
M. Hua
S. Krishnan
W. K. Sowder, Jr.
N. Young

Working Group on General Requirements (SG-FED) (BPV III)

P. Smith, *Chair*
L. Babu
T. P. Davis
M. Ellis
B. McGlone
P. Mokaria
W. K. Sowder, Jr.
D. White, *Contributing Member*

Working Group on In-Vessel Components (SG-FED) (BPV III)

M. Bashir, *Chair*
T. P. Davis
S. T. Madabusi

Working Group on Magnets (SG-FED) (BPV III)

D. S. Bartran
W. K. Sowder, Jr., *Contributing Member*

Working Group on Materials (SG-FED) (BPV III)

T. P. Davis

Working Group on Vacuum Vessels (SG-FED) (BPV III)

I. Kimihiro, *Chair*
B. R. Doshi
D. Johnson

Subgroup on General Requirements (BPV III)

B. McGlone, *Chair*
A. McLendon, *Secretary*
V. Apostolescu
A. Appleton
S. Bell
G. Brouette
P. J. Coco
G. C. Deleanu
N. DeSantis
O. Elkadim
J. V. Gardiner
J. Grimm
J. Harris
J. W. Highlands
E. V. Imbro
K. A. Kavanagh
Y.-S. Kim
D. T. Meisch
L. Noyes
E. C. Renaud
T. N. Rezk
J. Rogers
B. S. Sandhu
R. Spuhl
J. L. Williams
Y. Diaz-Castillo, *Alternate*
J. DeKleine, *Contributing Member*
S. F. Harrison, Jr., *Contributing Member*
H. Michael, *Contributing Member*
D. J. Roszman, *Contributing Member*
C. T. Smith, *Contributing Member*
G. E. Szabatura, *Contributing Member*

Working Group on General Requirements for Graphite and Ceramic Composite Core Components and Assemblies (SG-GR) (BPV III)

W. J. Geringer, *Chair*
A. Appleton
J. R. Berry
A. A. Campbell
C. Cruz
Y. Diaz-Castillo
J. Lang
M. N. Mitchell
J. Potgieter
E. C. Renaud
S. Sekar
R. Spuhl
W. Windes
B. Lin, *Alternate*

Subgroup on High Temperature Reactors (BPV III)

Yanli Wang, *Chair*
N. Broom
F. W. Brust
M. E. Cohen
W. J. Geringer
B. F. Hantz
M. Hiser
R. I. Jetter
K. Kimura
G. H. Koo
W. Li
M. C. Messner
X. Wei
W. Windes
R. Wright
G. L. Zeng
J. Bass, *Alternate*
P. Carter, *Contributing Member*
W. O'Donnell, Sr., *Contributing Member*
T.-L. Sham
L. Shi, *Contributing Member*
R. W. Swindeman, *Contributing Member*

Special Working Group on High Temperature Reactor Stakeholders (SG-HTR) (BPV III)

M. E. Cohen, *Chair*
M. C. Albert
M. Arcaro
R. W. Barnes
R. Bass
N. Broom
K. Burnett
A. A. Campbell
V. Chugh
W. Corwin
G. C. Deleanu
R. A. Fleming
K. Harris
R. I. Jetter
G. H. Koo
N. J. McTiernan
M. N. Mitchell
K. J. Noel
J. Roll
B. Song
Yanli Wang
X. Wei
G. L. Zeng
R. M. Iyengar, *Alternate*
T. Asayama, *Contributing Member*

Task Group on Alloy 709 Code Case (SG-HTR) (BPV III)

Yanli Wang, *Chair*
H. Mahajan, *Secretary*
R. I. Jetter
M. C. Messner
W. J. Sperko
R. Wright
T.-L. Sham, *Contributing Member*

Task Group on Class A Rewrite (SG-HTR) (BPV III)

Yanli Wang, *Chair*
R. W. Barnes
M. E. Cohen
R. I. Jetter
H. Mahajan
S. McKillop
N. J. McTiernan
M. C. Messner
T. Nguyen
D. Pease
X. Wei
J. Young

Task Group on Division 5 AM Components (SG-HTR) (BPV III)

R. Wright, *Chair*
R. W. Barnes
F. W. Brust
Z. Feng
S. Lawler
X. Lou
M. McMurtrey
M. C. Messner
T. Patterson
E. C. Renaud
D. Rudland
B. Sutton
I. J. Van Rooyen
Yanli Wang
X. Wei
R. Bass, *Alternate*

Task Group on Graphite Design Analysis (SG-HTR) (BPV III)

A. Mack, *Chair*
J. Bass
S. Baylis
G. Beirnaert
O. Booler
P.-A. Juan
J. Potgieter
J. Quick
M. Saitta
A. Walker

Task Group on High Temperature Piping Design (SG-HTR) (BPV-III)

G. A. Antaki, *Chair*
S. Weindorf, *Secretary*
R. Adibi-Asl
T. D. Al-Shawaf
D. Bankston, Jr.
R. P. Deubler
R. I. Jetter
H. Mahajan
J. C. Minichiello
D. Pease
Yanli Wang
C. D. Weary
T.-L. Sham, *Contributing Member*

Working Group on Allowable Stress Criteria (SG-HTR) (BPV III)

R. Wright, *Chair*
M. McMurtrey, *Secretary*
R. W. Barnes
R. Bass
K. Kimura
W. Li
D. Maitra
R. J. McReynolds
M. C. Messner
T. Patterson
Yanli Wang
X. Wei
R. M. Iyengar, *Alternate*
R. W. Swindeman, *Contributing Member*

Working Group on Analysis Methods (SG-HTR) (BPV III)

M. C. Messner, *Chair*
H. Mahajan, *Secretary*
R. Adibi-Asl
R. W. Barnes
J. A. Blanco
P. Carter
R. I. Jetter
G. H. Koo
T. Nguyen
M. Petkov
K. Pigg
H. Qian
T. Riordan
X. Song
Yanli Wang
X. Wei
S. X. Xu
J. Young
J. Bass, *Alternate*
M. R. Breach, *Contributing Member*
Y.-J. Gao, *Contributing Member*
T. Hassan, *Contributing Member*
S. Krishnamurthy, *Contributing Member*
M. J. Swindeman, *Contributing Member*

Working Group on Creep-Fatigue and Negligible Creep (SG-HTR) (BPV III)

W. Li, *Chair*
J. Bass
C. M. Brusconi
P. Carter
M. E. Cohen
J. I. Duo
R. I. Jetter
G. H. Koo
H. Mahajan
M. McMurtrey
M. C. Messner
H. Qian
R. Rajasekaran
M. Shah
Yanli Wang
X. Wei
J. Young
R. Bass, *Alternate*

Working Group on Nonmetallic Design and Materials (SG-HTR) (BPV III)

W. Windes, *Chair*
W. J. Geringer, *Vice Chair*
J. Potgieter, *Secretary*
G. Beirnaert
A. A. Campbell
C. Chen
A. N. Chereskin
V. Chugh
C. Contescu
N. Gallego
S. T. Gonczy
K. Harris
M. G. Jenkins
P.-A. Juan
J. Lang
A. Mack
M. P. Metcalfe
M. N. Mitchell
J. Parks
K. Pigg
J. Podhiny
J. Roll
A. Tzelepi
A. Walker
Yanli Wang
G. L. Zeng
J. Bass, *Alternate*
A. Appleton, *Contributing Member*
R. W. Barnes, *Contributing Member*
S.-H. Chi, *Contributing Member*
Y. Katoh, *Contributing Member*
J. B. Ossmann, *Contributing Member*
J. Quick, *Contributing Member*
M. Saitta, *Contributing Member*

Subgroup on Materials, Fabrication, and Examination (BPV III)

D. W. Mann, *Chair*
J. Grimm, *Vice Chair*
J. B. Ossmann, *Vice Chair*
S. Hunter, *Secretary*
W. H. Borter
M. Brijlani
G. R. Cannell
A. Cardillo
S. Cho
P. J. Coco
R. H. Davis
D. B. Denis
B. D. Frew
D. W. Gandy
S. E. Gingrich
M. Golliet
L. S. Harbison
M. Kris
T. Melfi
I.-K. Nam
J. E. O'Sullivan
M. C. Scott
W. J. Sperko
J. F. Strunk
W. Windes
R. Wright
H. Xu
S. Yee
J. Wise, Jr., *Alternate*
S. Wolbert, Jr., *Alternate*
R. W. Barnes, *Contributing Member*
S. Levitus, *Contributing Member*
H. Michael, *Contributing Member*

Working Group on Advanced Manufacturing (SG-MFE) (BPV III)

D. W. Mann, *Chair*
D. W. Gandy, *Secretary*
D. Chowdhury
P. J. Coco
B. D. Frew
J. Grimm
J. Lambin
T. Lippucci
T. Melfi
A. Mori
E. C. Renaud
W. J. Sperko
J. F. Strunk
J. Sulley
S. Tate
J. Wise
S. Wolbert
H. Xu
R. H. Davis, *Alternate*
S. Malik, *Contibuting Member*

Joint Working Group on HDPE (SG-MFE) (BPV III)

M. Brandes, *Chair*
T. M. Musto, *Chair*
J. B. Ossmann, *Secretary*
G. Brouette
M. C. Buckley
S. Choi
M. Golliet
J. Hebeisen
J. Johnston, Jr.
P. Krishnaswamy
M. Kuntz
B. Lin
K. Manoly
D. P. Munson
J. O'Sullivan
V. Rohatgi
F. Schaaf, Jr.
S. Schuessler
R. Stakenborghs
M. Troughton
P. Vibien
J. Wright
T. Adams, *Contributing Member*

COMMITTEE ON HEATING BOILERS (BPV IV)

M. Wadkinson, *Chair*
J. L. Kleiss, *Vice Chair*
C. R. Ramcharran, *Staff Secretary*
B. Ahee
L. Badziagowski
T. L. Bedeaux
B. Calderon
J. P. Chicoine
C. Dinic
J. M. Downs
J. A. Hall
M. Mengon
Y. Teng
D. Picart, *Delegate*
Y. R. Cho, *Alternate*
B. J Iske, *Alternate*
T. Wagner, *Alternate*
H. Michael, *Contributing Member*
P. A. Molvie, *Contributing Member*

Executive Committee (BPV IV)

M. Wadkinson, *Chair*
C. R. Ramcharran, *Staff Secretary*
T. L. Bedeaux
J. P. Chicoine
J. A. Hall
J. L. Kleiss

Subgroup on Cast Boilers (BPV IV)

J. P. Chicoine, *Chair*
J. M. Downs, *Vice Chair*
C. R. Ramcharran, *Staff Secretary*
T. L. Bedeaux
J. A. Hall
J. L. Kleiss
M. Mengon
B. J. Iske, *Alternate*
T. Wagner, *Alternate*

Subgroup on Materials (BPV IV)

J. A. Hall, *Chair*
J. M. Downs, *Vice Chair*
C. R. Ramcharran, *Staff Secretary*
L. Badziagowski
T. L. Bedeaux
Y. Teng
M. Wadkinson

Subgroup on Water Heaters (BPV IV)

J. L. Kleiss, *Chair*
L. Badziagowski, *Vice Chair*
C. R. Ramcharran, *Staff Secretary*
B. Ahee
M. Carlson
J. P. Chicoine
C. Dinic
M. Mengon
Y. Teng
B. J. Iske, *Alternate*
T. Wagner, *Alternate*
P. A. Molvie, *Contributing Member*

Subgroup on Welded Boilers (BPV IV)

T. L. Bedeaux, *Chair*
J. P. Chicoine, *Vice Chair*
C. R. Ramcharran, *Staff Secretary*
B. Ahee
E. Alexis
L. Badziagowski
B. Calderon
M. Carlson
C. Dinic
J. L. Kleiss
M. Mengon
M. Wadkinson
M. Washington
B. J. Iske, *Alternate*
M. J. Melita, *Alternate*
T. J. Wagner, *Alternate*
P. A. Molvie, *Contributing Member*

COMMITTEE ON NONDESTRUCTIVE EXAMINATION (BPV V)

N. A. Finney, *Chair*
C. May, *Vice Chair*
C. R. Ramcharran, *Staff Secretary*
D. Bajula
P. L. Brown
M. A. Burns
N. Carter
C. Emslander
A. F. Garbolevsky
P. T. Hayes
G. W. Hembree
F. B. Kovacs
K. Krueger
B. D. Laite
P. Lang
T. R. Lerohl
J. Schoneweis
P. B. Shaw
C. Vorwald
M. Carlson, *Alternate*
J. E. Batey, *Contributing Member*
T. Clausing, *Contributing Member*
J. F. Halley, *Contributing Member*
R. W. Kruzic, *Contributing Member*
L. E. Mullins, *Contributing Member*
H. C. Graber, *Honorary Member*
T. G. McCarty, *Honorary Member*

Executive Committee (BPV V)

C. May, *Chair*
N. A. Finney, *Vice Chair*
C. R. Ramcharran, *Staff Secretary*
V. F. Godinez-Azcuaga
P. T. Hayes
G. W. Hembree
F. B. Kovacs
K. Krueger
B. D. Laite
E. Peloquin
C. Vorwald

Subgroup on General Requirements/Personnel Qualifications and Inquiries (BPV V)

C. Vorwald, *Chair*
K. Krueger, *Vice Chair*
D. Bajula
N. Carter
P. Chavdarov
C. Emslander
N. A. Finney
G. W. Hembree
F. B. Kovacs
P. Lang
T. R. Lerohl
C. May
J. Schoneweis
T. Clausing, *Contributing Member*
J. F. Halley, *Contributing Member*
D. I. Morris, *Contributing Member*
J. P. Swezy, Jr., *Contributing Member*

Subgroup on Volumetric Methods (BPV V)

C. May, *Chair*
P. T. Hayes, *Vice Chair*
P. L. Brown
N. A. Finney
A. F. Garbolevsky
V. F. Godinez-Azcuaga
C. Hansen
R. W. Hardy
G. W. Hembree
F. B. Kovacs
K. Krueger
N. Pasemko
E. Peloquin
J. Schoneweis
C. Vorwald
J. F. Halley, *Contributing Member*
R. W. Kruzic, *Contributing Member*
L. E. Mullins, *Contributing Member*
C. Wassink, *Contributing Member*

Working Group on Radiography (SG-VM) (BPV V)

C. Vorwald, *Chair*
D. M. Woodward, *Vice Chair*
D. Bajula
P. L. Brown
C. Emslander
A. F. Garbolevsky
R. W. Hardy
G. W. Hembree
P. Howie
F. B. Kovacs
B. D. Laite
T. R. Lerohl
C. May
R. J. Mills
J. F. Molinaro
N. Pasemko
J. Schoneweis
T. L. Clifford, *Contributing Member*
R. W. Kruzic, *Contributing Member*

Working Group on Ultrasonics (SG-VM) (BPV V)

K. Krueger, *Chair*
D. Bajula, *Vice Chair*
D. Adkins
C. T. Brown
C. Emslander
N. A. Finney
P. Furr
C. Hansen
P. T. Hayes
G. W. Hembree
B. D. Laite
T. R. Lerohl
C. May
E. Peloquin
J. Schoneweis
D. Van Allen
C. Vorwald
J. F. Halley, *Contributing Member*
R. W. Kruzic, *Contributing Member*
P. Mudge, *Contributing Member*
L. E. Mullins, *Contributing Member*
M. J. Quarry, *Contributing Member*
J. Vanvelsor, *Contributing Member*

Special Working Group for Advance UT Techniques (WG-UT) (BPV V)

K. Krueger, *Chair*
J. Schoneweis, *Vice Chair*
D. Bajula
C. David
N. A. Finney
P. Furr
J. Garner
C. Hansen
P. Hayes
B. D. Laite
T. R. Lerohl
E. Peloquin
D. Tompkins
D. Van Allen
C. Wassink

Working Group on Acoustic Emissions (SG-VM) (BPV V)

V. F. Godinez-Azcuaga, *Chair*
J. Catty, *Vice Chair*
S. R. Doctor
N. F. Douglas, Jr.

Working Group on Full Matrix Capture (SG-VM) (BPV V)

E. Peloquin, *Chair*
P. T. Hayes, *Vice Chair*
D. Bajula
J. Catty
N. A. Finney
J. L. Garner
R. T. Grotenhuis
G. W. Hembree
K. Krueger
M. Lozev
R. Nogueira
D. Richard
M. Sens
D. Tompkins
J. F. Halley, *Contributing Member*
L. E. Mullins, *Contributing Member*
C. Wassink, *Contributing Member*

Subgroup on Inservice Examination Methods and Techniques (BPV V)

P. T. Hayes, *Chair*
E. Peloquin, *Vice Chair*
D. Bajula
R. Barker
R. J. Bunte
M. A. Burns
M. Carlson
T. Demmer
N. Douglas, Jr.
N. A. Finney
V. F. Godinez-Azcuaga
C. Hansen
G. W. Hembree
K. Krueger
C. May
N. Pasemko
D. D. Raimander
B. Ray
J. Schoneweis
C. Vorwald

Working Group on Assisted Analysis (SG-ISI) (BPV V)

T. Demmer, *Chair*
C. Hansen, *Vice Chair*
J. Aldrin
J. Chen
M. Elen
N. A. Finney
V. F. Godinez-Azcuaga
R. T. Grotenhuis
K. Hayes
G. W. Hembree
G. I. Kraljic
G. M. Lozev
R. S. F. Orozco
E. Peloquin
T. Thulien
J. Williams
S. Zafar

Working Group on Methods and Techniques (SG-ISI) (BPV V)

C. May, *Chair*
R J. Bunte, *Vice Chair*
D. Bajula
R. Barker
M. A. Burns
M. Carlson
J. Catty
P. T. Hayes
K. Krueger
B. D. Laite
G. Morais
N. Pasemko
J. Schoneweis

Working Group on Supplemental Requirements for Corrosion and Other Damage Mechanisms (SG-ISI) (BPV V)

J. Schoneweis, *Chair*
N. Pasemko, *Vice Chair*
D. Bajula
R. Barker
N. A. Finney
C. Hansen
P. T. Hayes
K. Krueger
E. Peloquin
I. Roux

Subgroup on Surface Examination Methods (BPV V)

B. D. Laite, *Chair*
D. Bajula
R.. Behe
R. M. Beldyk
P. L. Brown
N. Carter
C. Emslander
N. Farenbaugh
N. A. Finney
A. F. Garbolevsky
G. W. Hembree
K. Krueger
T. R. Lerohl
C. May
G. Morais
J. Schoneweis
P. B. Shaw
R. Tedder
C. Vorwald
D. M. Woodward
T. Clausing, *Contributing Member*
J. F. Halley, *Contributing Member*
K. Hayes, *Contributing Member*
R. W. Kruzic, *Contributing Member*
L. E. Mullins, *Contributing Member*
C. Wassink, *Contributing Member*

Germany International Working Group (BPV V)

P. Chavdarov, *Chair*
V. Pohl, *Vice Chair*
H.-P. Schmitz, *Secretary*
D. Kaiser
C. Kringe
S. Mann
V. Reusch
P. Van IJS

India International Working Group (BPV V)

P. Kumar, *Chair*
A. V. Bhagwat, *Vice Chair*
V. Ligade, *Secretary*
S. Jobanputra
D. Joshi
G. R. Joshi
J. V. Muthukumaraswamy
A. Relekar
V. J. Sonawane
N. Suryawanshi
D. B. Tanpure

Italy International Working Group (BPV V)

D. D. Raimander, *Chair*
O. Oldani, *Vice Chair*
C. R. Ramcharran, *Staff Secretary*
P. Campli, *Secretary*
M. Agostini
T. Aldo
F. Bresciani
N. Caputo
M. Colombo
P. L. Dinelli
F. Ferrarese
E. Ferrari
M. A. Grimoldi
G. Luoni
U. Papponetti
P. Pedersoli
A. Veroni
M. Zambon
G. Gobbi, *Contributing Member*
A. Gusmaroli, *Contributing Member*
G. Pontiggia, *Contributing Member*

COMMITTEE ON PRESSURE VESSELS (BPV VIII)

S. C. Roberts, *Chair*
M. D. Lower, *Vice Chair*
J. Oh, *Staff Secretary*
S. J. Rossi, *Staff Secretary*
S. R. Babka
L. Bower
P. Chavdarov
B. F. Hantz
C. S. Hinson
J. Hoskinson
M. Kowalczyk
D. L. Kurle
R. Mahadeen
S. A. Marks
P. Matkovics
D. T. Peters
M. J. Pischke
M. D. Rana
G. B. Rawls, Jr.
F. L. Richter
C. D. Rodery
J. C. Sowinski
D. Srnic
P. L. Sturgill
K. Subramanian
J. P. Swezy, Jr.
S. Terada
E. Upitis
A. Viet
K. Xu
K. Oyamada, *Delegate*
M. E. Papponetti, *Delegate*
G. Aurioles, Sr., *Contributing Member*
R. J. Basile
A. Chaudouet, *Contributing Member*
D. B. DeMichael, *Contributing Member*
K. T. Lau, *Contributing Member*
H. Michael, *Contributing Member*
R. W. Mikitka, *Contributing Member*
D. A. Swanson, *Contributing Member*
G. G. Karcher, *Honorary Member*
U. R. Miller, *Honorary Member*
T. P. Pastor, *Honorary Member*
K. K. Tam, *Honorary Member*

Executive Committee (BPV VIII)

M. D. Lower, *Chair*
S. J. Rossi, *Staff Secretary*
G. Aurioles, Sr.
C. W. Cary
P. Chavdarov
T. Halligan
J. Hoskinson
P. Matkovics
S. C. Roberts
J. C. Sowinski
K. Subramanian
K. Xu

Subgroup on Design (BPV VIII)

J. C. Sowinski, *Chair*
C. S. Hinson, *Vice Chair*
S. R. Babka
O. A. Barsky
M. Faulkner
D. Francis
B. F. Hantz
C. E. Hinnant
S. Krishnamurthy
D. L. Kurle
K. Kuscu
M. D. Lower
R. W. Mikitka
B. Millet
M. D. Rana
G. B. Rawls, Jr.
S. C. Roberts
T. G. Seipp
D. Srnic
S. Terada
K. Xu
K. Oyamada, *Delegate*
M. E. Papponetti, *Delegate*
G. Aurioles, Sr., *Contributing Member*
R. J. Basile, *Contributing Member*
D. Chandiramani, *Contributing Member*
M. H. Jawad, *Contributing Member*
P. K. Lam, *Contributing Member*
K. Mokhtarian, *Contributing Member*
C. D. Rodery, *Contributing Member*
D. A. Swanson, *Contributing Member*
K. K. Tam, *Contributing Member*
E. Upitis, *Contributing Member*

Working Group on Design-by-Analysis (BPV VIII)

B. F. Hantz, *Chair*
T. W. Norton, *Secretary*
J. Bedoya
A. Feller
S. Guzey
C. E. Hinnant
S. Kataoka
S. Kilambi
K. D. Kirkpatrick
S. Krishnamurthy
C. Nadarajah
T. G. Seipp
M. Shah
S. Terada
D. A. Arnett, *Contributing Member*
A. Mann, *Contributing Member*
K. Saboda, *Contributing Member*

Working Group on Elevated Temperature Design (BPV I and VIII)

C. Nadarajah, *Chair*
L. S. Tsai, *Secretary*
D. Anderson
D. Dewees
B. F. Hantz
R. I. Jetter
S. Kataoka
S. Krishnamurthy
S. R. Kummari
T. Le
B.-L. Lyow
C T. McDaris
M. C. Messner
M. N. Mitchell
P. Prueter
A. Ramos
M. Rathinasabapathy
M. J. Swindeman
A. Mann, *Contributing Member*
N. McMurray, *Contributing Member*
B. J. Mollitor, *Contributing Member*

Subgroup on Fabrication and Examination (BPV VIII)

T. Halligan, *Chair*
D. I. Morris, *Vice Chair*
D. Smith, *Secretary*
J. Lu
S. A. Marks
O. Mulet
M. J. Pischke
M. J. Rice
J. Roberts
C. D. Rodery
B. F. Shelley
P. L. Sturgill
J. P. Swezy, Jr.
E. Upitis
C. Violand
K. Oyamada, *Delegate*
W. J. Bees, *Contributing Member*
L. F. Campbell, *Contributing Member*
N. Carter, *Contributing Member*

Subgroup on General Requirements (BPV VIII)

J. Hoskinson, *Chair*
M. Faulkner, *Vice Chair*
N. Barkley
T. P. Beirne
R. Darby
Z. Jakovljevic
M. D. Lower
T. Newman
I. A. Powell
J. Qu
G. B. Rawls, Jr.
F. L. Richter
S. C. Roberts
J. Rust
P. T. Shanks
J. C. Sowinski
P. Speranza
D. Srnic
D. B. Stewart
D. B. DeMichael, *Contributing Member*
T. P. Pastor, *Contributing Member*
R. Robles, *Contributing Member*
D. A. Swanson, *Contributing Member*
Y. Yang, *Contributing Member*

Task Group on Electrochemical Cell Stacks (TG-ECS) (BPV VIII)

K. Xu, *Chair*
K. Quackenbush, *Vice Chair*
N. Barkley
E. Gadsby
S. Goyette
T. Halligan
R. Kauer
P. Matkovics
L. Moulthrop
J. Panicker
E. Prause
P. T. Shanks
S. Ulemek
E. Andrade, *Contributing Member*
B. D. Carter, *Contributing Member*
K. Choi, *Contributing Member*
L. T. Dalton, *Contributing Member*
M. Duda, *Contributing Member*
R. Fournier, *Contributing Member*
E. Gernot, *Contributing Member*
S. Grimm, *Contributing Member*
N. Hart, *Contributing Member*
R. Müller, *Contributing Member*
P. K. Panigrahy, *Contributing Member*
R. Robles, *Contributing Member*
M. Stelzel, *Contributing Member*
M. Sweetland, *Contributing Member*

Task Group on Fired Heater Pressure Vessels (BPV VIII)

J. Hoskinson, *Chair*
D. Nelson
R. Robles
J. Rust
P. T. Shanks
E. Smith
D. Srnic

Subgroup on Heat Transfer Equipment (BPV VIII)

P. Matkovics, *Chair*
L. Bower, *Vice Chair*
T. Bunyarattaphantu, *Secretary*
S. R. Babka
J. H. Barbee
O. A. Barsky
A. Chaudouet
D. L. Kurle
R. Mahadeen
S. Mayeux
S. Neilsen
E. Smith
A. M. Voytko
R. P. Wiberg
G. Aurioles, Sr., *Contributing Member*
K. M. Chikhaliya, *Contributing Member*
J. Pasek, *Contributing Member*
D. Srnic, *Contributing Member*
Z. Tong, *Contributing Member*

Working Group on Plate Heat Exchangers (BPV VIII)

D. I. Morris, *Chair*
S. R. Babka
V. Gudge
T. Halligan
Z. Jakovljevic
P. Matkovics
M. J. Pischke
P. T. Shanks
E. Smith
D. Srnic

Subgroup on High Pressure Vessels (BPV VIII)

K. Subramanian, *Chair*
M. Sarzynski, *Vice Chair*
A. Dinizulu, *Staff Secretary*
L. P. Antalffy
N. Barkley
J. Barlow
R. C. Biel
P. N. Chaku
L. Fridlund
D. Fuenmayor
J. Gibson
R. T. Hallman
K. Karpanan
A. K. Khare
G. T. Nelson
D. T. Peters
E. D. Roll
J. R. Sims
E. Smith
F. W. Tatar
S. Terada
Y. Xu
A. M. Clayton, *Contributing Member*
R. Cordes, *Contributing Member*
R. D. Dixon, *Contributing Member*
J. Hademenos, *Contributing Member*
R. M. Hoshman, *Contributing Member*
F. Kirkemo, *Contributing Member*
G. M. Mital, *Contributing Member*
M. Parr, *Contributing Member*
M. D. Rana, *Contributing Member*
C. Tipple, *Contributing Member*
K.-J. Young, *Contributing Member*
D. J. Burns, *Honorary Member*
G. J. Mraz, *Honorary Member*

Subgroup on Materials (BPV VIII)

P. Chavdarov, *Chair*
M. Kowalczyk, *Vice Chair*
S. Kilambi, *Secretary*
J. Cameron
H. Dutta
J. F. Grubb
D. Maitra
R. K. Patadia
D. Pugh
D. W. Rahoi
E. Upitis
K. Xu
M. Katcher, *Contributing Member*
R. C. Sutherlin, *Contributing Member*

Subgroup on Toughness (BPV VIII)

K. Xu, *Chair*
T. Halligan, *Vice Chair*
T. Finn
C. S. Hinson
S. Kilambi
D. L. Kurle
T. Newman
J. Qu
M. D. Rana
F. L. Richter
K. Subramanian
J. P. Swezy, Jr.
S. Terada
E. Upitis
J. Vattappilly
K. Oyamada, *Delegate*
L. Dong, *Contributing Member*
S. Krishnamurthy, *Contributing Member*
D. A. Swanson, *Contributing Member*

Subgroup on Graphite Pressure Equipment (BPV VIII)

C. W. Cary, *Chair*
A. Viet, *Vice Chair*
G. C. Becherer
F. L. Brown
J. D. Clements
H. Lee, Jr.
S. Mehrez
T. Rudy
A. A. Stupica
J. Wince

Argentina International Working Group (BPV VIII)

A. Dominguez, *Chair*
R. Robles, *Vice Chair*
G. Glissenti, *Secretary*
A. Antipasti
D. A. Bardelli
R. A. Barey
O. S. Bretones
A. Burgueno
G. Casanas
D. A. Del Teglia
M. Favareto
J. A. Labastidas
F. P. Larrosa
M. A. Mendez
J. J. Monaco
C. Parente
M. A. A. Pipponzi
L. C. Rigoli
A. Rivas
D. Rizzo
M. A. Sena
G. Telleria
C. Alderetes, *Contributing Member*
D. H. Da Rold, *Contributing Member*
J. C. Rubeo, *Contributing Member*

China International Working Group (BPV VIII)

X. Chen, *Chair*
B. Shou, *Vice Chair*
Z. Fan, *Secretary*
Y. Chen
J. Cui
R. Duan
J.-G. Gong
B. Han
J. Hu
Q. Hu
H. Hui
K. Li
D. Luo
Y. Luo
C. Miao
L. Sun
C. Wu
J. Xiaobin
F. Xu
G. Xu
F. Yang
Y. Yang
Y. Yuan
Yanfeng Zhang
Yijun Zhang
S. Zhao
J. Zheng
G. Zhu

Germany International Working Group (BPV VIII)

R. Kauer, *Chair*
M. Sykora, *Vice Chair*
A. Aloui
P. Chavdarov
M. Delzeit
A. Emrich
C. Jaekel
S. Jetzlsperger
D. Koelbl
S. Krebs
T. Ludwig
R. A. Meyers
H. Michael
R. Müller
S. Reich
A. Spangenberg
C. Stobbe

India International Working Group (BPV VIII)

D. Chandiramani, *Chair*
D. Kulkarni, *Vice Chair*
A. D. Dalal, *Secretary*
P. Arulkumar
P. Gandhi
U. Ganesan
S. K. Goyal
V. Jayabalan
V. K. Joshi
A. Kakumanu
T. Mukherjee
P. C. Pathak
D. Prabhu
A. Sadasivam
M. P. Shah
Y. Z. Shaikh
R. Tiru
V. T. Valavan
M. Sharma, *Contributing Member*

Italy International Working Group (BPV VIII)

M. Millefanti, *Chair*
P. Campli, *Secretary*
P. Aliprandi
A. Avogadri
A. Camanni
M. Camposaragna
N. Caputo
M. Colombo
P. Conti
D. Cortassa
A. Fabiano
F. Finco
M. Guglielmetti
A. F. Magri
L. Moracchioli
P. Pacor
S. Sarti
A. Teli
N. Wagner
V. Calo, *Contributing Member*
G. Gobbi, *Contributing Member*
A. Gusmaroli, *Contributing Member*
G. Pontiggia, *Contributing Member*
D. D. Raimander, *Contributing Member*

Special Working Group on Bolted Flanged Joints (BPV VIII)

W. Brown, *Chair*
M. Osterfoss, *Vice Chair*
D. Bankston, Jr.
C. W. Cary
A. Chaudouet
H. Chen
D. Francis
H. Lejeune
A. Mann
W. McDaniel
R. W. Mikitka
D. Nash
M. Ruffin
M. Siddiqui
E. Jamalyaria, *Contributing Member*
G. Van Zyl, *Contributing Member*
J. Veiga, *Contributing Member*
R. Wacker, *Contributing Member*

Subgroup on Interpretations (BPV VIII)

P. Matkovics, *Chair*
J. Oh, *Staff Secretary*
S. R. Babka
L. Bower
T. Bunyarattaphantu
J. Cameron
C. W. Cary
P. Chavdarov
M. Faulkner
T. Halligan
B. F. Hantz
J. Hoskinson
M. Kowalczyk
D. L. Kurle
K. Kuscu
M. D. Lower
S. A. Marks
D. I. Morris
D. T. Peters
J. Qu
F. L. Richter
S. C. Roberts
C. D. Rodery
T. G. Seipp
E. Smith
J. C. Sowinski
K. Subramanian
J. P. Swezy, Jr.
A. Viet
K. Xu
G. Aurioles, Sr., *Contributing Member*
R. J. Basile, *Contributing Member*
D. A. Swanson, *Contributing Member*

COMMITTEE ON WELDING, BRAZING, AND FUSING (BPV IX)

M. J. Pischke, *Chair*
P. L. Sturgill, *Vice Chair*
R. Rahaman, *Staff Secretary*
D. Barborak
M. Bernasek
M. A. Boring
D. A. Bowers
N. Carter
J. G. Feldstein
P. Gilston
S. E. Gingrich
K. L. Hayes
J. S. Lee
W. M. Lundy
D. W. Mann
S. A. Marks
T. Melfi
W. F. Newell, Jr.
E. G. Reichelt
M. J. Rice
W. J. Sperko
J. P. Swezy, Jr.
A. D. Wilson
L. Costa, *Delegate*
D. Pojatar, *Delegate*
D. D. Raimander, *Delegate*
A. Roza, *Delegate*
M. Consonni, *Contributing Member*
R. M. Jessee, *Contributing Member*
P. L. Van Fosson, *Contributing Member*
R. K. Brown, Jr., *Honorary Member*
M. L. Carpenter, *Honorary Member*
B. R. Newmark, *Honorary Member*
S. D. Reynolds, Jr., *Honorary Member*

Subgroup on Brazing (BPV IX)

S. A. Marks, *Chair*
E. W. Beckman
A. F. Garbolevsky
N. Mohr
M. J. Pischke
P. L. Sturgill
J. P. Swezy, Jr.

Subgroup on General Requirements (BPV IX)

N. Carter, *Chair*
P. Gilston, *Vice Chair*
S. A. Marks, *Secretary*
J. P. Bell
D. A. Bowers
T. Bunyarattaphantu
M. Cox
M. Heinrichs
R. M. Jessee
P. Matkovics
W. May
K. Meszaros
H. B. Porter
D. Smith
P. L. Sturgill
J. P. Swezy, Jr.
E. W. Woelfel
L. Costa, *Delegate*
E. W. Beckman, *Contributing Member*
A. Davis, *Contributing Member*
B. R. Newmark, *Honorary Member*

Subgroup on Materials (BPV IX)

M. Bernasek, *Chair*
T. Anderson
L. Constantinescu
E. Cutlip
S. E. Gingrich
L. S. Harbison
M. James
R. M. Jessee
T. Melfi
S. D. Nelson
M. J. Pischke
D. D. Raimander
A. Roza
C. E. Sainz
P. L. Sturgill
C. Zanfir
L. Costa, *Delegate*
V. G. V. Giunto, *Delegate*
D. J. Kotecki, *Contributing Member*
B. Krueger, *Contributing Member*
W. J. Sperko, *Contributing Member*
M. J. Stanko, *Contributing Member*

Subgroup on Plastic Fusing (BPV IX)

K. L. Hayes, *Chair*
M. Brandes
R. M. Jessee
J. Johnston, Jr.
J. E. O'Sullivan
E. G. Reichelt
M. J. Rice
S. Schuessler
M. Troughton
C. Violand
E. W. Woelfel
J. Wright

Subgroup on Welding Qualifications (BPV IX)

T. Melfi, *Chair*
A. D. Wilson, *Vice Chair*
K. L. Hayes, *Secretary*
M. Bernasek
M. A. Boring
D. A. Bowers
R. Campbell
R. B. Corbit
L. S. Harbison
M. Heinrichs
J. S. Lee
W. M. Lundy
D. W. Mann
K. Meszaros
W. F. Newell, Jr.
E. G. Reichelt
M. J. Rice
M. B. Sims
A. Spangenberg
W. J. Sperko
P. L. Sturgill
J. P. Swezy, Jr.
C. Violand
L. Costa, *Delegate*
D. D. Raimander, *Delegate*
D. Chandiramani, *Contributing Member*
M. Consonni, *Contributing Member*
M. Dehghan, *Contributing Member*
T. C. Wiesner, *Contributing Member*

Argentina International Working Group (BPV IX)

A. Burgueno, *Chair*
A. R. G. Frinchaboy, *Vice Chair*
R. Rahaman, *Staff Secretary*
M. D. Kuhn, *Secretary*
P. J. Cabot
J. Caprarulo
M. Favareto
J. A. Gandola
M. A. Mendez
A. E. Pastor

Germany International Working Group (BPV IX)

P. Chavadarov, *Chair*
R. Rahaman, *Staff Secretary*
P. Khwaja, *Secretary*
B. Daume
D. Haase
S. Krebs
T. Ludwig
P. Müller
S. Wegener
J. Daldrup, *Contributing Member*
E. Floer, *Contributing Member*
A. Scherpenisse, *Contributing Member*
K.-G. Toelle, *Contributing Member*

Italy International Working Group (BPV IX)

D. D. Raimander, *Chair*
F. Ferrarese, *Vice Chair*
R. Rahaman, *Staff Secretary*
P. Campli, *Secretary*
M. Bernasek
A. Camanni
M. Mandina
A. S. Monastra
L. Moracchioli
P. Pacor
G. Signoretta
V. Calo, *Contributing Member*
G. Gobbi, *Contributing Member*
A. Gusmaroli, *Contributing Member*
G. Pontiggia, *Contributing Member*
P. Siboni, *Contributing Member*

Spain International Working Group (BPV IX)

F. J. Q. Pandelo, *Chair*
F. Manas, *Vice Chair*
R. Rahaman, *Staff Secretary*
F. R. Hermida, *Secretary*
C. A. Celimendiz
M. A. F. Garcia
B. B. Miguel
A. D. G. Munoz
A. B. Pascual
G. Gobbi, *Contributing Member*
R. G. Garcia, *Contributing Member*

COMMITTEE ON FIBER-REINFORCED PLASTIC PRESSURE VESSELS (BPV X)

J. L. Bustillos, *Chair*
D. Eisberg, *Vice Chair*
C. R. Ramcharran, *Staff Secretary*
A. L. Beckwith
B. R. Colley
T. W. Cowley
I. L. Dinovo
J. Eihusen
K. L. Gilmore
M. R. Gorman
B. Hebb
L. E. Hunt
B. Linnemann
D. H. McCauley
N. L. Newhouse
G. Ramirez
J. R. Richter
B. F. Shelley
G. A. Van Beek
S. L. Wagner
D. O. Yancey, Jr.
P. H. Ziehl
D. H. Hodgkinson, *Contributing Member*
D. L. Keeler, *Contributing Member*

COMMITTEE ON NUCLEAR INSERVICE INSPECTION (BPV XI)

D. W. Lamond, *Chair*
S. D. Kulat, *Vice Chair*
A. T. Roberts III, *Vice Chair*
D. Miro-Quesada, *Staff Secretary*
M. L. Benson
C. T. Brown
S. B. Brown
T. L. Chan
R. C. Cipolla
R. Clow
D. R. Cordes
H. Do
E. V. Farrell, Jr.
M. J. Ferlisi
J. Hakii
M. L. Hall
P. J. Hennessey
D. O. Henry
R. Hinkle
K. Hojo
A. E. Keyser
H. Malikowski
S. L. McCracken
L. A. Melder
S. A. Norman
T. Nuoffer
J. Nygaard
J. E. O'Sullivan
N. A. Palm
G. C. Park
D. A. Scarth
F. J. Schaaf, Jr.
R. W. Swayne
S. Takaya
A. Udyawar
D. Vetter
J. G. Weicks
M. Weis
B. K. Welch
Y.-K. Chung, *Delegate*
C. Ye, *Delegate*
M. Homiack , *Alternate*
C. Latiolais, *Alternate*
R. O. McGill, *Alternate*
T. J. Griesbach, *Contributing Member*
J. T. Lindberg, *Contributing Member*
T. V. Vo, *Contributing Member*
C. D. Cowfer, *Honorary Member*
E. B. Gerlach, *Honorary Member*
R. E. Gimple, *Honorary Member*
F. E. Gregor, *Honorary Member*
R. D. Kerr, *Honorary Member*
P. C. Riccardella, *Honorary Member*
R. A. West, *Honorary Member*
C. J. Wirtz, *Honorary Member*
R. A. Yonekawa, *Honorary Member*

Executive Committee (BPV XI)

S. D. Kulat, *Chair*
D. W. Lamond, *Vice Chair*
D. Miro-Quesada, *Staff Secretary*
M. L. Benson
M. J. Ferlisi
D. O. Henry
S. L. McCracken
N. A. Palm
G. C. Park
A. T. Roberts III
R. W. Swayne
D. Vetter
M. Homiack, *Alternate*

Latin American International Working Group (BPV XI)

O. Martinez, *Staff Secretary*
A. Claus
I. M. Guerreiro
L. R. Miño
F. J. Schaaf, Jr.
F. M. Schroeter
P. Yamamoto

China International Working Group (BPV XI)

T. Yuchun, *Chair*
J. F. Cai, *Vice Chair*
C. Ye, *Vice Chair*
M. W. Zhou, *Secretary*
M. Chao
H. D. Chen
Y. Cheng
C. Gao
Y. Guanghua
Y. B. Guo
Y. Hongqi
D. R. Horn
Y. Hou
Y. S. Li
Shangyuan Liu
Y. Nie
W. N. Pei
L. Shiwei
S. Shuo
Y. Sixin
Y. X. Sun
Z. Wan
Q. Wang
Q. W. Wang
Z. S. Wang
L. Xing
F. Xu
S. X. Xu
Q. Yin
Y. Zhe
Z. M. Zhong

European International Working Group (BPV XI)

R. Döring, *Chair*
M. Hagenbruch, *Vice Chair*
R. Piel, *Secretary*
P. Ancion
A. Casse
C. G. Frantescu
T. Hantzka
E. Iacopetta
A. Juengert
S. D. Kulat
H.-W. Lange
N. Legl
T. Ludwig
M. Reichert
L. Sybertz
I. Tewes
R. Tiete
Yixing Wang
J. Wendt

India International Working Group (BPV XI)

S. B. Parkash, *Chair*
D. Narain, *Vice Chair*
Z. M. Mansuri
M. R. Nadgouda
N. Palm
K. K. Rai
D. Rawal
R. Sahai
R. K. Sharma

Special Working Group on Editing and Review (BPV XI)

R. W. Swayne, *Chair*
R. C. Cipolla
D. O. Henry
M. Orihuela
D. A. Scarth
A. Udyawar

Task Group on Inspectability (BPV XI)

E. Henry, *Chair*
B. Langston, *Secretary*
D. Brown
A. Bushmire
A. Cardillo
K. Caver
D. R. Cordes
D. O. Henry
J. Honcharik
C. Latiolais
J. T. Lindberg
L. Loomis
S. Matsumoto
D. E. Matthews
P. J. O'Regan
J. B. Ossmann

Working Group on Spent Nuclear Fuel Storage and Transportation Containment Systems (BPV XI)

K. Hunter, *Chair*
M. Orihuela, *Secretary*
D. J. Ammerman
J. Broussard
C. R. Bryan
T. Carraher
D. Dunn
N. Fales
R. C. Folley
A. Gonzalez
G. Grant
B. Gutherman
M. W. Joseph
M. Keene
M. Liu
K. Mauskar
R. M. Meyer
R. M. Pace
M. A. Richter
B. Sarno
R. Sindelar
M. Staley
J. Tatman
J. Wellwood
K. A. Whitney
X. J. Zhai
P.-S. Lam, *Alternate*
G. White, *Alternate*
H. Smith, *Contributing Member*

Task Group on Mitigation and Repair of Spent Nuclear Fuel Canisters (WG-SNFS & TCS) (BPV XI)

J. Tatman, *Chair*
D. J. Ammerman
J. Broussard
C. R. Bryan
G. R. Cannell
K. Dietrich
D. Dunn
N. Fales
R. C. Folley
D. Jacobs
N. Klymyshyn
M. Kris
M. Liu
K. Mauskar
S. L. McCracken
M. Orihuela
M. Richter
K. E. Ross
B. Sarno
R. Sindelar
J. Wellwood
A. Williams

Subgroup on Evaluation Standards (BPV XI)

N. A. Palm, *Chair*
S. X. Xu, *Secretary*
M. L. Benson
R. C. Cipolla
C. M. Faidy
M. M. Farooq
T. J. Griesbach
K. Hojo
M. Kirk
D. R. Lee
Y. S. Li
R. O. McGill
R. M. Pace
S. Ranganath
C. J. Sallaberry
D. A. Scarth
D. J. Shim
A. Udyawar
T. V. Vo
G. M. Wilkowski
K. Hasegawa, *Contributing Member*
H. S. Mehta, *Contributing Member*

Task Group on Evaluation of Beyond Design Basis Events (SG-ES) (BPV XI)

R. M. Pace, *Chair*
S. X. Xu, *Secretary*
G. A. Antaki
P. R. Donavin
R. G. Gilada
T. J. Griesbach
M. Hayashi
K. Hojo
S. A. Kleinsmith
M. Moenssens
T. V. Vo
K. Voelsing
G. M. Wilkowski
F. G. Abatt, *Contributing Member*
H. S. Mehta, *Contributing Member*

Working Group on Flaw Evaluation (SG-ES) (BPV XI)

R. C. Cipolla, *Chair*
S. X. Xu, *Secretary*
M. L. Benson
H. D. Chung
N. G. Cofie
M. A. Erickson
C. M. Faidy
M. M. Farooq
B. R. Ganta
R. G. Gilada
C. Guzman-Leong
K. Hojo
F. Iwamatsu
S. Kalyanam
Y. Kim
V. Lacroix
D. R. Lee
Y. S. Li
C. Liu
M. Liu
G. A. Miessi
S. Noronha
R. K. Qashu
D. A. Scarth
W. L. Server
D. J. Shim
S. Smith
M. Uddin
A. Udyawar
T. V. Vo
M. Walter
K. Wang
B. Wasiluk
G. M. Wilkowski
H. S. Mehta, *Contributing Member*

Working Group on Flaw Evaluation Reference Curves (SG-ES) (BPV XI)

A. Udyawar, *Chair*
D. A. Scarth, *Secretary*
M. L. Benson
F. W. Brust
R. C. Cipolla
M. M. Farooq
A. E. Freed
K. Hasegawa
K. Hojo
F. Iwamatsu
V. Lacroix
A. Morley
B. Pellereau
S. Ranganath
D. J. Shim
S. Smith
M. Uddin
T. V. Vo
G. White
S. X. Xu
H. S. Mehta, *Contributing Member*

Working Group on High Temperature Flaw Evaluation (SG-ES) (BPV XI)

C. J. Sallaberry, *Chair*
F. W. Brust
P. Carter
K. Gresh
S. Kalyanam
B. Lin
B.-L. Lyow
M. C. Messner
M. Petkov
H. Qian
D. A. Scarth
D. J. Shim
A. Udyawar
X. Wei
S. X. Xu
J. Bass, *Alternate*

Working Group on Operating Plant Criteria (SG-ES) (BPV XI)

M. Kirk, *Chair*
D. Rudland, *Secretary*
D. B. Denis
M. A. Erickson
A. E. Freed
T. J. Griesbach
B. Hall
M. Hayashi
R. Janowiak
S. A. Kleinsmith
H. Kobayashi
A. D. Odell
R. M. Pace
N. A. Palm
S. Ranganath
W. L. Server
C. A. Tomes
A. Udyawar
T. V. Vo
H. Q. Xu
M. Yamamoto
E. Haywood, *Alternate*
H. S. Mehta, *Contributing Member*

Task Group on Appendix L (WG-OPC) (SG-ES) (BPV XI)

N. Glunt, *Chair*
R. M. Pace, *Secretary*
C. Coleman
J. I. Duo
A. E. Freed
M. A. Gray
T. J. Griesbach
H. Nam
A. Nana
A. D. Odell
C.-S. Oh
H. Park
S. Ranganath
A. Scott
D. J. Shim
S. Smith
A. Udyawar
T. V. Vo

Working Group on Pipe Flaw Evaluation (SG-ES) (BPV XI)

D. A. Scarth, *Chair*
S. Kalyanam, *Secretary*
K. Azuma
F. W. Brust
H. D. Chung
R. C. Cipolla
N. G. Cofie
C. M. Faidy
M. M. Farooq
B. R. Ganta
R. G. Gilada
S. R. Gosselin
C. E. Guzman-Leong
K. Hasegawa
K. Hojo
D. N. Hopkins
E. J. Houston
F. Iwamatsu
R. Janowiak
Y. Kim
V. Lacroix
Y. S. Li
R. O. McGill
G. A. Miessi
S. M. Parker
S. H. Pellet
D. Rudland
C. J. Sallaberry
W. L. Server
D. J. Shim
S. Smith
M. F. Uddin
A. Udyawar
T. V. Vo
K. Wang
B. Wasiluk
G. M. Wilkowski
S. X. Xu
Y. Zou
K. Gresh, *Alternate*
H. S. Mehta, *Contributing Member*

Task Group on Code Case N-513 (WG-PFE) (SG-ES) (BPV XI)

R. O. McGill, *Chair*
S. M. Parker, *Secretary*
G. A. Antaki
R. C. Cipolla
M. M. Farooq
K. Gresh
E. J. Houston
R. Janowiak
M. Kassar
S. H. Pellet
D. Rudland
D. A. Scarth
S. X. Xu

Task Group on Evaluation Procedures for Degraded Buried Pipe (WG-PFE) (SG-ES) (BPV XI)

R. O. McGill, *Chair*
S. X. Xu, *Secretary*
F. G. Abatt
G. A. Antaki
R. C. Cipolla
R. G. Gilada
R. Janowiak
M. Kassar
M. Moenssens
R. M. Pace
S. H. Pellet
D. Rudland
D. A. Scarth

Task Group on Flaw Evaluation for HDPE Pipe (WG-PFE) (SG-ES) (BPV XI)

S. Kalyanam, *Chair*
P. Krishnaswamy
C. Liu
M. Moenssens
D. P. Munson
D. A. Scarth
D. J. Shim
M. Troughton
R. Wolfe
J. Wright
S. X. Xu

Subgroup on Nondestructive Examination (BPV XI)

D. O. Henry, *Chair*
T. Cinson, *Secretary*
C. T. Brown
A. Bushmire
T. L. Chan
D. R. Cordes
S. E. Cumblidge
K. J. Hacker
J. Harrison
D. A. Kull
C. Latiolais
J. T. Lindberg
F. J. Schaaf, Jr.
D. R. Slivon
R. V. Swain
C. A. Nove, *Alternate*

Working Group on Personnel Qualification and Surface Visual and Eddy Current Examination (SG-NDE) (BPV XI)

C. T. Brown, *Chair*
M. Orihuela, *Secretary*
D. Brown
T. Cinson
S. E. Cumblidge
N. Farenbaugh
J. Harrison
D. O. Henry
B. Langston
C. Shinsky
R. Tedder
T. Thulien
J. T. Timm

Working Group on Procedure Qualification and Volumetric Examination (SG-NDE) (BPV XI)

J. Harrison, *Chair*
D. A. Kull, *Secretary*
A. Bushmire
D. R. Cordes
K. J. Hacker
R. E. Jacob
W. A. Jensen
C. Latiolais
C. A. Nove
D. R. Slivon
R. V. Swain
D. Van Allen
J. Williams
B. Lin, *Alternate*

Subgroup on Reliability and Integrity Management Program (BPV XI)

A. T. Roberts III, *Chair*
D. Vetter, *Secretary*
T. Anselmi
M. T. Audrain
N. Broom
F. W. Brust
S. R. Doctor
J. D. Fletcher
J. T. Fong
K. Harris
P. J. Hennessey
S. Kalyanam
D. R. Lee
C. Mallet
R. J. McReynolds
M. P. Metcalfe
R. Meyer
M. Orihuela
C. J. Sallaberry
F. J. Schaaf, Jr.
H. M. Stephens, Jr.
R. W. Swayne
S. Takaya
C. Wax
B. K. Welch
R. W. Youngblood
B. Lin, *Alternate*
V. Chugh, *Contributing Member*
R. Grantom, *Contributing Member*
T. Lupold, *Contributing Member*

Working Group on MANDE (SG-RIM) (BPV XI)

H. M. Stephens, Jr., *Chair*
M. Orihuela, *Vice Chair*
M. Turnbow, *Secretary*
T. Anselmi
M. T. Audrain
S. R. Doctor
N. A. Finney
J. T. Fong
D. O. Henry
R. J. McReynolds
R. Meyer
K. Yamada
T. Lupold, *Contributing Member*

Task Group on Nonmetallic Component Degradation and Failure Monitoring (SG-RIM) (BPV XI)

M. P. Metcalfe, *Chair*
A. Tzelepi, *Secretary*
M. T. Audrain
S. Baylis
G. Beirnaert
A. A. Campbell
C. Chen
N. Craft
W. J. Geringer
K. Harris
P.-A. Juan
J. Lang
C. Marks
J. Potgieter

ASME/JSME Joint Working Group on RIM Processes and System-Based Code (SG-RIM) (BPV XI)

S. Takaya, *Chair*
C. Wax, *Vice Chair*
M. T. Audrain
K. Dozaki
J. T. Fong
J. Hakii
K. Harris
M. Hayashi
S. Kalyanam
D. R. Lee
H. Machida
M. Mallet
R. J. McReynolds
R. Meyer
T. Muraki
S. Okajima
A. T. Roberts III
C. J. Sallaberry
F. J. Schaaf, Jr.
R. Vayda
D. Watanabe
H. Yada
K. Yamada
T. Asayama, *Contributing Member*
T. Lupold, *Contributing Member*

Subgroup on Repair/Replacement Activities (BPV XI)

S. L. McCracken, *Chair*
E. V. Farrell, Jr., *Secretary*
M. Brandes
S. B. Brown
R. Clow
S. J. Findlan
M. L. Hall
R. Hinkle
J. Honcharik
A. B. Meichler
L. A. Melder
G. T. Olson
J. E. O'Sullivan
G. C. Park
A. Patel
R. A. Patel
R. R. Stevenson
R. W. Swayne
J. G. Weicks

Working Group on Design and Programs (SG-RRA) (BPV XI)

S. B. Brown, *Chair*
R. A. Patel, *Secretary*
O. Bhatty
R. Clow
R. R. Croft
E. V. Farrell, Jr.
K. Harris
H. Malikowski
A. B. Meichler
G. C. Park
M. A. Pyne
A. Rezai
R. R. Stevenson
K. Sullivan
R. W. Swayne

Task Group on Repair and Replacement Optimization (WG-D&P) (SG-RRA) (BPV XI)

S. L. McCracken, *Chair*
S. J. Findlan, *Secretary*
T. Basso
R. Clow
K. Dietrich
E. V. Farrell, Jr.
M. J. Ferlisi
R. C. Folley
M. L. Hall
D. Jacobs
H. Malikowski
G. C. Park
A. Patel
R. R. Stevenson
J. G. Weicks

Working Group on Nonmetals Repair/Replacement Activities (SG-RRA) (BPV XI)

J. E. O'Sullivan, *Chair*
S. Schuessler, *Secretary*
M. Brandes
S. W. Choi
M. Golliet
J. Johnston, Jr.
T. M. Musto
A. Rezai
S. Rios
F. J. Schaaf, Jr.
R. Stakenborghs
P. Vibien
M. P. Marohl, *Contributing Member*
A. Pridmore, *Contributing Member*

Task Group on Repair by Carbon Fiber Composites (WG-NMRRA) (SG-RRA) (BPV XI)

S. W. Choi, *Chair*
W. Bushika
D. Cimock
M. J. Constable
M. Elen
M. Golliet
P. Krishnaswamy
M. Kuntz
H. Lu
L. Nadeau
C. A. Nove
R. P. Ojdrovic
J. E. O'Sullivan
N. Otten
A. Pridmore
S. Rios
J. Sealey
R. Stakenborghs
D. J. Swaim
M. Tatkowski
M. F. Uddin
J. Wen

Working Group on Welding and Special Repair Processes (SG-RRA) (BPV XI)

J. G. Weicks, *Chair*
G. T. Olson, *Secretary*
D. Barborak
K. Dietrich
S. J. Findlan
R. C. Folley
M. L. Hall
J. Honcharik
D. Jacobs
M. Kris
S. E. Marlette
S. L. McCracken
L. A. Melder
J. E. O'Sullivan
A. Patel

Task Group on Temper Bead Welding (WG-W&SRP) (SG-RRA) (BPV XI)

S. J. Findlan, *Chair*
J. Tatman, *Secretary*
D. Barborak
D. Barton
R. C. Folley
J. Graham
M. L. Hall
D. Jacobs
H. Kobayashi
S. L. McCracken
N. Mohr
G. T. Olson
J. E. O'Sullivan
A. Patel
J. G. Weicks

Task Group on Weld Overlay (WG-W&SRP) (SG-RRA) (BPV XI)

S. L. McCracken, *Chair*
S. Hunter, *Secretary*
D. Barborak
D. Barton
S. J. Findlan
J. Graham
M. L. Hall
D. Jacobs
S. E. Marlette
S. K. Min
G. T. Olson
A. Patel
D. W. Sandusky
J. Tatman
J. G. Weicks

Subgroup on Water-Cooled Systems (BPV XI)

M. J. Ferlisi, *Chair*
J. Nygaard, *Secretary*
S. T. Chesworth
J. Collins
H. Q. Do
K. W. Hall
P. J. Hennessey
A. Keller
A. E. Keyser
S. D. Kulat
D. W. Lamond
T. Nomura
S. A. Norman
M. A. Pyne
H. M. Stephens, Jr.
M. Weis
B. K. Welch
I. A. Anchondo-Lopez, *Alternate*
Y.-K. Chung, *Contributing Member*

Task Group on High Strength Nickel Alloys Issues (SG-WCS) (BPV XI)

H. Malikowski, *Chair*
C. Waskey, *Secretary*
T. Cinson
J. Collins
O. Cruz
K. Dietrich
H. Kobayashi
S. E. Marlette
J. Robinson
D. Van Allen
G. White
K. A. Whitney

Working Group on Containment (SG-WCS) (BPV XI)

M. J. Ferlisi, *Chair*
S. Walden, *Secretary*
H. T. Hill
S. Johnson
A. E. Keyser
P. Leininger
J. A. Munshi
S. Richter
M. Sircar
P. C. Smith
R. S. Spencer
A. Staller
J. Swan
C. Tillotson
G. Z. Wang
M. Weis

Working Group on Inspection of Systems and Components (SG-WCS) (BPV XI)

H. Q. Do, *Chair*
M. Weis, *Secretary*
R. W. Blyde
J. Collins
M. J. Ferlisi
M. L. Garcia Heras
K. W. Hall
E. Henry
J. Howard
A. Keller
E. E. Keyser
S. D. Kulat
E. Lantz
J. C. Nygaard
S. Orita
R. S. Spencer
M. Walter
A. W. Wilkens

Working Group on Pressure Testing (SG-WCS) (BPV XI)

S. A. Norman, *Chair*
M. Moenssens, *Secretary*
T. Anselmi
A. Knighton
D. W. Lamond
S. Levitus
R. A. Nettles
J. Swan
K. Whitney

Working Group on Risk-Informed Activities (SG-WCS) (BPV XI)

M. A. Pyne, *Chair*
S. T. Chesworth, *Secretary*
G. Brouette
R. Fougerousse
J. Hakii
K. W. Hall
M. J. Homiack
J. T. Jewell
S. D. Kulat
D. W. Lamond
E. Lantz
P. J. O'Regan
N. A. Palm
S. E. Woolf

Working Group on General Requirements (BPV XI)

D. Vetter, *Chair*
S. E. Woolf, *Secretary*
T. L. Chan
P. J. Hennessey
R. Hinkle
K. A. Kavanagh
A. Mills
G. Ramaraj
T. N. Rezk
A. T. Roberts III
B. K. Welch
B. Harris, *Alternate*

COMMITTEE ON TRANSPORT TANKS (BPV XII)

N. J. Paulick, *Chair*
M. D. Rana, *Vice Chair*
J. Oh, *Staff Secretary*
A. N. Antoniou
K. W. A. Cheng
P. Chilukuri
O. Mulet
M. Pitts
J. Roberts
T. A. Rogers
R. C. Sallash
M. Shah
S. Staniszewski
A. P. Varghese
R. Meyers, *Contributing Member*

Executive Committee (BPV XII)

M. D. Rana, *Chair*
N. J. Paulick, *Vice Chair*
J. Oh, *Staff Secretary*
P. Chilukuri
M. Pitts
T. A. Rogers
S. Staniszewski

Subgroup on Design and Materials (BPV XII)

P. Chilukuri, *Chair*
K. W. A. Cheng
S. L. McWilliams
N. J. Paulick
M. D. Rana
T. J. Rishel
T. A. Rogers
R. C. Sallash
M. Shah
S. Staniszewski
A. P. Varghese
K. Xu
D. K. Chandiramani, *Contributing Member*
Y. Doron, *Contributing Member*
M. Pitts, *Contributing Member*
D. G. Shelton, *Contributing Member*
B. E. Spencer, *Contributing Member*
J. Zheng, *Contributing Member*

Subgroup on Fabrication, Inspection, and Continued Service (BPV XII)

M. Pitts, *Chair*
P. Chilukuri, *Secretary*
K. W. A. Cheng
Y. Doron
M. Koprivnak
O. Mulet
T. J. Rishel
J. Roberts
R. C. Sallash
S. Staniszewski
K. Mansker, *Contributing Member*
G. McRae, *Contributing Member*
T. A. Rogers, *Contributing Member*

Subgroup on General Requirements (BPV XII)

S. Staniszewski, *Chair*
A. N. Antoniou
P. Chilukuri
J. L. Freiler
O. Mulet
B. F. Pittel
M. Pitts
T. J. Rishel
R. C. Sallash
Y. Doron, *Contributing Member*
S. L. McWilliams, *Contributing Member*
T. A. Rogers, *Contributing Member*
D. G. Shelton, *Contributing Member*

Subgroup on Nonmandatory Appendices (BPV XII)

T. A. Rogers, *Chair*
S. Staniszewski, *Secretary*
P. Chilukuri
N. J. Paulick
M. Pitts
T. J. Rishel
R. C. Sallash
D. G. Shelton
Y. Doron, *Contributing Member*

COMMITTEE ON OVERPRESSURE PROTECTION (BPV XIII)

B. K. Nutter, *Chair*
A. Donaldson, *Vice Chair*
C. E. Rodrigues, *Staff Secretary*
R. Antoniuk
T. P. Beirne
Joey Burgess
D. B. DeMichael
J. W. Dickson
B. Engman
K. R. May
D. Miller
T. Patel
B. F. Pittel
T. R. Tarbay
D. E. Tompkins
J. A. West
M. Edwards, *Alternate*
J. F. Ball, *Contributing Member*
R. W. Barnes, *Contributing Member*
R. D. Danzy, *Contributing Member*
J. Grace, *Contributing Member*
S. F. Harrison, Jr., *Contributing Member*
A. Hassan, *Contributing Member*
P. K. Lam, *Contributing Member*
M. Mengon, *Contributing Member*
J. Mize, *Contributing Member*
M. Mullavey, *Contributing Member*
J. Phillips, *Contributing Member*
S. Ruesenberg, *Contributing Member*
K. Shores, *Contributing Member*
D. E. Tezzo, *Contributing Member*
A. Wilson, *Contributing Member*

Executive Committee (BPV XIII)

A. Donaldson, *Chair*
B. K. Nutter, *Vice Chair*
C. E. Rodrigues, *Staff Secretary*
T. Beirne
K. R. May
T. Patel
B. F. Pittel

Subgroup on Design and Materials (BPV XIII)

T. Patel, *Chair*
V. Kalyanasundaram, *Vice Chair*
A. Williams, *Secretary*
T. K. Acharya
W. E. Chapin
B. Joergensen
R. Krithivasan
J. Latshaw
D. Miller
T. R. Tarbay
J. A. West
D. J. Azukas, *Contributing Member*
R. D. Danzy, *Contributing Member*
M. Mullavey, *Contributing Member*
G. Ramirez, *Contributing Member*
S. Zalar, *Contributing Member*

Subgroup on General Requirements (BPV XIII)

B. F. Pittel, *Chair*
J. Grace, *Secretary*
R. Antoniuk
J. F. Ball
Joey Burgess
John Burgess
D. B. DeMichael
A. Donaldson
S. T. French
J. Horne
R. Klimas, Jr.
Z. E. Kumana
D. Mainiero-Cessna
K. R. May
J. Mize
L. Moedinger
M. Mullavey
A. Peck
D. E. Tezzo
D. E. Tompkins
J. F. White
M. Edwards, *Alternate*
P. Chavdarov, *Contributing Member*
J. L. Freiler, *Contributing Member*
G. D. Goodson, *Contributing Member*
B. Joergensen, *Contributing Member*
P. K. Lam, *Contributing Member*
E. Pearson, *Contributing Member*
J. Phillips, *Contributing Member*
S. Ruesenberg, *Contributing Member*
S. Zalar, *Contributing Member*

Subgroup on Nuclear (BPV XIII)

K. R. May, *Chair*
J. F. Ball, *Vice Chair*
R. Krithivasan, *Secretary*
M. Brown
J. W. Dickson
N. Hansing
S. Jones
D. Miller
T. Patel
B. J. Yonsky
J. Yu, *Alternate*
S. T. French, *Contributing Member*

Subgroup on Testing (BPV XIII)

T. P. Beirne, *Chair*
J. W. Dickson, *Vice Chair*
C. Hofmeister, *Secretary*
V. Chicola III
B. Engman
R. J. Garnett
R. Houk
N. Jump
B. K. Nutter
J. R. Thomas, Jr.
C. Bauer, *Alternate*
R. Lack, *Alternate*
M. Brown, *Contributing Member*
J. Mize, *Contributing Member*
M. Mullavey, *Contributing Member*
S. Ruesenberg, *Contributing Member*
C. Sharpe, *Contributing Member*
K. Shores, *Contributing Member*
A. Strecker, *Contributing Member*
A. Wilson, *Contributing Member*

COMMITTEE ON BOILER AND PRESSURE VESSEL CONFORMITY ASSESSMENT (CBPVCA)

L. E. McDonald, *Chair*
E. Whittle, *Vice Chair*
G. Moino, *Staff Secretary*
P. Chavdarov
J. P. Chicoine
A. Donaldson
T. E. Hansen
W. Hibdon
M. Prefumo
R. Rockwood
G. Scribner
D. E. Tuttle
R. V. Wielgoszinski
P. Williams
T. P. Beirne, *Alternate*
N. Caputo, *Alternate*
J. M. Downs, *Alternate*
Y.-S. Kim, *Alternate*
B. L. Krasiun, *Alternate*
K. Roewe, *Alternate*
B. C. Turczynski, *Alternate*
R. Underwood, *Alternate*
J. Yu, *Alternate*
D. Cheetham, *Contributing Member*
A. J. Spencer, *Honorary Member*

COMMITTEE ON NUCLEAR CERTIFICATION (CNC)

R. R. Stevenson, *Chair*
M. A. Lockwood, *Vice Chair*
H. Ruan, *Secretary*
S. Andrews
A. Appleton
G. Claffey
N. DeSantis
C. Dinic
G. Gobbi
J. Grimm
J. W. Highlands
K. A. Kavanagh
J. C. Krane
B. McGlone
I. Olson
E. L. Pleins
L. Ponce
T. E. Quaka
T. N. Rezk
E. A. Whittle
T. Aldo, *Alternate*
M. Blankinship, *Alternate*
G. Brouette, *Alternate*
Y. Diaz-Castillo, *Alternate*
P. D. Edwards, *Alternate*
R. Hinkle, *Alternate*
K. M. Hottle, *Alternate*
J. Kiefer, *Alternate*
S. J. Montano, *Alternate*
R. Spuhl, *Alternate*
M. Wilson, *Alternate*
S. Yang, *Alternate*
M. Burke, *Contributing Member*
S. F. Harrison, Jr., *Contributing Member*

PREFACE TO SECTION XI

(25)

INTRODUCTION

Section XI, Division 1, Rules for Inservice Inspection of Nuclear Power Plant Components, of the ASME Boiler and Pressure Vessel Code provides requirements for examination, testing, and inspection of components and systems, and repair/replacement activities in a nuclear power plant. Application of Division 1 begins when the requirements of the Construction Code have been satisfied.

Section XI, Division 2, Requirements for Reliability and Integrity Management (RIM) Programs for Nuclear Reactor Facilities, is a technology-neutral standard of the ASME Boiler and Pressure Vessel Code. It provides requirements for protecting pressure or structural integrity of structures, systems, and components (SSCs) that affect reliability. Application of Division 2 begins when the requirements of the Construction Code have been satisfied. It is applicable regardless of the Construction Code classification used for an SSC if the SSC is designated as important to the safety and reliability of an operating facility. Division 2 is also intended to be used during the design phase of a nuclear facility structure, system, or component and enhance coordination between the design organization and the RIM program developers. These provisions are intended to ensure access to the applicable SSCs and to ensure the existence of the proper conditions to conduct monitoring and nondestructive examination (MANDE) to support achieving SSC Reliability Targets.

GENERAL

The rules of this Section constitute requirements to maintain the nuclear reactor facility and to return the facility to service, following facility outages, in a safe and expeditious manner.

Division 1 rules require a mandatory program of examinations, testing, and inspections to evidence adequate safety and to manage deterioration and aging effects. The rules also stipulate duties of the Authorized Nuclear Inservice Inspector to verify that the mandatory program has been completed, permitting the plant to return to service in an expeditious manner.

Division 2 rules require the development of a Reliability and Integrity Management (RIM) Program that considers the combination of design, fabrication, degradation mechanisms, inspection, examination, monitoring, operation, and maintenance of SSCs to ensure they will meet their required Reliability Targets. The rules also stipulate duties of the Authorized Nuclear Inservice Inspector to verify that the program has been completed, implemented, and updated in accordance with the requirements of Division 2.

(25)

ORGANIZATION OF SECTION XI

1 DIVISIONS

Section XI consists of two Divisions, as follows:

Division 1 = Rules for Inservice Inspection of Nuclear Power Plant Components
Division 2 = Requirements for Reliability and Integrity Management (RIM) Programs for Nuclear Reactor Facilities

2 ORGANIZATION OF DIVISION 1

2.1 SUBSECTIONS

Division 1 is broken down into Subsections that are designated by capital letters, preceded by the letters IW. Division 1 consists of Subsections covering the following aspects of the rules:

Subsection	Title
IWA	General Requirements
IWB	Class 1 Components
IWC	Class 2 Components
IWD	Class 3 Components
IWE	Class MC and CC Components
IWF	Class 1, 2, 3, and MC Component Supports
IWG	Core Internal Structures (In course of preparation)
IWL	Class CC Concrete Components

Subsections are divided into Articles, subarticles, paragraphs, and, where necessary, subparagraphs.

2.2 ARTICLES

Articles are designated by the applicable letters indicated above for the Subsections, followed by Arabic numbers, such as IWA-1000 or IWB-2000. Where possible, Articles dealing with the same general topics are given the same number in each Subsection, in accordance with the following scheme:

Article Number	Title
1000	Scope and Responsibility
2000	Examination and Inspection
3000	Acceptance Standards
4000	Repair/Replacement Activities
5000	System Pressure Tests
6000	Records and Reports

The numbering of Articles and material contained in the Articles may not, however, be consecutive. Due to the fact that the complete outline may cover phases not applicable to a particular Subsection or Article, the requirements have been prepared with some gaps in the numbering.

2.3 SUBARTICLES

Subarticles are numbered in units of 100, such as IWA-1100 or IWA-1200.

2.4 SUBSUBARTICLES

Subsubarticles are numbered in units of 10, such as IWA-2130, and may have no text. When a number such as IWA-1110 is followed by text, it is considered a paragraph.

2.5 PARAGRAPHS

Paragraphs are numbered in units of 1, such as IWA-2131 or IWA-2132.

2.6 SUBPARAGRAPHS

Subparagraphs, when they are *major* subdivisions of a paragraph, are designated by adding a decimal followed by one or more digits to the paragraph number, such as IWA-1111.1 or IWA-1111.2. When they are *minor* subdivisions of a paragraph, subparagraphs may be designated by lowercase letters in parentheses, such as IWA-1111(a) or IWA-1111(b).

3 ORGANIZATION OF DIVISION 2

Division 2 is broken down into Articles that are designated by the capital letters RIM, followed by the Article number. Division 2 Articles consist of the following:

Article	Title
RIM-1	Scope and Responsibility
RIM-2	Reliability and Integrity Management (RIM) Program
RIM-3	Acceptance Standards
RIM-4	Repair/Replacement Activities
RIM-5	System Leak Monitoring and Periodic Tests
RIM-6	Records and Reports
RIM-7	Glossary

Division 2 also maintains Mandatory Appendices that are required for the development and implementation of the RIM Program. Mandatory Appendices consist of the following:

Appendix	Title
I	RIM Decision Flowcharts for Use With the RIM Program
II	Derivation of Component Reliability Targets From Facility Safety Requirements
III	Owner's Record and Report for RIM Program Activities
IV	Monitoring and NDE Qualification
V	Catalog of NDE Requirements and Areas of Interest
VI	Reliability and Integrity Management Expert Panel (RIMEP)
VII	Supplements for Types of Nuclear Reactor Facilities

Articles are divided into paragraphs and subparagraphs. Appendices are divided into Articles, paragraphs, and subparagraphs.

4 REFERENCES

References used within this Section generally fall into one of six categories, as explained below.

(a) References to Other Portions of This Section. When a reference is made to another Article, subarticle, or paragraph number, all numbers subsidiary to that reference shall be included. For example, reference to IWA-2000 includes all materials in Article IWA-2000; reference to IWA-2200 includes all material in subarticle IWA-2200; reference to IWA-2220 includes all paragraphs in IWA-2220, IWA-2221, and IWA-2222.

(b) References to Other Sections. Other Sections referred to in Section XI are as follows:

(1) Section II, Material Specifications. When a requirement for a material or for the examination or testing of a material is to be in accordance with a specification such as SA-105, SA-370, or SB-160, the reference is to material specifications in Section II. These references begin with the letter "S." Materials conforming to ASTM specifications may be used in accordance with the provisions of the last paragraph of the Foreword to the Boiler Code.

(2) Section III, Nuclear Power Plant Components. Section III references begin with the letter "N" and relate to nuclear power plant design or construction requirements.

(3) Section V, Nondestructive Examination. Section V references begin with the letter "T" and relate to the nondestructive examination of material or welds.

(4) Section IX, Welding and Brazing Qualifications. Section IX references begin with the letter "Q" and relate to welding and brazing requirements.

(c) References to Specifications and Standards Other Than Published in Code Sections

(1) Specifications for examination methods and acceptance standards to be used in connection with them are published by ASTM International.

(2) Recommended practices for qualifying and certifying nondestructive examination personnel are published by the American Society for Nondestructive Testing (ASNT). These documents are designated SNT-TC-1A and CP-189. A reference to SNT-TC-1A or CP-189 shall be understood to mean the practice and its supplements.

(3) Specifications and standards for materials, processes, examination and test procedures, qualifications of personnel, and other requirements of the Code approved by the American National Standards Institute are designated by the letters ANSI followed by the serialization for the particular specification or standard. Standards published by ASME are available from ASME (https://www.asme.org/).

(4) Specifications and standards for materials, processes, examination and test procedures, and other requirements of the Code relating to concrete are listed in Table IWA-1600-1, designated by the letters ACI, and are approved and published by the American Concrete Institute.

(5) Specifications and standards for determining water chemistry as identified in Table IWA-1600-1 by the letter designation APHA are approved and published by the American Public Health Association.

(6) Specifications and standards for welding are listed in Table IWA-1600-1 and are approved and published by the American Welding Society.

(d) References to Government Regulations. U.S. Federal regulations issued by executive departments and agencies, as published in the Federal Register, are codified in the Code of Federal Regulations. The Code of Federal Regulations is published by the Office of the Federal Register, National Archives and Records Service, General Service Administration. Title 10 of the Code of Federal Regulations contains the regulations for atomic energy. The abbreviated reference "10 CFR 50" is used to mean "Title 10, Code of Federal Regulations, Part 50."

(e) References to Appendices. Two types of Appendices are used in Section XI and are designated Mandatory and Nonmandatory.

(1) Mandatory Appendices contain requirements which must be followed in Section XI activities; such references are designated by a Roman numeral followed by Arabic numerals. A reference to III-1100, for example, refers to a Mandatory Appendix.

(2) Nonmandatory Appendices provide information or guidance for the use of Section XI; such references are designated by a capital letter followed by Arabic numerals. A reference to A-3300, for example, refers to a Nonmandatory Appendix.

(f) References to Technical Reports. The following reports prepared at the request of the American Society of Mechanical Engineers and published by Electric Power Research Institute are relevant to Code-related articles of Section XI.

(1) NP-1406-SR — Nondestructive Examination Acceptance Standards Technical Basis and Development for Boiler and Pressure Vessel Code, ASME Section XI, Division 1, Special Report, May 1980.

(2) NP-719-SR — Flaw Evaluation Procedures — Background and Application of ASME Section XI Appendix A — Special Report, August 1978.

SUMMARY OF CHANGES

Changes listed below are identified on the pages by a margin note, **(25)**, placed next to the affected area.

Page	*Location*	*Change*
xxvi	List of Sections	Title of Section XI, Division 1 revised
xxvii	Foreword	Third, fourth, seventh, tenth, and eleventh paragraphs editorially revised
xxxii	Personnel	Updated
lv	Preface to Section XI	Introduction and last paragraph of General section revised
lvi	Organization of Section XI	Paragraphs 1 and 4(c), 4(d), and 4(f) revised
1	Division 1	Title revised
3	Table IWA-1600-1	Updated
3	IWA-1700	Subparagraph (a) revised
5	IWA-2110	*(1)* Subparagraphs (b)(1), (b)(1)(-e), and (b)(1)(-f) revised *(2)* Subparagraphs (b)(1)(-g) and (b)(1)(-h) and subsequent paragraph deleted
5	IWA-2200	Subparagraph (d) revised
9	IWA-2316	Revised in its entirety
13	IWA-2420	Revised in its entirety
13	IWA-2425	Revised in its entirety
16	IWA-3300	Subparagraph (a)(3) revised
19	Figure IWA-3320-1	Note (1) added
29	IWA-4131.2	Subparagraph (a) revised
29	IWA-4132	First paragraph revised
29	IWA-4134	First paragraph revised
37	IWA-4440	*(1)* "Owner" revised to "Owner or Repair/Replacement Organization" throughout *(2)* Subparagraphs (b) and (c)(8) revised
39	IWA-4520	*(1)* Subparagraph (b)(2) revised *(2)* IWA-4521 deleted
44	IWA-4633.1	Subparagraph (g) revised and subpara. (h) deleted
44	IWA-4633.2	Subparagraph (e) revised and subpara. (f) deleted
44	IWA-4643.1	Subparagraph (g) revised and subpara. (h) deleted
45	IWA-4643.2	Subparagraph (e) revised and subpara. (f) deleted
60	IWA-5212	Subparagraph (c) revised
60	IWA-5213	Subparagraph (b)(2) revised
61	IWA-5241	Revised in its entirety
62	IWA-5242	Subparagraph (e) added

Page	*Location*	*Change*
62	IWA-5243	Added
63	IWA-5250	Deleted
65	IWA-6220	Subparagraph (f) revised
66	IWA-6340	Subparagraph (g) revised
68	Article IWA-9000	Definitions of *Material Organization (Metallic)* and *qualified source material* revised
84	Table IWB-2500-1 (B-D)	Note (8) revised
88	Table IWB-2500-1 (B-G-1)	Note (8) added
127	Table IWB-3510-1	Note (1) revised
131	Table IWB-3514-1	*(1)* Under "Volumetric Examination Method ...," first and last wall thickness subheadings revised *(2)* Note (1) revised
132	Table IWB-3514-2	Under "Wall Thickness ...," first and last subheadings revised
132	Table IWB-3514-3	Under "Nominal Pipe Wall Thickness ...," last entry revised
133	Table IWB-3514-4	Under "Nominal Wall Thickness ...," last subheading revised
135	IWB-3522.1	Revised in its entirety
138	IWB-3612	Revised in its entirety
140	IWB-3613	Subparagraph (a) revised
143	IWB-5221	Revised in its entirety
143	IWB-5222	Subparagraph (b) revised
153	Table IWC-2500-1 (C-C)	Note (3) revised
180	IWC-3132.3	Subparagraph (b) revised
186	Table IWC-3514-1	Under "Volumetric Examination Method ...," first and last wall thickness subheadings revised
187	IWC-3516.1	Revised in its entirety
187	IWC-3516.2	First paragraph revised
199	IWD-3132.3	Subparagraph (b) revised
200	IWD-3511.1	Revised in its entirety
200	IWD-3511.2	First paragraph revised
202	IWD-5222	Subparagraph (c) revised
203	IWD-5240	Revised in its entirety
205	IWE-1241	First paragraph and subpara. (a) revised
207	IWE-2313	Subparagraph (a) revised
207	IWE-2420	Revised in its entirety
207	IWE-2430	Revised in its entirety
208	IWE-2500	Subparagraph (d) and Figure IWE-2500 deleted

Page	Location	Change
210	Table IWE-2500-1 (E-A)	*(1)* "Examination Requirements/Fig. No." entry for Item No. E1.31 revised *(2)* Notes added, revised, and renumbered
213	IWE-3122.3	Subparagraph (b) revised
215	IWE-3514	Last sentence revised
216	IWE-5221	Revised in its entirety
217	IWF-1210	Revised in its entirety
228	IWL-2320	In subpara. (a)(3)(-d), "recorded questions" corrected by errata to "reworded questions"
245	I-2400	Subparagraph (a) added and existing paragraph designated as (b)
269	Mandatory Appendix III, Supplement 2	Subparagraph (c)(1)(-e) revised
273	Table IV-3110-1	Last row added
282	Mandatory Appendix IV, Supplement 5	Added
305	Table VIII-3110-1	Penultimate row and Note (2) added
324	Mandatory Appendix VIII, Supplement 10	Title and paras. 1.0, 2.0, 2.1(c), and 2.4 revised
337	Article XI-2000	Subparagraph (f)(1) revised
338	Article XI-3000	First paragraph revised
340	A-1100	First paragraph revised
347	A-3311	In subpara. (b), definition of a/ℓ revised
358	A-3540	Subparagraph (e)(3) revised
390	Table A-3610-1	Revised in its entirety
390	Table A-3610-2	Revised in its entirety
397	Table A-3610-3	Revised in its entirety
400	Table A-3610-4	Revised in its entirety
403	Table A-3610-5	Revised in its entirety
406	Table A-3610-6	Revised in its entirety
421	Table A-3630-9	Title revised and third column added
422	Table A-3630-10	Title revised and third column added
423	Table A-3630-11	Title revised and third column added
424	Table A-3630-12	Title revised and third column added
425	Table A-3630-13	Title revised and third column added
426	Table A-3630-14	Title revised and third column added
427	Table A-3630-15	Title revised and third column added
428	Table A-3630-16	Title revised and third column added
445	Table A-3650-9	Title revised and third column added

Page	Location	Change
446	Table A-3650-10	Title revised and third column added
447	Table A-3650-11	*(1)* Title revised and third column added *(2)* For Coefficient G_0, last entry under "4.0" added by errata
448	Table A-3650-12	Title revised and third column added
449	Table A-3650-13	Title revised and third column added
450	Table A-3650-14	Title revised and third column added
451	Table A-3650-15	Title revised and third column added
452	Table A-3650-16	Title revised and third column added
453	Table A-3660-1	For Coefficient G_1, first entry under "0.25" corrected by errata
461	A-4200	In subpara. (c), first paragraph revised and last paragraph added
484	C-4222	Last sentence revised
485	C-4300	Title revised
485	C-4310	Last paragraph revised
485	C-4311	Subparagraphs (a), (a)(2), (b), and (c) revised
489	C-4312	Subparagraphs (a) and (b) revised
491	Figure C-4220-1	Title revised
493	Figure C-4310-3	Revised
493	Figure C-4310-5	Revised
507	C-6330	In subpara. (a), second and fifth equations revised
528	G-2110	Last paragraph revised
532	G-2215	Subparagraphs (a)(3), (a)(4)(-b), (b)(3), and (b)(4) revised
564	Nonmandatory Appendix K	Revised in its entirety
586	L-1300	Definitions of P_n and P_o deleted
588	L-3211	Subparagraphs (b) through (d) revised
590	L-3312	Revised in its entirety
591	L-3331	Subparagraphs (a) and (c) revised
591	L-3332	Revised in its entirety
591	L-3341	Subparagraphs (a) and (c) revised
592	L-3342	Revised in its entirety
606	P-1200	In in-text table of subpara. (e), first "Difference, %" entry revised
608	P-1300	In in-text table, "Factor" entry for Btu/hr (W) revised
614	Nonmandatory Appendix R	Revised in its entirety
667	Nonmandatory Appendix U-S, Supplement U-S1	Deleted
703	Y-3100	Subparagraphs (b) and (c) revised
704	Figure Y-3100-1	Revised

Page	*Location*	*Change*
705	Figure Y-3100-1M	Revised
706	Y-3200	Subparagraph (b) revised
722	Nonmandatory Appendix AA	Added

CROSS-REFERENCING IN THE ASME BPVC

Paragraphs within the ASME BPVC may include subparagraph breakdowns, i.e., nested lists. The following is a guide to the designation and cross-referencing of subparagraph breakdowns:

(a) Hierarchy of Subparagraph Breakdowns

(1) First-level breakdowns are designated as (a), (b), (c), etc.

(2) Second-level breakdowns are designated as (1), (2), (3), etc.

(3) Third-level breakdowns are designated as (-a), (-b), (-c), etc.

(4) Fourth-level breakdowns are designated as (-1), (-2), (-3), etc.

(5) Fifth-level breakdowns are designated as (+a), (+b), (+c), etc.

(6) Sixth-level breakdowns are designated as (+1), (+2), etc.

(b) Cross-References to Subparagraph Breakdowns. Cross-references within an alphanumerically designated paragraph (e.g., PG-1, UIG-56.1, NCD-3223) do not include the alphanumerical designator of that paragraph. The cross-references to subparagraph breakdowns follow the hierarchy of the designators under which the breakdown appears. The following examples show the format:

(1) If X.1(c)(1)(-a) is referenced in X.1(c)(1), it will be referenced as (-a).

(2) If X.1(c)(1)(-a) is referenced in X.1(c)(2), it will be referenced as (1)(-a).

(3) If X.1(c)(1)(-a) is referenced in X.1(e)(1), it will be referenced as (c)(1)(-a).

(4) If X.1(c)(1)(-a) is referenced in X.2(c)(2), it will be referenced as X.1(c)(1)(-a).

DIVISION 1
RULES FOR INSERVICE INSPECTION OF NUCLEAR POWER PLANT COMPONENTS

(25)

SUBSECTION IWA
GENERAL REQUIREMENTS

ARTICLE IWA-1000
SCOPE AND RESPONSIBILITY

IWA-1100 SCOPE

This Division provides requirements for inservice inspection and testing of light-water-cooled nuclear power plants. The requirements identify the areas subject to inspection, responsibilities, provisions for accessibility and inspectability, examination methods and procedures, personnel qualifications, frequency of inspection, record keeping and report requirements, procedures for evaluation of inspection results and subsequent disposition of results of evaluations, and repair/replacement activity requirements, including procurement, design, welding, brazing, defect removal, fabrication, installation, examination, and pressure testing.

IWA-1200 JURISDICTION

The jurisdiction of this Division covers individual components and complete plants that have met all the requirements of the Construction Code, commencing when the Construction Code requirements have been met, irrespective of physical location. When portions of systems or plants are completed at different times, jurisdiction of this Division shall cover only those portions for which all of the construction requirements have been met. Prior to installation, an item that has met all requirements of the Construction Code may be corrected using the rules of either the Construction Code or this Division, as determined by the Owner.

IWA-1300 APPLICATION

IWA-1310 COMPONENTS SUBJECT TO INSPECTION AND TESTING

Components identified in this Division for inspection and testing shall be included in the inservice inspection plan. These components include nuclear power plant items such as vessels, containments, piping systems, pumps, valves, core support structures, and storage tanks, including their respective supports.

IWA-1320 CLASSIFICATIONS

(a) Application of the rules of this Division shall be governed by the group classification criteria of the regulatory authority having jurisdiction at the plant site as follows.

(1) The rules of Subsection IWB shall be applied to those systems whose components are classified ASME Class 1.

(2) The rules of Subsection IWC shall be applied to those systems whose components are classified ASME Class 2, with the exception that those portions of Class 3 systems that penetrate the containment and are classified as Class 2 solely for the containment boundary function shall meet the Class 3 requirements of Subsections IWD and IWF.

(3) The rules of Subsection IWD shall be applied to those systems whose components are classified ASME Class 3.

(4) The requirements of Subsection IWE shall be applied to components classified ASME Class MC and to metallic shell and penetration liners classified ASME Class CC.

(5) The requirements of Subsection IWF shall be applied to supports classified ASME Class 1, 2, 3, or MC.

(6) The requirements of Subsection IWL shall be applied to reinforced concrete and post-tensioning systems classified ASME Class CC.

(b) Optional construction of a component within a system boundary to a classification higher than the minimum class established in the component Design Specification (either upgrading from Class 2 to Class 1 or from Class 3 to Class 2) shall not affect the overall system classification by which the applicable rules of this Division are determined.

(c) Where all components within the system boundary or isolable portions of the system boundary are classified to a higher class than required by the group classification criteria, the rules of (a) may be applied to the higher classification, provided the rules of the applicable Subsection are applied in their entirety.

(d) The portion of piping that penetrates a containment vessel, which may differ from the classification of the balance of the piping system, need not affect the overall system classification that determines the applicable rules of this Division.

(e) If systems safety criteria permit a system to be nonnuclear safety Class and an Owner optionally classifies and constructs that system, or a portion thereof, to Class 2 or Class 3 requirements, the application of the rules of (a) is at the option of the Owner and is not a requirement of this Division.

IWA-1400 OWNER'S RESPONSIBILITY

The responsibilities of the Owner shall include the following:

(a) determination of the appropriate Code class(es) for each component[1] of the plant, and identification of the system boundaries for each class of components subject to inspection and the components exempt from examination requirements.

(b) design and arrangement of system components to include allowances for adequate access and clearances for conduct of the examination and tests.

(c) preparation of plans, schedules, and the Owner's Activity Report, Form OAR-1, for preservice and inservice examinations.

(d) submittal of Form OAR-1 for preservice and inservice examinations to the regulatory and enforcement authorities having jurisdiction at the plant site, if required by these authorities.

(e) preparation of written examination instructions and procedures, including diagrams or system drawings identifying the extent of areas of components subject to examination.

(f) verification of qualification to the required level of responsibility of personnel who perform the examinations.

(g) possession of an arrangement with an Authorized Inspection Agency to provide inspection services.

(h) performance of required examinations and tests.

(i) recording of examination and test results that provide a basis for evaluation and facilitate comparison with the results of subsequent examinations.

(j) evaluation of examination and test results.

(k) performance of repair/replacement activities in accordance with written programs and plans.

(l) maintenance of adequate inspection, examination, test, evaluation, and repair/replacement activity records such as radiographs, diagrams, drawings, calculations, examination and test data, description of procedures used, and evidence of personnel qualifications.

(m) retention of all inspection, examination, test, and repair/replacement activity records and evaluation calculations for the service lifetime of the component or system.

(n) the retention and maintenance of all basic calibration blocks used for ultrasonic examination of the components.

(o) documentation of a Quality Assurance Program in accordance with one of the following:

(1) Title 10, Code of Federal Regulations, Part 50

(2) ASME NQA-1, Part I

(p) recording of regions in ferritic steel components where acceptance standards have been modified as required in IWB-3410.2.

(q) recording of regions in components where flaws or relevant conditions exceeding the acceptance standards have had an evaluation performed to allow continued service in accordance with IWB-3132.3, IWB-3142.4, IWC-3122.3, IWC-3132.3, IWD-3132.3, IWE-3122.3, IWF-3112.3, IWF-3122.3, IWL-3112, IWL-3212, and IWL-3222. Any continued service time or cycle limits inherent in the evaluation shall also be recorded.

(r) methods other than written signature may be used for indicating certification, authorization, and approval of records; controls and safeguards shall be provided and described in the Quality Assurance Program to ensure the integrity of the certification, authorization, and approval.

IWA-1500 ACCESSIBILITY

Provisions for accessibility shall include the following considerations:[2]

(a) access for the Inspector, examination personnel, and equipment necessary to conduct the examinations

(b) sufficient space for removal and storage of structural members, shielding, and insulation

(c) installation and support of handling machinery (e.g., hoists) where required to facilitate removal, disassembly, and storage of equipment, components, and other materials

(d) performance of examinations alternative to those specified in the event structural defects or indications are revealed that may require such alternative examinations

(e) performance of necessary operations associated with repair/replacement activities

IWA-1600 REFERENCED STANDARDS AND SPECIFICATIONS

When standards and specifications are referenced in this Division, their revision date or indicator shall be as shown in Table IWA-1600-1.

(25)

Table IWA-1600-1
Referenced Standards and Specifications

Standard, Method, or Specification	Revision Date or Indicator
ACI 201.1R	2008
ACI 349.3R	2018
ANSI/ASNT CP-105	2006
ANSI/ASNT CP-189	2006
ANSI/AWS D3.6M	Current edition
APHA 427	1981
APHA 4500-S^{2-}	1989 through 1992
4110 [Note (1)]	2000 through 2022
4500-NO_3^- [Note (1)]	2000 through 2022
4500-S^{2-} [Note (1)]	2000 through 2022
ASME/ANS RA-S	2008 with RA-Sa–2009 Addenda and RA-Sb–013 Addenda
ASME B36.10M	1985 through current edition
ASME NQA-1	1994, 2008 through 2015
ASME QAI-1	Current edition
ASTM D95	1970 through 2023
ASTM D512	1981 through 2023
ASTM D974	1987 through 2022
ASTM D992	1971 (Reapproved 1978)
ASTM D3867	1979 through 2021
ASTM D4327	1988 through 2017
ASTM E29	2019 through 2022
ASTM E185	2021
ASTM E1065	2020
ASTM E1324	2021
ASTM E1921	2022 through 2023b
ASTM E2215	2019 through 2024
AWWA C105	2018

NOTE:
(1) This method is published in "Standard Methods for the Examination of Water and Wastewater," published jointly by the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF).

IWA-1700 STANDARD UNITS (25)

(a) U.S. Customary, SI, or any local customary units may be used to demonstrate compliance with all requirements of this edition related to materials, fabrication, examination, inspection, testing, certification, and overpressure protection.

(b) In general, it is expected that a single system of units shall be used for all aspects of design except where unfeasible or impracticable. When components are manufactured at different locations where local customary units are different from those used for the general design, the local units may be used for the design and documentation of that component. Similarly, for proprietary components or those uniquely associated with a system of units different from that used for the general design, the alternate units may be used for the design and documentation of that component.

(c) For any single equation, all variables shall be expressed in a single system of units. When separate equations are provided for U.S. Customary and SI units, those equations must be executed using variables in the units associated with the specific equation. Data expressed in other units shall be converted to U.S. Customary or SI units for use in these equations. The result obtained from execution of these equations may be converted to other units.

(d) Production, measurement and test equipment, drawings, welding procedure specifications, welding procedure and performance qualifications, and other fabrication documents may be in U.S. Customary, SI, or local customary units in accordance with the fabricator's practice. When values shown in calculations and analysis, fabrication documents, or measurement and test equipment are in different units, any conversions necessary for verification of Code compliance, and to ensure that dimensional consistency is maintained, shall be in accordance with the following:

(1) Conversion factors shall be accurate to at least four significant figures.

(2) The results of conversions of units shall be expressed to a minimum of three significant figures.

(e) Material that has been manufactured and certified to either the U.S. Customary or SI material specification (e.g., SA-516 or SA-516M) may be used regardless of the unit system used in design. Standard fittings (e.g., flanges, elbows, etc.) that have been certified to either U.S. Customary units or SI units may be used regardless of the units system used in design.

(f) Conversion of units, using the precision specified in (d), shall be performed to assure that dimensional consistency is maintained. Conversion factors between U.S. Customary and SI units may be found in Nonmandatory Appendix P, Guidance for the Use of U.S. Customary and SI Units in the ASME Boiler and Pressure Vessel Code. Whenever local customary units are used, the Owner shall

provide the source of the conversion factors, which shall be subject to verification and acceptance by the Authorized Nuclear Inservice Inspector.

(g) Nonmandatory Appendix P provides guidance for use of the U.S. Customary and SI units in this Division.

IWA-1800 TOLERANCES

The Code does not fully address tolerances. When dimensions, sizes, or other parameters are not specified with tolerances, the values of these parameters are considered nominal, and allowable tolerances or local variances may be considered acceptable, when based on engineering judgment and standard practices, as determined by the engineer.

ARTICLE IWA-2000
EXAMINATION AND INSPECTION

IWA-2100 GENERAL

(25) IWA-2110 DUTIES OF THE INSPECTOR AND AUTHORIZED NUCLEAR INSERVICE INSPECTOR SUPERVISOR

(a) The duties of the Authorized Nuclear Inservice Inspector Supervisor shall be conducted in accordance with the requirements of ASME QAI-1.

(b) The duties of the Inspector shall be conducted in accordance with ASME QAI-1 and shall include, but are not limited to, the following:

(1) The Inspector shall review the inspection plan and the schedule required by IWA-2420 for the preservice inspection and each inspection interval. The review shall cover any features that are affected by the requirements of this Division, as applicable, and shall include the following:

(-a) examination categories and items
(-b) test and examination requirements
(-c) examination methods
(-d) percentage of parts selected for examination
(-e) examination and test frequency and scheduling
(-f) disposition of test results

(2) The Inspector shall review any revisions to the inspection plan and, as necessary, the implementation schedule during the preservice inspection or the inspection interval.

(3) The Inspector shall submit a report to the Owner documenting review of the items identified in (1)and (2).

(4) The Inspector shall verify that the required examinations and system pressure tests have been performed and the results recorded.

(5) The Inspector shall verify that the required visual examinations have been performed and the results recorded.

(6) The Inspector shall perform any additional investigations necessary to verify that all applicable requirements of IWA-2110 have been met.

(7) The Inspector shall verify that the nondestructive examination methods used follow the techniques specified in this Division and that the examinations are performed in accordance with written qualified procedures and by personnel employed by the Owner or the Owner's agent and qualified in accordance with IWA-2300.

(8) The Inspector may require, at any time, requalification of any procedure or operator if the Inspector has reason to believe that the requirements are not being met.

(9) The Inspector shall certify the examination records after verifying that the requirements have been met and that the records are correct.

(10) The Inspector shall verify that repair/replacement activities are performed in accordance with the requirements of the Owner's Repair/Replacement Program.

(11) The Inspector shall review the Repair/Replacement Program and its implementation.

IWA-2120 QUALIFICATION OF AUTHORIZED INSPECTION AGENCIES, INSPECTORS, AND SUPERVISORS

(a) The inspection required by this Division shall be performed by an Inspector employed by an ASME-accredited Authorized Inspection Agency or by an Inspector employed or appointed by enforcement authorities in the country or region having jurisdiction over the designated plant.

(b) The ASME-accredited Authorized Inspection Agency, including its staff of Authorized Nuclear Inservice Inspector Supervisors and the Inspectors, shall meet the requirements of ASME QAI-1.

IWA-2130 ACCESS FOR INSPECTOR

The Owner shall arrange for an Inspector to have access to all parts of the plant as necessary to make the required inspections. The Owner shall keep the Inspector informed of the progress of the preparatory work necessary to permit inspections and shall notify the Inspector at a time reasonably in advance of when the components will be ready for inspection.

IWA-2200 EXAMINATION METHODS (25)

(a) The three types of examinations used during inservice inspection are defined as visual, surface, and volumetric. The examination method to be used is specified in Tables IWB-2500-1 (B-A) through IWB-2500-1 (B-Q), IWC-2500-1 (C-A) through IWC-2500-1 (C-J), IWD-2500-1 (D-A) through IWD-2500-1 (D-C), IWE-2500-1 (E-A) through IWE-2500-1 (E-G), IWF-2500-1 (F-A), and IWL-2500-1 (L-A) through IWL-2500-1 (L-B). If a component must be examined in a high radiation area, remotely controlled equipment may be advisable.

(b) When preparation of a surface for nondestructive examination is required, the preparation shall be by a mechanical method. Such surfaces shall be blended into the surrounding area as may be required to perform the examination. The wall thickness shall not be reduced below the minimum thickness required by design. Nonmandatory Appendix D may be used for such surface preparation.

(c) All nondestructive examinations of the required examination volume or area shall be conducted to the maximum extent practicable. When performing VT-1, surface, radiographic, or ultrasonic examination on a component with defined volume or area, essentially 100% of the required volume or area shall be examined. Essentially 100% coverage is achieved when the applicable examination coverage is greater than 90%; however, in no case shall the examination be terminated when greater than 90% coverage is achieved, if additional coverage of the required examination volume or area is practicable. Nonmandatory Appendix S provides guidance that may be used for calculating examination coverage.

(d) When Section V is referenced for examination methodology, the Edition and Addenda of Section V shall be the same as that of Section XI. Alternatively, Articles from later Editions and Addenda of Section V may be used, provided related requirements of those Articles are met. The Section V Edition and Addenda shall be referenced in the inspection plan or procedure. The personnel qualification requirements of Section V, Article 1 shall not apply unless explicitly referenced in this Division.

IWA-2210 VISUAL EXAMINATION

Visual examination shall be conducted in accordance with the requirements of Section V, Article 9, except that the angle of view requirements for direct visual only apply to VT-1, and the requirements for illumination, distance, and resolution demonstration shall be in accordance with Table IWA-2211-1.

IWA-2211 VT-1 Examination

(a) VT-1 examination is conducted to detect discontinuities and imperfections on the surface of components, including such conditions as cracks, wear, corrosion, or erosion.

(b) The VT-1 examination procedure shall be demonstrated capable of resolving characters in accordance with Table IWA-2211-1.

(c) Direct visual examination distance requirements shall be as specified in Table IWA-2211-1.

(d) Illumination for examinations shall meet the requirements specified in Table IWA-2211-1.

(e) It is not necessary to measure illumination levels on each examination surface when the same portable nonbattery-powered light source (e.g., drop light) or similar installed lighting equipment is demonstrated to provide the illumination specified at the maximum examination distance.

(f) When battery powered lights are used, the adequacy of illumination levels shall be checked before and after each examination or series of examinations, not to exceed 4 hr between checks.

(g) Remote visual examination may be substituted for direct examination. The remote examination procedure shall be demonstrated capable of resolving characters as specified in Table IWA-2211-1. Additionally, the remote examination system shall have the capability of distinguishing and differentiating between the colors applicable to the component examination being conducted.

IWA-2212 VT-2 Examination

(a) VT-2 examination is conducted to detect evidence of leakage from pressure-retaining components, as required during the conduct of system pressure test.

(b) VT-2 examination shall be conducted in accordance with Article IWA-5000.

(c) VT-2 examination shall be performed, either directly or remotely, with adequate illumination and resolution to detect evidence of leakage. As indicated in Table IWA-2211-1, there are no specific illumination, distance, and resolution demonstration requirements for VT-2.

IWA-2213 VT-3 Examination

(a) VT-3 examination is conducted to determine the general mechanical and structural condition of components and their supports by verifying parameters such as clearances, settings, and physical displacements; and to detect discontinuities and imperfections, such as loss of integrity at bolted or welded connections, loose or missing parts, debris, corrosion, wear, or erosion. VT-3 includes examination for conditions that could affect operability or functional adequacy of constant load and spring-type supports.

(b) The VT-3 examination procedure shall be demonstrated capable of resolving characters as specified in Table IWA-2211-1.

(c) There are no direct visual examination distance requirements provided the examiner can resolve the characters specified in Table IWA-2211-1.

(d) Illumination for examinations shall meet the requirements specified in Table IWA-2211-1.

(e) It is not necessary to measure illumination levels on each examination surface when the same portable nonbattery-powered light source (e.g., drop light) or similar installed lighting equipment is demonstrated to provide the illumination specified at the maximum examination distance.

(f) When battery-powered lights are used, the adequacy of illumination levels shall be checked before and after each examination or series of examinations, not to exceed 4 hr between checks.

(g) Remote visual examination may be substituted for direct examination. The remote examination procedure shall be demonstrated capable of resolving characters in

Table IWA-2211-1
Visual Examinations

Visual Examination	Minimum Illumination, fc (lx) [Note (1)]	Maximum Direct Examination Distance, ft (mm)	Maximum Height for Procedure Demonstration Characters, in. (mm) [Note (2)]
VT-1	50 (550)	2 (600)	0.044 (1.1)
VT-2	N/A	N/A	N/A
VT-3	50 (550)	N/A	0.105 (2.7)

NOTES:
(1) Resolution of the specified characters can be used in lieu of illumination measurement to verify illumination adequacy.
(2) For procedure demonstration, a test chart or card containing text with some lowercase characters, without an ascender or descender (e.g., a, c, e, o), that meet the specified height requirements is required. Measurements on the test chart or card shall be made once before its initial use with an optical comparator (10X or greater) or other suitable instrument. At least one character of each specified character size shall be measured, to ensure that the card meets the applicable requirements. Alternatively, a production lot of cards may be verified by measurements on the first and last cards produced and at least one card in the approximate middle of the production run. A production lot shall not exceed 50 cards.

accordance with Table IWA-2211-1. Additionally, the remote examination system shall have the capability of distinguishing and differentiating between the colors applicable to the component examination being conducted.

IWA-2215 Replication

Surface replication methods may be used for VT-1 and VT-3 examinations when the surface resolution is at least equivalent to that of direct visual observation.

IWA-2220 SURFACE EXAMINATION

(a) A surface examination indicates the presence of surface discontinuities. It may be conducted using a magnetic particle, liquid penetrant, eddy current, or ultrasonic method.

(b) Any linear indication detected by magnetic particle, liquid penetrant, or eddy current examination that exceeds the allowable linear surface flaw standards shall be recorded.

(c) Any flaw recorded by ultrasonic examination shall be compared to the volumetric examination acceptance standards of Table IWB-3514-1 or Table IWB-3514-2 for surface planar flaw.

IWA-2221 Magnetic Particle Examination

(a) Magnetic particle examination shall be conducted in accordance with Section V, Article 7.

(b) Magnetic particle examination of coated materials shall be conducted in accordance with Section V, Article 7, Mandatory Appendix I.

(c) For nonfluorescent particles the visible light intensity required is 50 fc (550 lx). Alternatively, light shall be sufficient if the examination can resolve standard test chart characters as described for VT-1 in IWA-2210.

IWA-2222 Liquid Penetrant Examination

(a) Liquid penetrant examination shall be conducted in accordance with Section V, Article 6.

(b) For visible dye penetrant, the visible light intensity required is 50 fc (550 lx). Alternatively, lighting shall be sufficient if the examiner can resolve standard test chart characters as described for VT-1 in IWA-2210.

IWA-2223 Eddy Current Examination

Eddy current examination for detection of surface flaws shall be conducted in accordance with Mandatory Appendix IV.

IWA-2224 Ultrasonic Examination

An ultrasonic examination performed from the inside surface of piping may be used as a surface examination method for Categories B-J and B-F piping welds NPS 4 and larger. The ultrasonic examination technique shall be demonstrated capable of detecting an acceptable flaw having the greatest a/t ratio or a 0.50 aspect ratio at the surface being examined.

IWA-2230 VOLUMETRIC EXAMINATION

A volumetric examination indicates the presence of discontinuities throughout the volume of material and may be conducted from either the inside or outside surface of a component.

IWA-2231 Radiographic Examination

For radiographic examinations employing either X-ray equipment or radioactive isotopes, the procedure shall be as specified in Section V, Article 2.

IWA-2232 Ultrasonic Examination

Ultrasonic examination shall be conducted in accordance with Mandatory Appendix I except for steam generator tubing examinations.

IWA-2233 Eddy Current Examination

Eddy current examination shall be conducted in accordance with Section V, Article 8, Mandatory Appendix II.

IWA-2234 Acoustic Emission Examination

Acoustic emission may be used in lieu of the successive inspections of IWB-2420(b) or IWC-2420(b) to monitor growth of flaws detected by other NDE methods. The flaws shall be sized by ultrasonic examination in accordance with Mandatory Appendix I prior to initiating use of acoustic emission. Acoustic emission monitoring shall be initiated prior to resuming operation of the system. Acoustic emission shall be conducted in accordance with Section V, Article 13, with the following additional requirements:

(a) The following flaw growth calculation and acceptance criteria shall be used:

(1) Every two months during the current inspection period, calculate the flaw growth in accordance with Section V, Article 13, Mandatory Appendix I. Using this growth rate, predict the flaw size at the end of the current inspection period.

(2) If the calculated flaw size at the end of the current inspection period meets the acceptance criteria of IWB-3600 or IWC-3600, as applicable, continue the two-month monitoring process described in (1) above.

(3) If the calculated flaw size at the end of the current inspection period does not meet the acceptance criteria of IWB-3600 or IWC-3600, as applicable, the following actions shall be performed:

(-a) Calculate the flaw size at the end of the next two-month time span. If this calculated flaw size meets the acceptance criteria of IWB-3600 or IWC-3600, as applicable, continue the two-month monitoring process described in (1).

(-b) If the calculated flaw size at the end of the next two-month time span does not meet the acceptance criteria of IWB-3600 or IWC-3600, as applicable, the component shall be corrected by repair/replacement activity in accordance with IWB-3130 or IWC-3120, as applicable.

(b) If no flaw growth is observed for one operating cycle, the component examination schedule may revert to the original schedule of successive inspections of IWB-2410 or IWC-2410, as applicable.

IWA-2240 ALTERNATIVE EXAMINATIONS

Alternative examination methods, a combination of methods, or newly developed techniques may be substituted for the methods specified in this Division, provided the Inspector is satisfied that the results are demonstrated to be equivalent or superior to those of the specified method.

IWA-2300 QUALIFICATIONS OF NONDESTRUCTIVE EXAMINATION PERSONNEL

IWA-2310 GENERAL

(a) Personnel performing nondestructive examinations (NDE) shall be qualified and certified using a written practice prepared in accordance with ANSI/ASNT CP-189, Standard for Qualification and Certification of Nondestructive Testing Personnel, and ANSI/ASNT CP-105, Standard for Topical Outlines for Qualification of Nondestructive Testing Personnel, as amended by the requirements of this Division. Certifications based on earlier editions of ANSI/ASNT CP-189 are valid until recertification is required. Recertification shall be in accordance with the edition of ANSI/ASNT CP-189 referenced in IWA-1600 as amended by the requirements of this Division. Outside agencies, as defined in Mandatory Appendix VII, may be used to qualify NDE personnel; however, the Employer shall be solely responsible for the certification of Level I, II, and III personnel. Nondestructive and visual examination personnel qualified and certified in accordance with the requirements of this Division are qualified and certified to perform examinations in accordance with the requirements of previous Editions and Addenda.

(b) As an alternative to a personnel qualification program based on CP-189, the ASNT Central Certification Program (ACCP) may be used. The supplemental requirements of this Division shall apply to qualification of personnel in accordance with the ACCP.

IWA-2311 Written Practice

(a) The Employer shall prepare a written practice in accordance with ANSI/ASNT CP-189.

(b) The written practice shall specify the duties and responsibilities of the Principal Level III.

IWA-2312 NDE Methods Listed in ANSI/ASNT CP-189

(a) Qualifications shall be based on the methods, techniques, procedures, and equipment used for the NDE required by this Division.

(b) Training, qualification, and certification of ultrasonic examination personnel shall also comply with the requirements of Mandatory Appendix VII.

(c) Training, qualification, and certification of visual examination personnel shall also comply with the requirements of Mandatory Appendix VI.

(d) Training, qualification, and certification of steam generator tubing examination personnel shall include the requirements of IWA-2315.

(e) The visual examination training and experience hours specified in ANSI/ASNT CP-189 shall be applied to the combined certification of an individual for VT-1, VT-2, and VT-3 visual examination. Certification in only one of the VT techniques is a limited certification, and the requirements of IWA-2350 apply.

(f) Personnel certified in an NDE method, and whose training and experience in that method met the requirements of an edition of ASNT SNT-TC-1A or ANSI/ASNT CP-189 referenced by a previous edition or addenda of this Division, do not require additional training or experience hours when being certified or recertified to the same level by an employer, except as specified in (b).

IWA-2313 NDE Methods Not Listed in ANSI/ASNT CP-189

Personnel using NDE methods not addressed in ANSI/ASNT CP-189 shall be qualified as defined in ANSI/ASNT CP-189 or the ACCP and the Employer's written practice.

IWA-2314 Certification and Recertification

(a) Personnel shall be qualified by examination and shall be certified in accordance with ANSI/ASNT CP-189, except that the ASNT Level III certificate is not required. Level I, II, and III personnel shall be recertified by qualification examinations every 5 yr.

(b) Personnel qualified in accordance with the ACCP shall be recertified by examination every 5 yr.

(c) An ACCP certificate with current endorsements obtained by examination satisfies the General and Practical Examination requirements for Level I and II NDE personnel.

(d) Level I, II, and III NDE personnel may be certified or recertified without additional training or experience hours when

(1) certification or recertification is to the same level, and

(2) the candidate's training and experience in the NDE method met the requirements of an edition of ASNT SNT-TC-1A or ANSI/ASNT CP-189 referenced by a previous edition or addenda of this Division.

IWA-2315 Personnel Requirements for Examination of Steam Generator Tubing

Personnel performing analysis or NDE evaluation of the data shall be qualified. The qualification shall include a practical examination that includes techniques used and the types of flaws that may be found during examination of steam generator tubing.

IWA-2316 Alternative Qualifications of VT-2 Visual Examination Personnel (25)

(a) For system leakage tests and hydrostatic tests performed in accordance with IWA-5211(a) and IWA-5211(b), in lieu of the requirements of IWA-2310 through IWA-2314, personnel may perform VT-2 visual examinations after satisfying the following requirements:

(1) at least 40 hr plant walkdown experience, such as that gained by licensed and nonlicensed operators, local leak rate personnel, system engineers, quality control personnel, and nondestructive examination personnel.

(2) training in the Section XI VT-2 examination requirements. As a minimum, the training shall include the following:

(-a) IWA-5240
(-b) VT-2 relevant conditions
(-c) hold times
(-d) test pressures
(-e) pressurizing medium
(-f) visual examination boundaries
(-g) plant-specific procedures for pressure testing and VT-2 visual examination

The training shall include an examination sufficient to demonstrate that the necessary information has been comprehended. Training and examination records shall be maintained for at least 5 yr after the individual's termination of employment.

(3) the vision test requirements of IWA-2321.

(b) Personnel meeting these alternative requirements shall not perform VT-2 functions other than examinations (e.g., verifying adequacy of procedures, training VT-2 personnel).

(c) These alternative VT-2 visual examination personnel requirements shall be described in the Owner's program or procedures and in the Employer's written practice if the Employer is not the Owner.

IWA-2317 Alternative Qualifications of VT-3 Visual Examination Personnel

(a) In lieu of the requirements of IWA-2310 through IWA-2314, VT-3 visual examination personnel may be qualified by satisfying the following requirements:

(1) at least 40 hr plant experience, such as that gained by plant personnel involved in installation, maintenance, or examination of pumps, valves, and supports, quality control personnel, and nondestructive examination personnel

(2) at least 8 hr of training in the Section XI requirements and plant-specific procedures for VT-3 visual examination

(3) the vision test requirements of IWA-2321

(4) for initial qualification, and at least every 3 yr thereafter, pass a written examination of at least 30 questions covering VT-3 examination attributes, VT-3 examination requirements, and plant-specific VT-3 procedures.

(b) The alternative qualification requirements shall be described in the Employer's written practice.

IWA-2318 Qualifications for Pneumatic Pressure Test Personnel

(a) For system leakage tests of pneumatic systems and components performed in accordance with IWA-5242, test personnel shall be certified in accordance with the requirements of IWA-2310, IWA-2311, IWA-2312(a) and IWA-2312(e), IWA-2313, and IWA-2314.

(b) In lieu of (a), test personnel performing pneumatic system or component leakage tests using a bubble test method may be qualified by satisfying the following requirements:

(1) the alternate VT-2 visual examination personnel requirements of IWA-2316, and

(2) a minimum of 8 hr of additional training in the specific test method for which they are to be qualified. This additional training shall include the following:

(-a) the basic principles of the test method

(-b) the use, limitations, and calibration requirements of the test equipment to be used

(-c) the requirements of Section V, Article 10 specific to the test method

(c) Written and practical demonstrations shall be administered in accordance with the requirements of CP-189.

(d) These qualification requirements shall be described in the Employer's written practice.

IWA-2320 QUALIFICATION EXAMINATIONS

IWA-2321 Vision Tests

The following tests shall be administered annually to NDE personnel:

(a) Personnel shall demonstrate natural or corrected near-distance acuity of 20/25 or greater Snellen fraction, with at least one eye, by reading words or identifying characters on a near-distance test chart, such as a Jaeger chart, that meets the requirements of IWA-2322. Equivalent measures of near-distance acuity may be used. In addition, personnel performing VT-2 or VT-3 visual examinations shall demonstrate natural or corrected far-distance acuity of 20/30 or greater Snellen fraction or equivalent with at least one eye.

(b) As an alternative to the visual acuity demonstration requirements of (a), any vision test administered by an optometrist, ophthalmologist, or other healthcare professional who administers vision tests and documents compliance with the acuity requirements of (a) is acceptable.

(c) Personnel shall demonstrate the capability to distinguish the colors applicable to the NDE methods for which certified and to differentiate contrast between these colors.

IWA-2322 Near-Distance Test Chart Qualification

A measurement of one of the near-distance test chart characters shall be made once before initial use, with an optical comparator (10X magnification or greater) or other suitable instrument, to verify that the height of a representative lowercase character, without an ascender or descender (e.g., a, c, e, o), for the selected type size, meets the requirements of Table IWA-2322-1. This measurement shall be documented and traceable to the test chart.

IWA-2323 Level III Personnel

The qualifications of Level III NDE personnel shall be evaluated using written examinations and a Demonstration Examination. The written examinations shall cover the Basic, Method, Specific, and Practical areas of knowledge as defined in (a), (b), (c), and (d). The Demonstration Examination shall be in accordance with ANSI/ASNT CP-189, Level II Practical Examination rules. The administration of multiple-choice written examinations may be delegated by the Level III, with valid Level III certifications in the applicable test methods, to a noncertified proctor, if so documented.

(a) The Basic Examination shall consist of at least 65 questions (required only once if certification is sought in more than one method).

(1) at least 20 questions related to understanding of ANSI/ASNT CP-189

(2) at least 30 questions related to applicable materials, fabrication, and product technology

(3) at least 15 questions that are similar to published Level II questions for other NDT methods

(b) The Method Examination shall consist of at least 65 questions.

(1) at least 30 questions related to fundamentals and principles that are similar to published ASNT Level III questions for each method

Table IWA-2322-1
Near-Distance Acuity Test Distances and Character Heights

Test Distance, in. (mm)	Maximum Lowercase Character Height, in. (mm)
12 (300)	0.022 (0.56)
13 (330)	0.024 (0.61)
14 (350)	0.025 (0.64)
15 (380)	0.027 (0.69)
16 (400)	0.029 (0.74)

GENERAL NOTE: The test distances (eye to chart) and corresponding character heights provide a visual angle of 6.25 minutes, which is equivalent to a Snellen fraction of 20/25.

(2) at least 15 questions related to application and establishment of procedures and techniques that are similar to published ASNT Level III questions for each method

(3) at least 20 questions related to capability for interpreting codes, standards, and specifications related to the method

(c) The Specific Examination shall contain at least 30 questions covering equipment, techniques, procedures, and administration of the Employer's written practice. The Specific Examination shall also cover the NDE requirements of this Division, including acceptance standards and referenced codes and standards.

(d) The Practical Examination shall be in accordance with ANSI/ASNT CP-189 requirements.

(e) An ASNT Level III certificate with current endorsements obtained by examination for the applicable method satisfies the Basic and Method Examination requirements.

(f) When an outside agency administers the examination and only a pass or fail grade is issued, the Employer shall assign a grade of 80% for a pass grade.

(g) Level III personnel shall be recertified using the written Method, Specific, and Practical Examinations and the Demonstration Examination. Alternatively, Level III personnel may be recertified using only the written Method and Specific Examinations, provided the following conditions are met.

(1) The Level III candidate was previously certified or recertified using all the written examinations and the Demonstration Examination.

(2) The Level III candidate is not being recertified due to interrupted service as defined in the Employer's written practice.

(3) The Level III candidate is not being certified by a new Employer.

(h) For initial certification, the grades for the Basic, Method, Specific, Practical, and Demonstration Examinations shall be averaged to determine the overall grade. For recertification, the grades of applicable examinations administered in accordance with (g) shall be averaged to determine the overall grade.

(i) An ACCP certificate with current endorsements obtained by examination satisfies the Basic, Method, Practical, and Demonstration examination requirements for Level III NDE personnel.

IWA-2324 Practical Examination Techniques for CP-189

(a) For an unlimited initial certification of personnel under programs based on ANSI/ASNT CP-189, the techniques demonstrated for purposes of practical examination shall be in accordance with Table IWA-2324-1. An individual demonstrating all of the techniques listed in Table IWA-2324-1 for a specific NDE method shall be considered qualified to perform examinations using any technique within that method.

(b) For recertification of Level I and II personnel who have completed the initial certification technique demonstrations described in (a) and documented performance of examinations in a specific NDE method on an annual basis, demonstration of only one technique in the method is required for recertification for methods other than visual examination.

IWA-2330 LEVEL I RESPONSIBILITIES

Level I personnel shall use written procedures when performing specific setups, calibrations, and examinations and when recording data. These activities shall be conducted under the guidance of Level II or Level III personnel. Level I personnel shall not perform an NDE evaluation or accept the results of a nondestructive examination.

IWA-2340 LEVEL III EDUCATION

Level III candidates shall have high school or equivalent education.

IWA-2350 LIMITED CERTIFICATION

Limited certification provisions of ANSI/ASNT CP-189 do not apply. Limited certification in a method is permitted for personnel who are restricted to performing examinations of limited scope, i.e., limited operations or limited techniques within the method. Topics that are not relevant to the limited certification may be deleted from the applicable training outline and may be accompanied by a corresponding reduction in training hours, examination content, and number of examination questions. Only questions related to the limited training are required. In addition, the required experience may be reduced by a corresponding amount. The specific methods and techniques covered by limited certification and the training, examination, and experience requirements for limited certification shall be defined in the written practice and documented in the individual's certification records.

IWA-2360 LEVEL I AND LEVEL II TRAINING AND EXPERIENCE

(a) A candidate may be qualified directly to Level II with no time as a Level I provided the required training and experience consists of the sum of the hours required for Level I and Level II certification.

(b) NDE training course outlines and materials shall be approved by a Level III. Previous training and experience may be accepted if verified by a Level III. The method of verification shall be documented in the candidate's certification records.

(c) Experience is work time in an NDE method. Classroom and laboratory training time shall not be credited as experience.

Table IWA-2324-1
Practical Examination NDE Techniques

Examination Method	Techniques
Radiographic [Note (1)]	RT — film radiography CR — computed radiography DR — digital radiography
Ultrasonic	Mandatory Appendix VII practical examination requirements apply in lieu of the requirements of ANSI/ASNT CP-189 Thickness measurement (limited, Subsection IWE): (a) digital or (b) a-scan
Ultrasonic (Subsection IWE only)	Thickness measurement (Subsection IWE)
Magnetic particle [Note (2)]	Coil (longitudinal magnetization) Yoke (longitudinal magnetization Direct contact (circular magnetization) Prods (circular magnetization)
Liquid penetrant [Note (3)]	WW — water washable PE — post emulsified SR — solvent removable
Eddy current [Note (4)]	Single frequency (a) absolute (b) differential (c) driver pickup Multifrequency (a) absolute (b) differential (c) driver pickup
Visual	VT-1 VT-2 VT-3

NOTES:
(1) At least one of the above shall be demonstrated with X-ray and at least one demonstrated with gamma radiography.
(2) At least one of the above shall be demonstrated with fluorescent particles and at least one of the above shall be demonstrated with visible particles.
(3) At least one of the above shall be demonstrated with fluorescent dye and at least one of the above shall be demonstrated with visible dye.
(4) Personnel qualified for multifrequency satisfy the requirements for single frequency.

IWA-2370 LEVEL III EXPERIENCE

Candidates for Level III certification shall meet one of the following criteria:

(a) Graduate of a 4-yr accredited engineering or science college or university with a degree in engineering or science, plus 1 yr experience in NDE in an assignment comparable to that of a Level II in the examination method.

(b) Completion with a passing grade of at least the equivalent of 2 full years of engineering or science study at a university, college, or technical school, plus 2 yr experience in an assignment comparable to that of a Level II in the examination method.

(c) Four years experience in an assignment comparable to that of a Level II in the examination method.

IWA-2380 NDE INSTRUCTOR

In lieu of the requirements of CP-189, a candidate being considered for qualification as an NDE Instructor shall satisfy the Level III Basic and Method Examination requirements of IWA-2323 and shall meet one of the following requirements:

(a) maintain a current teacher or vocational instruction certificate issued by a state, municipal, provincial, or federal authority; or

(b) complete a minimum of 40 hr instruction in training and teaching techniques.

IWA-2400 INSPECTION PROGRAM

IWA-2410 APPLICATION OF CODE EDITION AND ADDENDA

The Code Edition and Addenda for preservice inspection and for initial and successive inservice inspection intervals shall be as required by the regulatory authority having jurisdiction at the plant site.

(25) IWA-2420 INSPECTION PLANS AND SCHEDULES

Inspection plans and schedules shall be prepared for the preservice inspection, the first inservice inspection interval, and subsequent inservice inspection intervals.

(a) Each inspection plan shall include the following:

(1) identification of inspection period and interval dates

(2) identification of the Edition and Addenda of this Division that apply to the required examinations and tests

(3) the classification and identification of the components subject to examination and test

(4) identification of Code Cases proposed for use in accordance with IWA-2441

(5) identification of alternatives to Code requirements approved by the regulatory authority having jurisdiction at the plant site

(b) A schedule for performance of examinations and tests shall be prepared for each inspection plan. The schedule shall include the following:

(1) identification of the components selected for examination and test, including successive exams from prior periods

(2) the Code requirements by examination category and item number for each component requiring examination or test, the examination or test to be performed, and the extent of the examination or test

(3) identification of drawings showing items that require examination

(4) description of alternative examinations and identification of components to be examined using alternative methods

(c) Preservice inspection plans and schedules shall be completed prior to the start of preservice inspection, except as provided in (d). Any revisions to the preservice inspection plan or schedule shall be made prior to completion of Form OAR-1.

(d) Shop and field preservice examinations and tests may be performed prior to preparation and approval of a preservice inspection plan and schedule provided the following requirements are met:

(1) The preservice examination and tests are performed and documented in accordance with IWB-2200, IWC-2200, IWD-2200, IWE-2200, IWF-2200, and IWL-2200, as applicable for the item to be examined and tested.

(2) The Code Edition used for the preservice examination or test shall be identified on the examination or test record.

(e) Inservice inspection plans and schedules shall comply with the following:

(1) Inservice inspection plans and implementation schedules for the first inservice interval and subsequent inservice inspection intervals shall be prepared prior to the start of the interval.

(2) Inservice inspection plans and schedules shall be updated during the inspection interval, as necessary, for changes such as the addition of Code Cases to document the status of examinations and tests and to comply with the requirements of IWB-2411(b), IWC-2411(b), IWD-2411(b), IWE-2411(b), and IWF-2410(c).

IWA-2425 Inspection Plan and Schedule Supporting Documents (25)

Supporting documents necessary to the implementation of the inspection plan and schedule shall be available at the plant site. The documents may include the following:

(a) diagrams or system drawings showing boundaries and system classifications

(b) examination and test procedures

(c) specifications

(d) refueling outage schedules

(e) other documents required for implementation of the inservice examinations and tests

IWA-2430 INSPECTION INTERVALS

(a) The inservice examinations and system pressure tests required by Subsection IWB, Subsection IWC, Subsection IWD, Subsection IWE, and inservice examinations and tests of Subsection IWF shall be completed during each of the inspection intervals for the service lifetime of the plant. The inspections shall be performed in accordance with the schedule of the Inspection Program of IWA-2431.

(b) The inspection interval shall be determined by calendar years following placement of the plant into commercial service.

(c) For components inspected under the Inspection Program, the following shall apply:

(1) Each inspection interval may be extended by as much as 1 yr. Each inspection interval may be reduced without restriction, provided the examinations required for the interval have been completed. Successive intervals shall not extend more than 1 yr beyond the original pattern of 10-yr intervals and shall not exceed 11 yr in length. If an inspection interval is extended, neither the start and end dates nor the inservice inspection program for the successive interval need be revised.

(2) Examinations may be performed to satisfy the requirements of the extended period or interval in conjunction with examinations performed to satisfy the requirements of the successive period or interval. However, an examination performed to satisfy requirements

of either the extended period or interval or the successive period or interval shall not be credited to both periods or intervals.

(3) That portion of an inspection interval described as an inspection period may be extended by as much as 1 yr. An inspection period may be reduced without restriction, provided the examinations required for that period have been completed. This adjustment shall not alter the requirements for scheduling inspection intervals.

(4) The inspection interval for which an examination was performed shall be identified on examination records.

(d) In addition to (c), for plants that are out of service continuously for 6 months or more, the inspection interval during which the outage occurred may be extended for a period equivalent to the outage and the original pattern of intervals extended accordingly for successive intervals.

(e) The inspection intervals for items installed by repair/replacement activities shall coincide with remaining intervals, as determined by the calendar years of plant service at the time of the repair/replacement activities.

(f) The inspection intervals for inservice examination of Class CC components shall be in accordance with the requirements of IWA-2431.

IWA-2431 Inspection Program

The inspection intervals shall comply with the following, except as modified by IWA-2430(c) and IWA-2430(d):

(a) 1st Inspection Interval — 10 yr following initial start of plant commercial service

(b) Successive Inspection Intervals — 10 yr following the previous inspection interval

IWA-2440 APPLICATION OF CODE CASES

IWA-2441 Section XI Code Cases

(a) Code Cases to be used during a preservice or inservice inspection shall be identified in the Inspection Plan.

(b) Code Cases shall be applicable, as indicated in the Applicability Index for Section XI Cases found in the *Code Cases: Nuclear Components* book, to the Edition and Addenda specified in the Inspection Plan.

(c) Code Cases shall be in effect at the time the Inspection Plan becomes effective, except as provided in (d), (e), or IWA-2442.

(d) Cases superseded at the time the Inspection Plan becomes effective, but acceptable to the regulatory and enforcement authorities having jurisdiction at the plant site, may be used.

(e) Code Cases issued subsequent to the Inspection Plan effective date may be incorporated into the Inspection Plan.

(f) Superseded Code Cases approved for use in accordance with (a) through (e) may continue to be used.

(g) The use of any Code Case and revisions to previously approved Code Cases are subject to acceptance by the regulatory and enforcement authorities having jurisdiction at the plant site.

IWA-2442 Annulled Section XI Code Cases

Code Cases approved for use in accordance with IWA-2441 may be used after annulment for the duration of that Inspection Plan.

IWA-2500 EXTENT OF EXAMINATION

Requirements for examination of welds apply only to welds joining items and not welds correcting flaws in base material (including core closure welds in casting), unless otherwise stated.

IWA-2600 WELD REFERENCE SYSTEM

IWA-2610 GENERAL

A reference system shall be established for all welds and areas subject to surface or volumetric examination. Each such weld and area shall be located and identified by a system of reference points. The system shall permit identification of each weld, location of each weld centerline, and designation of regular intervals along the length of the weld.

IWA-2620 PIPING

Requirements for piping are provided in III-4300. The rules of III-4300 may also be applied to piping not within the scope of III-1100.

IWA-2630 VESSELS

The requirements of Section V, Article 4, Nonmandatory Appendix A are acceptable for vessels examined in accordance with Section V, Article 4.

IWA-2640 OTHER COMPONENTS

A reference system for component welds is given in IWA-2641. A different system may be used provided it meets the requirements of IWA-2610.

IWA-2641 Layout of Component Reference Points

The layout of the weld shall consist of placing reference points on the center line of the weld. The standard spacing of the reference points shall be 12 in. (300 mm). All points shall be identified with their numbers: 0, 1, 2, 3, 4, etc. The numbers of points, distance apart, and starting point shall be recorded on the reporting form. The weld center line shall be the divider for the two examination surfaces.

(a) Circumferential (Girth) Welds. The standard starting point shall be component 0 deg. The reference points shall be numbered clockwise as viewed from the top of the component. The examination surfaces shall be identified as above or below the weld.

(b) Longitudinal (Vertical) Welds. Longitudinal welds shall be laid out from the center line of circumferential welds at the top end of the weld. The examination surface shall be identified as clockwise or counterclockwise as viewed from the top of the component.

(c) Nozzle-to-Vessel Welds. The external reference circle shall have a sufficient whole number of inches radius so that the circle falls on the vessel external surface beyond the weld fillet. The internal reference circle shall have a sufficient whole number of inches radius so that the circle falls within $\frac{1}{2}$ in. (13 mm) of the weld centerline. Zero deg point on the weld shall be the top of the nozzle. The 0 deg point for welds of nozzles centered in heads shall be located at the 0 deg axis of the vessel. Angular layout of the weld shall be made clockwise on the external surface, counterclockwise on the internal surface. Zero, 90, 180, and 270 deg lines shall be marked on all nozzle welds examined; 30 deg increment lines shall be marked on nozzle welds greater than 4 in. (100 mm) radius; 15 deg increment lines shall be marked on nozzle welds greater than 12 in. (300 mm) radius; 5 deg increment lines shall be marked on nozzle welds greater than 24 in. (600 mm) radius.

ARTICLE IWA-3000
STANDARDS FOR EXAMINATION EVALUATION

IWA-3100 EVALUATION

(a) Evaluation shall be made of flaws detected during an inservice examination as required by Article IWB-3000 for Class 1 pressure-retaining components, Article IWC-3000 for Class 2 pressure-retaining components, Article IWD-3000 for Class 3 pressure-retaining components, Article IWE-3000 for Class MC pressure-retaining components, or Article IWF-3000 for component supports.

(b) If acceptance standards for a particular component, Examination Category, or examination method are not specified in this Division, flaws that exceed the acceptance standards for materials and welds specified in the Construction Code Edition or Addenda applicable to the construction of the component shall be evaluated to determine disposition.

IWA-3200 SIGNIFICANT DIGITS FOR LIMITING VALUES

(a) All observed or calculated values of dimensions of component thickness and of flaws detected by nondestructive examinations to be used for comparison with the acceptance standards of Article IWB-3000, Article IWC-3000, Article IWD-3000, or Article IWE-3000, whether obtained as decimals or converted from fractions, shall be expressed to the nearest 0.1 in. (2 mm) for values 1 in. (25 mm) and greater and to the nearest 0.05 in. (1.5 mm) for values less than 1 in. (25 mm). Rounding-off of values shall be performed in accordance with the Rounding-off Method of ASTM Recommended Practice E29.

(b) Interpolation of percentage values for acceptance standards, as required for intermediate flaw aspect ratios in the tables of allowable flaw standards, shall be rounded to the nearest 0.1%.

(c) Interpolation of decimal or fractional dimensions specified in the tables of allowable flaw standards shall be rounded to the nearest 0.1 in. (2 mm) or $^{1}/_{16}$ in. (2 mm), respectively.

(25) IWA-3300 FLAW CHARACTERIZATION

(a) Flaws detected by the preservice and inservice examinations shall be sized by the bounding rectangle or square for the purpose of description and dimensioning. The dimensions of a flaw shall be determined by the size of a rectangle or square that fully contains the area of the flaw.

(1) The length ℓ of the rectangle or one side of the square shall be drawn parallel to the inside pressure-retaining surface of the component.

(2) The depth of the rectangle or one side of the square shall be drawn normal to the inside pressure-retaining surface of the component and shall be denoted as a for a surface flaw and $2a$ for a subsurface flaw.

(3) The aspect ratio of a flaw shall be defined by a/ℓ. For use of acceptance standards, the flaw aspect ratio a/ℓ shall be set to 0.5 when the detected a/ℓ exceeds 0.5. For analytical evaluation of the flaw, a/ℓ may exceed 0.5. (See Figure IWA-3320-1, Flaw #3, as an example.)

(b) Flaws shall be characterized in accordance with IWA-3310 through IWA-3390, as applicable. If multiple flaws exist, each flaw shall be evaluated for its interaction with each adjacent flaw on an individual flaw basis, using the original flaw dimensions. First, the proximity of each flaw to the surface shall be determined. Any individual subsurface flaw that is determined to satisfy the criteria for surface interaction ($S < 0.4d_1$) shall be reclassified as a surface flaw. Next, the proximity of any flaw to adjacent flaws shall be evaluated using the original dimensions of each individual flaw. If two or more flaws are combined by the proximity rules, it is not required to consider further interactions based on the dimensions of the combined flaw with any other flaws or with the surface.

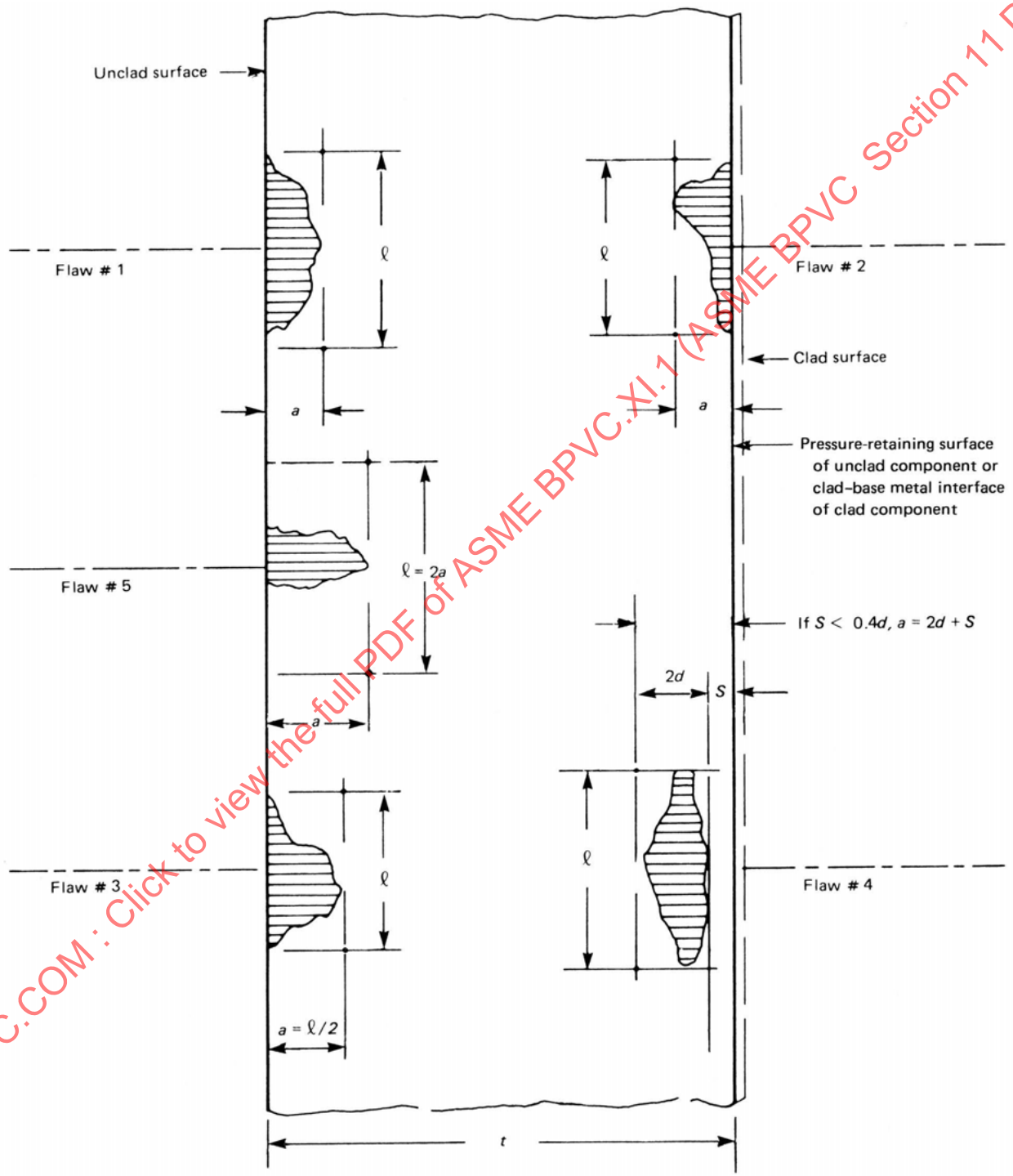
(c) The clad thickness dimension may be taken from the manufacturer's drawings.

IWA-3310 SURFACE PLANAR FLAWS

(a) A continuous indication shall be considered as a surface planar flaw if the detected area of the flaw is oriented primarily in any single plane, other than parallel to the surface of the component, and any portion of the flaw penetrates a surface of the component, as shown in Figure IWA-3310-1.

(b) A subsurface indication shall be considered a surface flaw if any portion of the flaw is less than $0.4d$ from the surface of the component nearest the flaw. If the nearest surface of the component is clad, S shall be measured to the clad–base metal interface. S is measured as shown in Figure IWA-3310-1. The thickness of the cladding used to establish the clad–base metal interface may be the nominal clad thickness specified on design drawings of the component.

Figure IWA-3310-1
Surface Planar Flaws Oriented in Plane Normal to Pressure-Retaining Surface
Illustrative Flaw Configurations and Determination of Dimensions a and ℓ (1/2 in. = 13 mm)



IWA-3320 SUBSURFACE PLANAR FLAWS

(a) A continuous indication shall be considered a subsurface planar flaw if the detected area of the flaw is oriented primarily in any single plane other than parallel to the surface of the component, and if the distance S from the flaw to the nearest surface of the component is as shown in Figure IWA-3320-1. If the nearest surface of the component is clad, S shall be measured to the clad–base metal interface. The thickness of cladding used to establish the clad–base metal interface may be the nominal clad thickness specified on design drawings of the component.

(b) The modified surface proximity rule for discriminating surface from subsurface indications of Figure IWA-3320-2 may be used to eliminate the need for successive examinations of IWB-2420(b) and IWC-2420(b) for subsurface flaws in vessels.

IWA-3330 MULTIPLE PLANAR FLAWS

(a) Discontinuous indications shall be considered single planar flaws if the distance between adjacent flaws is equal to or less than the dimension S, where S is determined as shown in Figure IWA-3330-1.

(b) The rules of IWA-3310 and IWA-3320 shall be applied to characterize multiple planar flaws as surface or subsurface planar flaws, respectively.

(c) The dimensions a and ℓ of such multiple planar flaws shall be those of the square or rectangle that contains the detected area of all flaws within the proximity limits defined in (a).

(d) Combination of multiple planar flaws is not required for fatigue or stress corrosion cracking assessment.

IWA-3340 NONPLANAR FLAWS

(a) A continuous indication whose detected area is not oriented in a single plane (such as two or more intersecting inclined planes, curvilinear geometry, or combinations of nonplanar geometry) shall be resolved into two planar flaws by projection of the flaw area into planes normal to the maximum principal stresses, as shown in Figure IWA-3340-1.

(b) The rules of IWA-3310 and IWA-3320 shall be applied to characterize the projected areas of the flaws as surface or subsurface flaws, respectively.

(c) The dimensions a and ℓ of such flaws shall be those of a rectangle that contains the projected area of the flaw as shown in Figure IWA-3340-1.

IWA-3350 PARALLEL PLANAR FLAWS

(a) Discontinuous indications whose areas are oriented primarily in parallel planes, and other than parallel to the surface of the component, shall be considered single planar flaws if the adjacent planes are within a distance S, where S is determined as shown in Figure IWA-3350-1.

(b) The dimensions a and ℓ of such flaws shall be those of the square or rectangle that contains the detected area of all flaws within the flaw–plane adjacency limits of (a), as shown in Figure IWA-3350-1.

IWA-3360 LAMINAR FLAWS

(a) Planar indications oriented within 10 deg of a plane parallel to the surface of the component shall be considered laminar flaws, except where noted otherwise in referenced figures of IWB-3500.

(b) Multiple laminar flaws, as shown in Figure IWA-3360-1, shall be combined into a single flaw if all three of the following proximity criteria are met:

(1) $S_1 \le 0.37 \min[\max(W_1, \ell_1), \max(W_2, \ell_2)]$

(2) $S_2 \le 0.37 \min[\max(W_1, \ell_1), \max(W_2, \ell_2)]$

(3) $H \le 0.17 \min[\max(W_1, \ell_1), \max(W_2, \ell_2)]$

If the detected areas of those flaws are partially or totally overlapping in any one direction, the proximity criteria in that direction are met.

(c) The area of a laminar flaw shall be 0.75 times the area of the square or rectangle that contains the detected area of those flaws that are within the proximity limits defined in (b).

IWA-3370 RADIOGRAPHIC EXAMINATION

(a) An indication detected by radiographic examination shall be considered to be a linear flaw unless the indication can be characterized as surface planar, subsurface planar, or laminar by supplemental examination.

(b) The supplemental examination of (a) may be by additional radiography, ultrasonic examination, or other methods provided they comply with the rules of IWA-2240.

IWA-3380 MULTIPLE NONALIGNED COPLANAR FLAWS

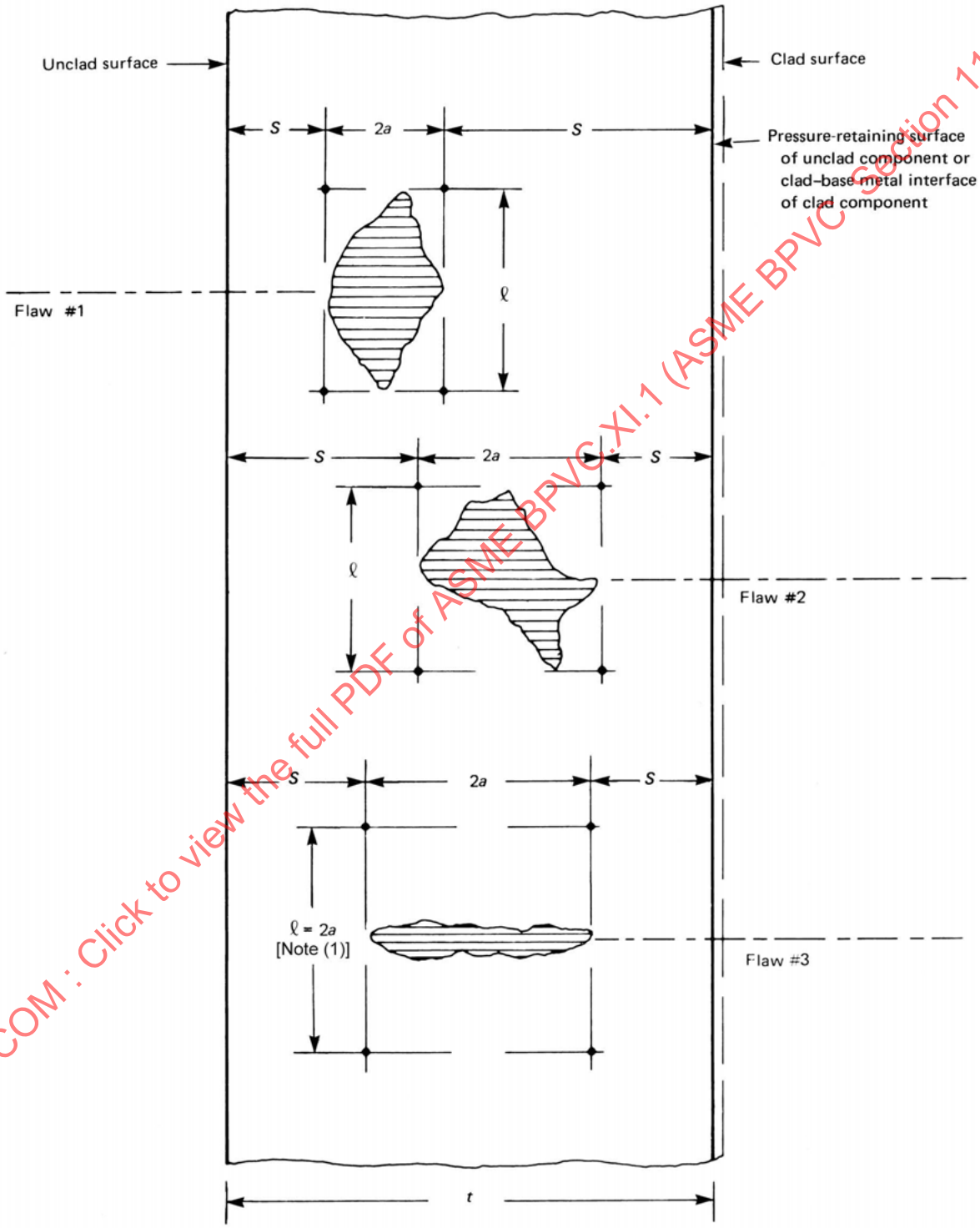
(a) Discontinuous indications that are coplanar and nonaligned in the through-wall direction of the section thickness t, and with at least one indication characterized as a surface flaw, shall be considered single planar surface flaws if the separation distances S_1 and S_2 between the individual flaws are equal to or less than the dimensions specified in Flaw #1 of Figure IWA-3380-1.

(b) The dimensions a and ℓ of the combined single flaw of (a) shall be defined by the size of the bounding square or rectangle that contains the individual nonaligned flaws as delineated in Figure IWA-3380-1.

(c) Discontinuous indications that are coplanar and nonaligned in the through-wall direction of the section thickness and characterized as subsurface flaws shall be considered single planar subsurface flaws if the separation distances S_1, S_2, S_3, and S_4 are equal to or less than the dimensions specified in Flaw #2 of Figure IWA-3380-1.

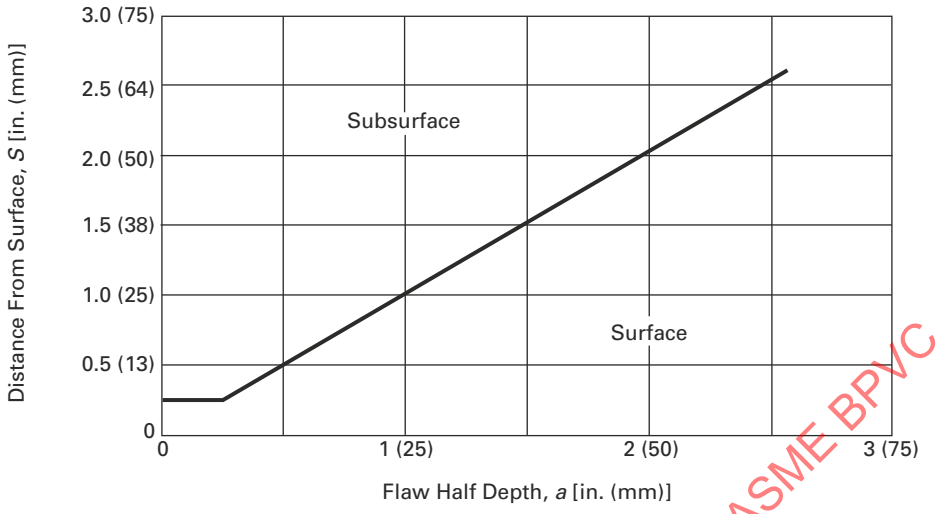
(25)

Figure IWA-3320-1
Subsurface Planar Flaws Oriented in Plane Normal to Pressure-Retaining Surface
Illustrative Flaw Configurations and Determination of Dimensions $2a$ and ℓ Where $S \geq 0.4a$
(1 in. = 25 mm)



NOTE:
(1) For analytical evaluation of the flaw, l may be less than $2a$.

Figure IWA-3320-2
Successive Examination Surface Proximity Rule for Class 1 and Class 2 Vessels



(d) The dimensions a and ℓ of the combined single flaw of (c) shall be defined by the size of the bounding square or rectangle that contains the individual nonaligned flaws as delineated in Figure IWA-3380-1.

(e) Flaw interaction within a group containing a greater number of individual flaws than shown in Figure IWA-3380-1 shall be governed by the same criterion of (a) or (c). However, in all cases, the initial characterization of flaw interactions shall not require a recharacterization even if the bounding square or rectangle reduces the separation distance S to another adjoining flaw to within the flaw interaction distance.

(f) Combination of multiple nonaligned coplanar flaws is not required for fatigue or stress corrosion cracking assessment.

IWA-3390 MULTIPLE ALIGNED SEPARATE FLAWS

Discontinuous flaws, as shown in Figure IWA-3390-1, that are coplanar in the through-wall direction of the section thickness, that are located within two parallel planes $^1/_2$ in. (13 mm) apart (i.e., normal to the pressure-retaining surface of the component), and that are aligned to reduce the net section thickness may be treated as separate and individual planar flaws if the following requirements are met.

(a) The a dimensions for the flaw aspect ratio, a/ℓ, of the individual flaws do not exceed the allowable flaw standards for the respective Examination Category applicable to the component, as provided in IWA-3310 for surface flaws and IWA-3320 for subsurface flaws.

(b) The additive flaw depth dimensions within the bounding parallel planes shown in Figure IWA-3390-1 are not in excess of the following limits:[3]

(1) two surface flaws (one a_1 on the outer and the other a_2 on the inner surface of the component), $(a_1 + a_2) \le (a_s + a'_s)/2$ within planes A–A′ and B–B′

(2) two subsurface flaws, $(a_1 + a_2) \le (a_e + a'_e)/2$ within planes C–C′ and D–D′

(3) two surface flaws and one subsurface flaw

(-a) $(a_1 + a_3) \le (a_s + a_e)/2$ within planes E–E′ and F–F′ (flaw depth dimensions a_1 and a_3 are not illustrated in Figure IWA-3390-1 for parallel planes E–E′ and F–F′)

(-b) $(a_1 + a_2 + a_3) \le (a_s + a_e + a'_s)/3$ within planes F–F′ and G–G′ (flaw depth dimensions a_1, a_2, and a_3 are illustrated in Figure IWA-3390-1 for parallel planes F–F′ and G–G′)

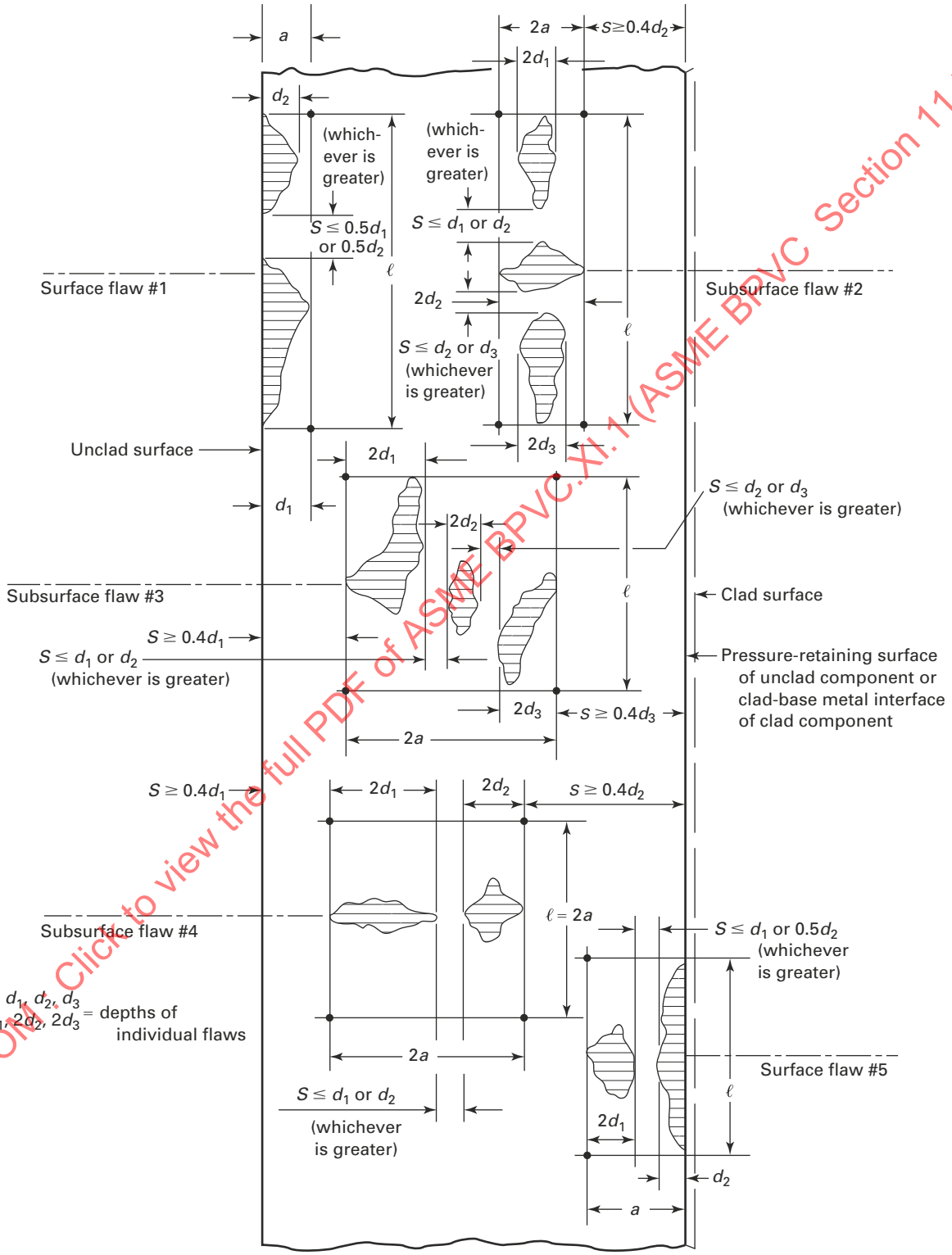
(-c) $(a_2 + a_3) \le (a'_s + a_e)/2$ within planes G–G′ and H–H′ (flaw depth dimensions a_2 and a_3 are not illustrated in Figure IWA-3390-1 for parallel planes G–G′ and H–H′)

IWA-3400 LINEAR FLAWS DETECTED BY SURFACE OR VOLUMETRIC EXAMINATIONS

(a) Linear flaws detected by surface (PT/MT) or volumetric (RT) examination methods shall be considered single linear surface flaws provided the separation distance between flaws is equal to or less than the dimension S, where S is determined as shown in Figure IWA-3400-1.

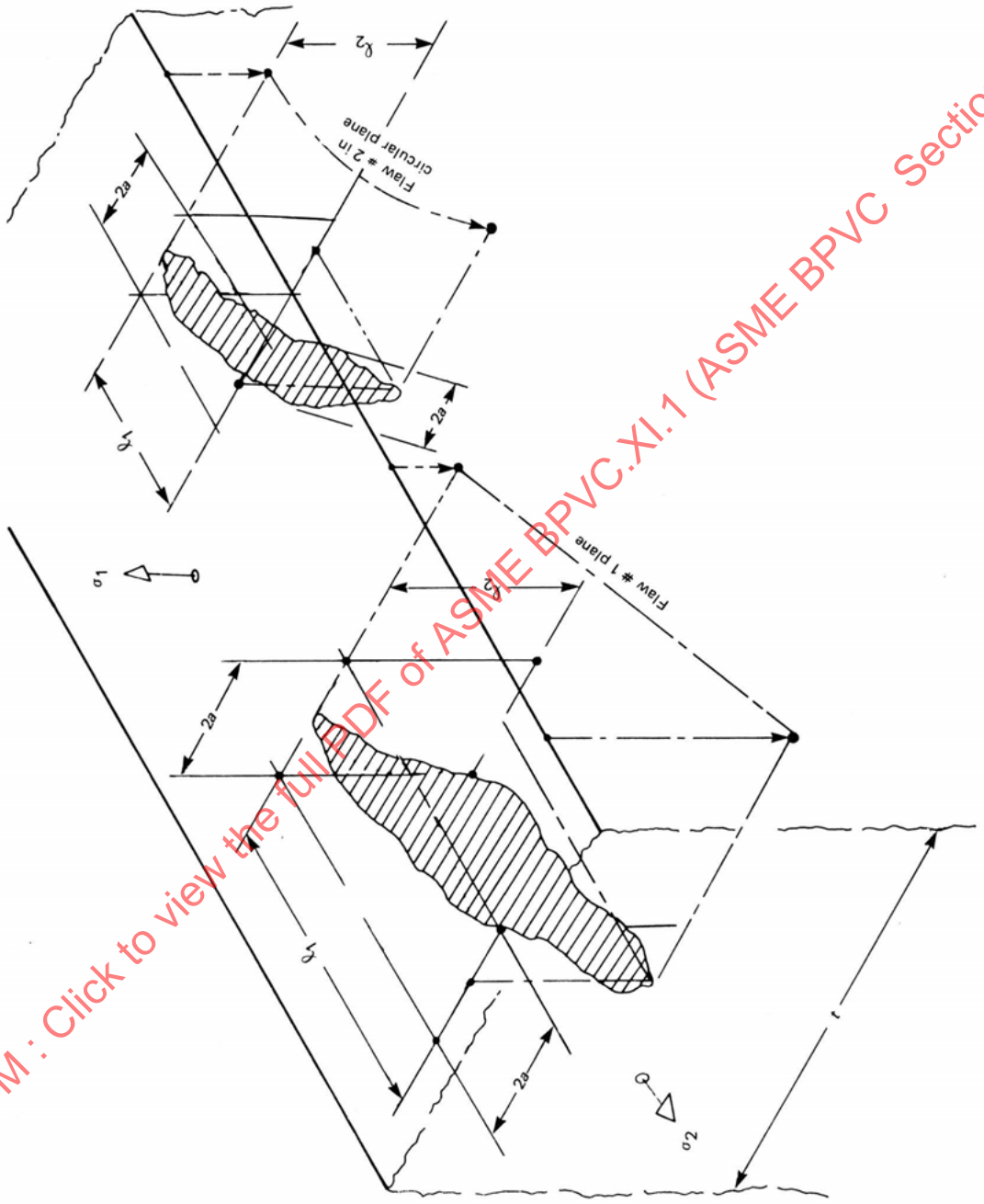
(b) The overall length ℓ of a single and discontinuous linear flaw shall be determined as shown in Figure IWA-3400-1.

Figure IWA-3330-1
Multiple Planar Flaws Oriented in Plane Normal to Pressure-Retaining Surface



GENERAL NOTE: For use in determining allowable flaw size and comparison with acceptance standards of IWB-3500.

Figure IWA-3340-1
Nonplanar Elliptical Subsurface Flaws



GENERAL NOTE: Flaw area shall be projected in planes normal to principal stresses σ_1 and σ_2 to determine critical orientation for comparison with allowable indication standards.

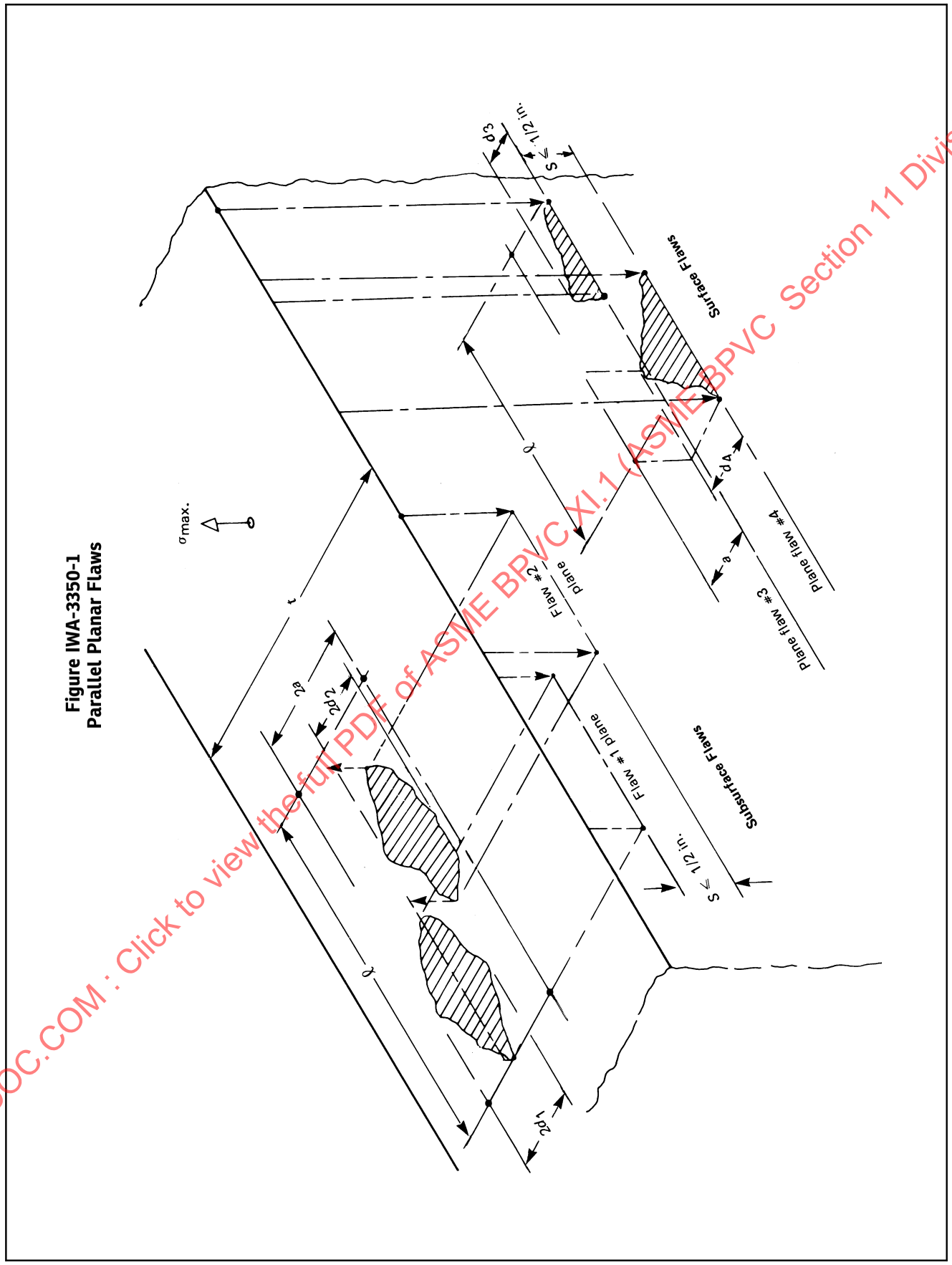


Figure IWA-3350-1
Parallel Planar Flaws

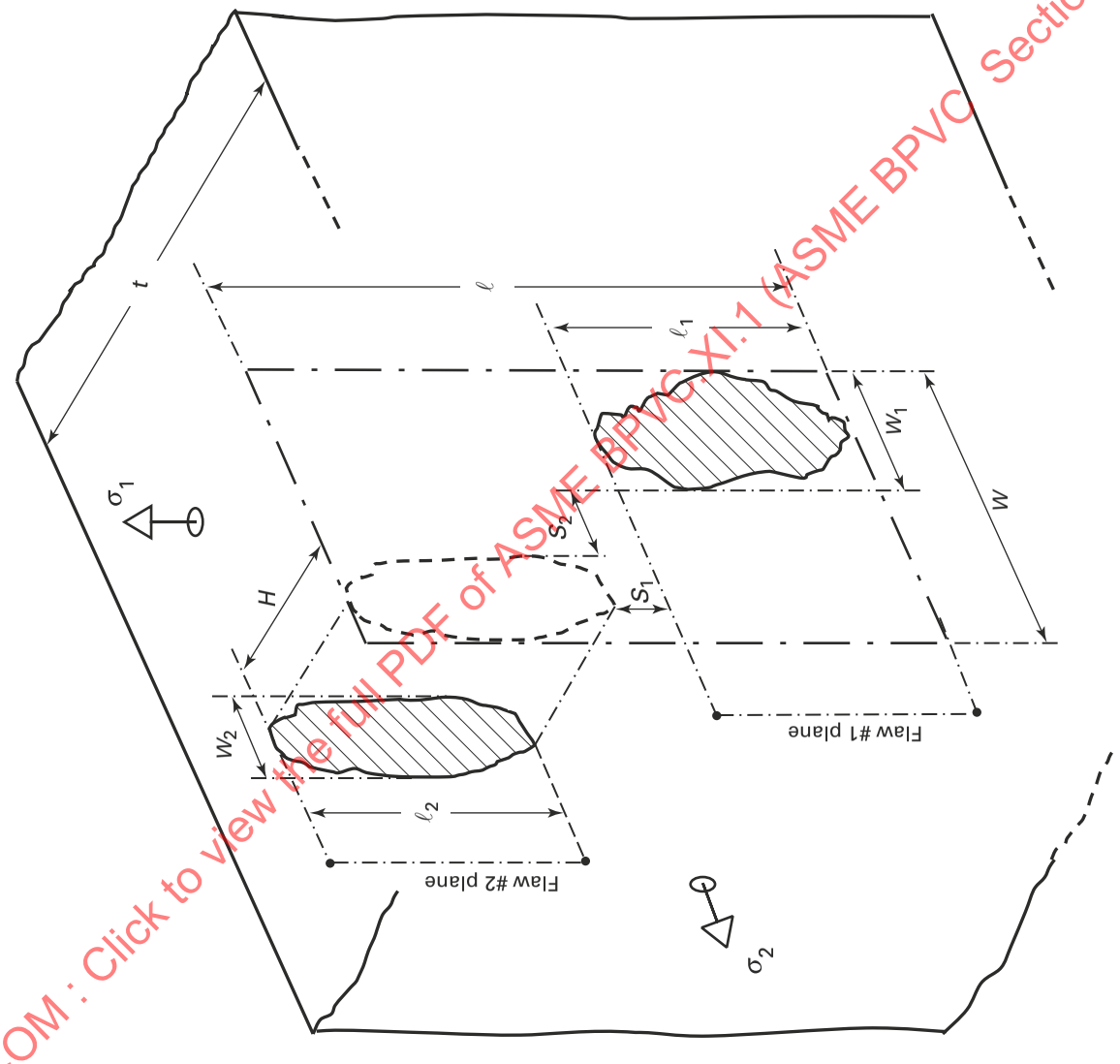
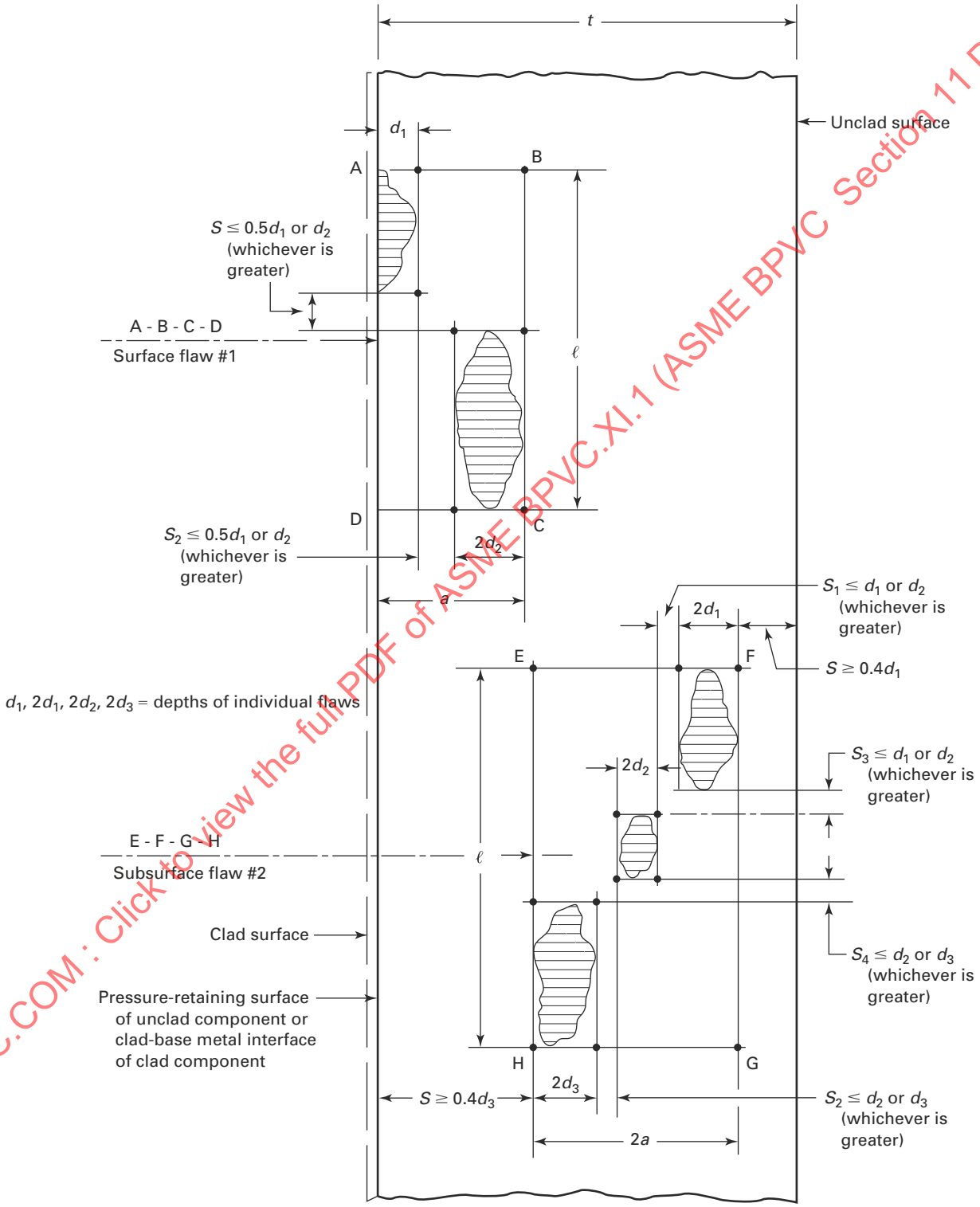


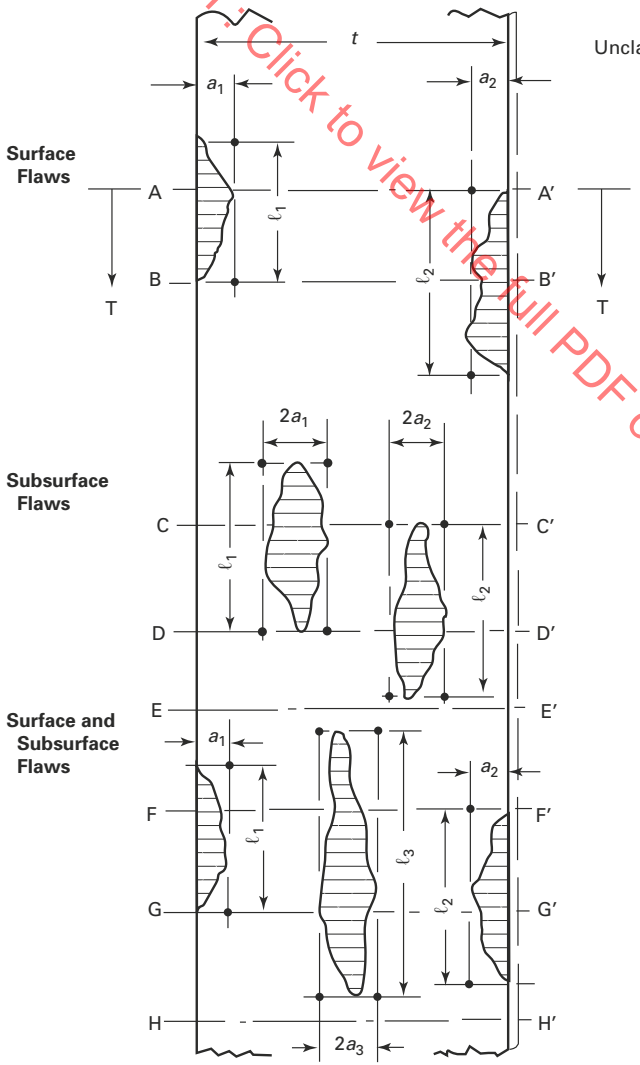
Figure IWA-3360-1
Laminar Flaws

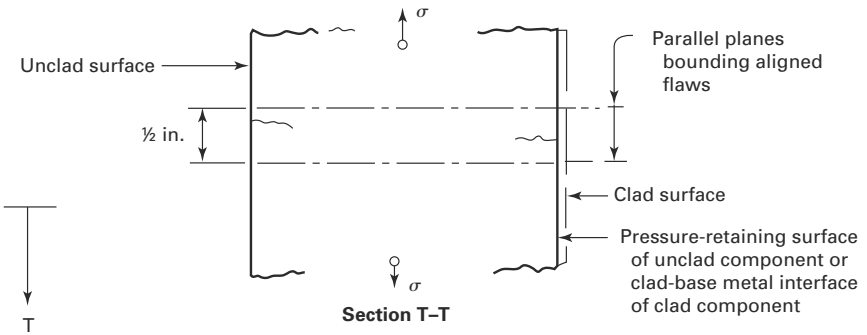
Figure IWA-3380-1
Nonaligned Coplanar Flaws in Plane Normal to Pressure-Retaining Surface
Illustrative Flaw Configurations



GENERAL NOTE: For use in determining allowable flaw size and comparison with acceptance standards of IWB-3500.

Figure IWA-3390-1
Multiple Aligned Planar Flaws (½ in. = 13 mm)

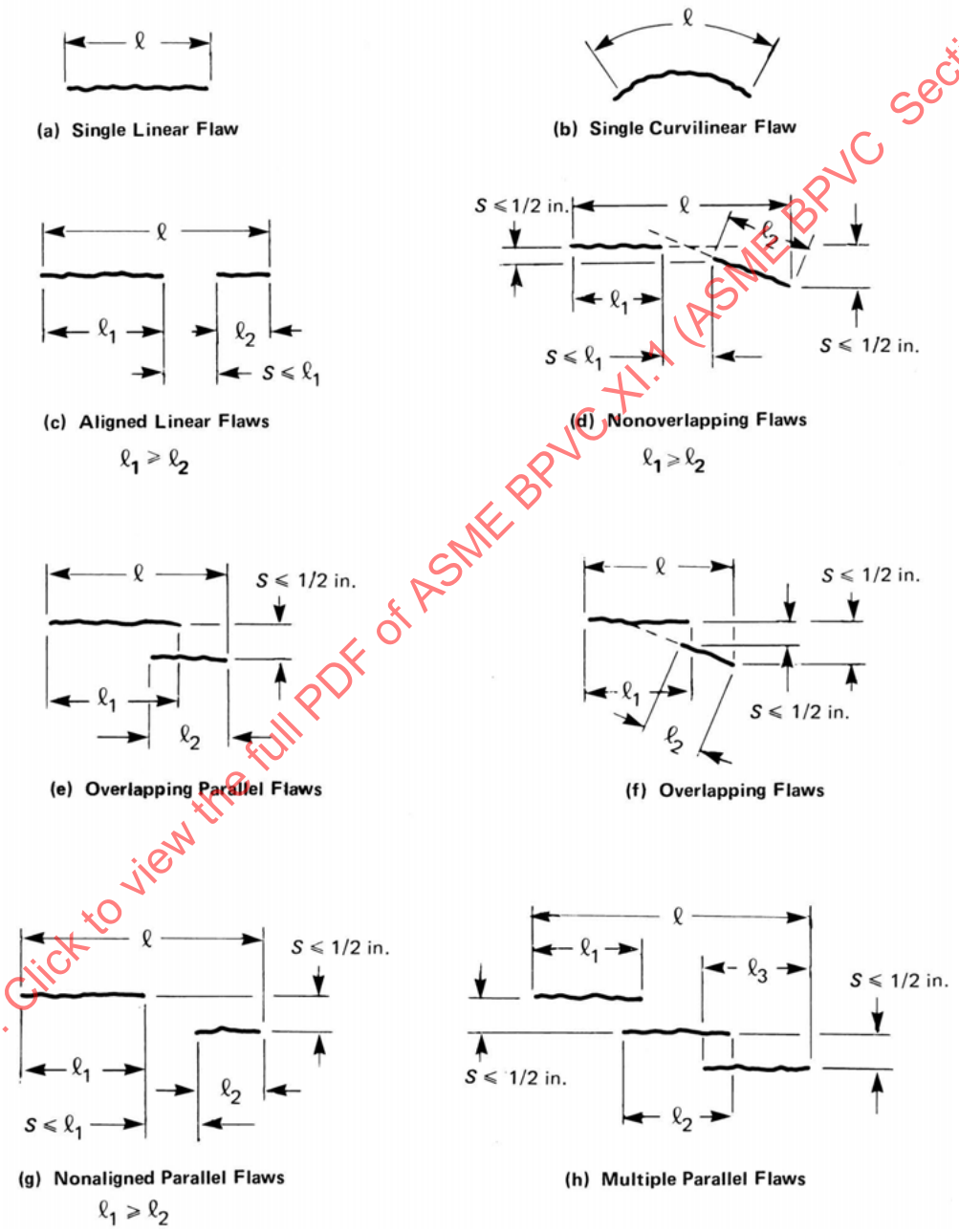




Section T–T

Illustrative Example for Sections Between A–A′ and B–B′

Figure IWA-3400-1
Linear Surface Flaws
Illustrative Flaw Configurations and Determination of Length ℓ ($\frac{1}{2}$ in. = 13 mm)



ARTICLE IWA-4000
REPAIR/REPLACEMENT ACTIVITIES

IWA-4100 GENERAL REQUIREMENTS

IWA-4110 SCOPE

(a) The requirements of this Article apply regardless of the reason for the repair/replacement activity[4] or the method that detected the condition requiring the repair/replacement activity.

(b) This Article provides requirements for repair/replacement activities[4] involving pressure-retaining components and their supports, including appurtenances, subassemblies, parts of a component, core support structures, metal containments and their integral attachments, and metallic portions of Class CC containments and their integral attachments. Repair/replacement activities include welding, brazing, defect removal, metal removal by thermal means, rerating, removing, adding, or physically modifying pressure-retaining items or supports, or adding systems. These requirements are applicable to procurement, design, fabrication,[5] installation, examination, and pressure testing of items within the scope of this Division.

(c) This Article provides requirements for repair/replacement activities performed on concrete containments and post-tensioning system items for concrete containments as specified in Article IWL-4000.

(d) Requirements for repair/replacement activities involving buried Class 3 polyethylene piping are in Mandatory Appendix XI of this Section.

IWA-4120 APPLICABILITY

(a) The requirements of this Article apply to items classified by the Owner in accordance with IWA-1400(a) as Code Class 1, 2, 3, MC, or CC, and their associated supports. Class 1 heat exchanger tube plugs and sleeves and Class 2 and 3 welded or brazed heat exchanger tube plugs and sleeves shall be considered pressure-retaining material.

(b) The requirements of this Article do not apply to the following, except as provided in (c) through (e):[6]

(1) valve operators, controllers, position indicators, pump impellers, pump drivers, or other accessories and devices unless they have been classified as Code Class 1, 2, or 3 pressure-retaining items in accordance with IWA-1320

(2) instruments or permanently-sealed, fluid-filled tubing systems furnished with instruments, but do apply to instrument, control, and sampling piping when classified as Code Class 1, 2, or 3 in accordance with IWA-1320

(3) rupture disk material (the requirements of this Article do apply to the portion of a rupture disk holder that forms the pressure boundary)

(4) orifice plates connecting piping of the same design pressure that are held in place mechanically

(5) other than component supports or core supports, material that is not associated with the pressure-retaining function of a component, such as shafts, stems, trim, spray nozzles, bearings, bushings, springs, wear plates, seals, packing, gaskets, valve seats, and ceramic insulating material and special alloys used as seal material in electrical penetration assemblies

(6) component support items such as gaskets, seals, bushing, springs, compression spring end plates, bearings, retaining rings, washers, wear shoes, shims, slide plates, and hydraulic fluids. Requirements, if any, for these items shall be stated in the Owner's Requirements.

(7) Class 2 and 3 heat exchanger tube mechanical plugs or sleeves

(c) If items identified in (b) require welding or brazing to the pressure-retaining portion of a component or to a component support such installation shall comply with the requirements of this Article.

(d) Applicable Construction Code requirements, such as design requirements for Class 1 valve stems, Owner responsibilities for assuring adequacy of intervening elements in the component support load path, and nondestructive examination of springs for Class 1 component supports, shall be met for items identified in (b).

(e) Nonmandatory Appendix J provides guidance in determining applicability of this Article.

IWA-4130 ALTERNATIVE REQUIREMENTS

IWA-4131 Small Items

IWA-4131.1 Applicability. Repair/replacement activities involving the following items need not meet any other requirement of Article IWA-4000, provided the alternative requirements of IWA-4131.2 are met.[6]

(a) Class 1 piping, tubing (except heat exchanger tubing, and sleeves and plugs used for heat exchanger tubing), valves, fittings, and associated supports, no larger than the smaller of (1) or (2) below:

(1) NPS[7] 1 (DN 25); or

(2) the size and design such that, in the event of postulated failure during normal plant operating conditions, the reactor can be shut down and cooled in an orderly

manner, assuming makeup is provided by normal reactor coolant makeup systems operable from on-site emergency power.

(b) Class 2 and 3 piping, tubing [except heat exchanger tubing, and sleeves and welded or brazed plugs used for heat exchanger tubing in heat exchangers not included in (c)], valves, and fittings, NPS 1 (DN 25) and smaller, and associated supports.

(c) Class 2 and Class 3 items, other than those described in (b), in segments of piping or tubing NPS 1 (DN 25) and smaller, and associated supports, that satisfy the following requirements:

(1) The interior free volume of the item shall be 1 ft^3 (0.028 m^3) or less.

(2) The item shall have no more than a total of four process connections. Instrument connections and normally closed vent and drain lines are not required to be counted as process connections.

(3) All connections shall meet the NPS 1 (DN 25) and smaller size criteria for the item to be considered a small item.

(d) Mechanical clamping devices installed on small items under IWA-4131 need not meet the provisions of IWA-4133, provided the requirements of IWA-4131.2 are met.

(25) **IWA-4131.2 Requirements.** For repair/replacement activities involving items identified in IWA-4131.1, the requirements of Article IWA-4000 need not be met except as provided in (a) through (e) below.

(a) Items shall be procured in accordance with the requirements of IWA-4142 and the technical requirements of IWA-4200. For Section III items, the requirements of Subsection NCA, NCA-3300 (previously NA-3700 or NCA-3800) need not be met, provided the Owner's Quality Assurance Program provides measures to assure that material is furnished in accordance with the material specification and the applicable material requirements of Section III. A repair/replacement plan, possession of a Certificate of Authorization, and an agreement with an Authorized Inspection Agency are not required for the organization constructing or fabricating these items.

(b) Repair/replacement activities shall be performed and documented in accordance with the requirements of IWA-4142 and the technical requirements of IWA-4400 and IWA-4520. A repair/replacement plan, pressure testing, services of an Authorized Inspection Agency, and completion of NIS-2 forms are not required.

(c) If an item to be subjected to a repair/replacement activity does not satisfy the requirements of this Division, the evaluation and corrective provisions of IWA-4160 apply.

(d) The applicable provisions of IWA-4310, IWA-4320, and IWA-4330 shall apply, except for IWA-4331(d).

(e) Use of these alternative requirements, including specifying the size of Class 1 items to which these requirements will be applied, shall be documented by the Owner in the Repair/Replacement program.

IWA-4132 Items Rotated From Stock (25)

Snubbers and pressure-retaining items[6] rotated from stock need not meet any other requirement of Article IWA-4000, provided the following requirements are met:

(a) The rotation shall be only for testing or preventive maintenance of the removed items.

(b) Items being removed and installed shall be of the same design and construction.

(c) Items being removed shall have no evidence of failure at the time of removal.

(d) Items being rotated shall be removed and installed only by mechanical means.

(e) Items being installed shall previously have been in service.

(f) The Owner shall track the items, by unique item identification, to ensure traceability of the installed location and in-service inspection and testing records.

(g) Use of an Inspector and an NIS-2 form are not required.

(h) Repair/replacement activities on removed items shall be performed in accordance with the requirements of this Article.

IWA-4133 Mechanical Clamping Devices Used as Piping Pressure Boundary

Mechanical clamping devices used to replace piping pressure boundary need not meet any other requirement of Article IWA-4000, provided the requirements of Nonmandatory Appendix W or IWA-4131.1(d) are met.

IWA-4134 Purchase, Exchange, or Transfer of Material Between Owners (25)

Material to be used in an application requiring compliance with Section III, Subsection NCA, NCA-3300 (previously NA-3700 or NCA-3800) may be purchased, exchanged, or transferred between Owners, provided the following requirements are met in lieu of the administrative requirements of IWA-4220.

(a) Materials shall have been procured by the supplying Owner in accordance with their Quality Assurance Program meeting the requirements of IWA-1400(o).

(b) Since receipt by the supplying Owner, the material shall not have been placed in service, welded, brazed, or subjected to any operation that might affect the mechanical properties of the material (e.g., heat treatment or forming).

(c) Documentation required by the supplying Owner's Construction Code and/or Owner's Requirements and Quality Assurance Program shall be provided to the receiving Owner with the material.

(d) When the material is fabricated in accordance with specific dimensional requirements in addition to those provided in a national standard (e.g., nonwelded valve bonnet or nonwelded pump casing), the evaluation of suitability required by IWA-4160 shall include an evaluation of the material for its intended application, including any differences that might affect form, fit, or function.

(e) The receiving Owner shall obtain certification for the following:

(1) The supplying Owner purchased and maintained the material in accordance with their Quality Assurance Program.

(2) Since receipt by the supplying Owner, the material has not been placed in service, welded, brazed, or subjected to any operation that might affect the mechanical properties of the material (e.g., heat treatment or forming).

(f) The receiving Owner shall verify the Owner's Requirements and ensure the technical requirements of the Construction Code in accordance with IWA-4221 are met.

IWA-4140 RESPONSIBILITIES

IWA-4141 Owner's Responsibilities

It is the responsibility of the Owner to provide or cause to be provided the following:

(a) Repair/Replacement Program and plans required by IWA-4150;

(b) specification requirements for repair/replacement activities.

IWA-4142 Repair/Replacement Organization's Quality Assurance Program

(a) The organization that performs repair/replacement activities shall establish a Quality Assurance Program for control of their activities in accordance with the Repair/Replacement Program and Plans. The Quality Assurance Program shall comply with either of the following:

(1) IWA-1400(o), when the Owner is the Repair/Replacement Organization.

(2) When the Repair/Replacement Organization is other than the Owner, the Repair/Replacement Organization's Quality Assurance Program shall be documented and shall comply with the applicable quality assurance program criteria of 10 CFR 50 Appendix B supplemented as necessary to be consistent with the Owner's Quality Assurance Program; ASME NQA-1, Part 1; or Section III, Subsection NCA, Article NCA-4000. The Owner shall ensure that the Repair/Replacement Organization's Quality Assurance Program meets the requirements of this Article for the activities to be performed. The program shall be reviewed and accepted by the Owner.

(b) When the performance of repair/replacement activities is split between the Owner and a Repair/Replacement Organization, each organization's Quality Assurance Program shall comply with (a)(1) or (a)(2) for their respective activities. The Owner shall be responsible for establishing interfaces and for assuring that the requirements of this Article are met by the combination of the two Quality Assurance Programs.

IWA-4142.1 Alternative Quality Assurance Program Requirements for Owners.

(a) When the original Construction Code is Section III, the following alternative requirements may be used by the Owner in lieu of the requirements of Section III, Subsection NB/NCD/NC/ND/NE/NF/NG-2600:

(1) When procuring qualified source material, the Owner may qualify the supplier under the provisions of their Quality Assurance Program required by IWA-1400(o).

(2) Certified Material Test Reports or Certificates of Compliance, as required by the Edition or Addenda of Section III applicable to the purchase, shall be obtained for all purchased material.

(3) Small products, as defined by Subsection NB/NCD/NC/ND/NE/NF/NG-2610(b) and (c), may be accepted by the Owner under the provisions of their Quality Assurance Program required by IWA-1400(o) with measures to ensure that the material is furnished in accordance with the material specification, the Owner's Requirements, and the technical requirements of the Construction Code.

(b) Owners shall qualify unqualified source material for their use under the provisions of their Quality Assurance Program required by IWA-1400(o) with the following additional requirements:

(1) The organization that establishes the material form and issues the source material test report shall not perform any welding with filler metal and shall confirm that no welding with filler metal has been performed.

(2) Appropriate testing shall be performed to verify the chemical composition of each piece of unqualified source material.

(3) Other requirements and nondestructive examination required by the material specification, Construction Code, or Owner's Requirements shall be either verified or performed for each piece.

(4) Upon receipt of the unqualified source material, the Owner shall verify by review of objective evidence that the requirements of the procurement document have been met.

(5) When the Owner credits actions taken by the supplier for meeting (2), (3), or (4), the Owner shall verify an audit of the supplier is conducted, or has been conducted within the last 3 yr, to ensure that controls are in place confirming that the actions and information are accurate and reliable. The audit shall also verify heat/lot controls, including markings with traceability, to any documentation provided by the supplier.

(6) Material obtained by an Owner under the provisions of (b) may be used only for the nuclear plants operated by the Owner performing these activities.

(c) When using unqualified source material or accepting small products, the Owner shall record use of these alternative requirements on a Certified Material Test Report or a Certificate of Compliance, as applicable.

IWA-4143 Application of the ASME Certification Mark

(a) Application of the ASME Certification Mark with the NPT Designator is neither required nor prohibited for the fabrication of parts, appurtenances, piping subassemblies, and supports to be used by the Owner when performed by the Owner or Owner's contracted Repair/Replacement Organization with a quality assurance program that complies with IWA-4142. This fabrication is subject to the inspection requirements of IWA-4170. These provisions may not be used to manufacture complete pumps, valves, vessels, or tanks.

(b) Application of the ASME Certification Mark with the NA Designator is neither required nor prohibited for installation.

IWA-4150 REPAIR/REPLACEMENT PROGRAM AND PLAN

(a) Repair/replacement activities shall be completed in accordance with the Repair/Replacement Program. The Program is a document or set of documents that defines the managerial and administrative control for completion of repair/replacement activities.

(b) The Edition of Section XI used for the Repair/Replacement Program shall correspond with the Edition identified in the inservice inspection program applicable to the inspection interval. Alternatively, later Editions of Section XI, or specific provisions within an Edition later than those specified in the Owner's Inservice Inspection Program may be used. When provisions of later Editions are used, all related requirements shall be met.

(c) A repair/replacement plan shall be prepared in accordance with the Repair/Replacement Program whenever a repair/replacement activity is to be performed.

(d) A repair/replacement plan may be a single document or a set of documents[8] used to implement the applicable Article IWA-4000 requirements for each repair/replacement activity, which shall include the essential requirements for completion of the repair/replacement activity. A repair/replacement plan is not required for the design phase of a repair/replacement activity. However, a repair/replacement plan shall be prepared for rerating activities, other than for supports, as defined in IWA-4331(d), whether or not there is accompanying physical work. A repair/replacement plan shall identify the following for the specific repair/replacement activity:

(1) applicable Code Edition and Cases of Section XI

(2) Construction Code Edition, Addenda, Cases, and Owner's Requirements used for the following:

(-a) construction of the item to be affected by the repair/replacement activity

(-b) construction of the item to be installed by the repair/replacement activity

(-c) performance of the repair/replacement activities

(3) The following items, when applicable to the specific repair/replacement activity, shall be documented.

(-a) a description of any defects and nondestructive examination methods used to detect the defects

(-b) the defect removal method, the method of measurement of the cavity created by removing a defect, and, when required by IWA-2600, requirements for reference points

(-c) the applicable welding or brazing procedure, heat treatment, nondestructive examination, tests, and material requirements

(-d) the applicable examination, test, and acceptance criteria to be used to verify acceptability

(4) description of the repair/replacement activities to be performed

(5) expected life of the item after completion of the repair/replacement activity, when less than the remainder of the previous intended life (design life when specified by the Design Specification) of the item;

(6) whether application of the ASME Certification Mark and appropriate Designator is required in accordance with IWA-4143;

(7) documentation in accordance with Article IWA-6000.

IWA-4160 VERIFICATION OF ACCEPTABILITY

(a) If an item does not satisfy the requirements of this Division, the Owner shall determine the cause of unacceptability. Prior to returning the item to service the Owner shall evaluate the suitability of the item subjected to the repair/replacement activity. If the requirements for the original item are determined to be deficient, appropriate corrective provisions shall be included in the Owner's Requirements and Design Specification, as applicable.

(b) Whether or not the repair/replacement activity results from a failure to satisfy the requirements of this Division, the following requirements shall be met. If the expected life of the item after completion of the repair/replacement activity is less than the remainder of the previous intended life [IWA-4150(d)(5)], the Owner shall initiate actions that will result in a plan for additional examinations and evaluations to verify the acceptability of the item for continued service or shall schedule subsequent repair/replacement activities prior to the end of the expected life of the item.

IWA-4170 INSPECTION

The services of an Authorized Inspection Agency shall be used. The Owner shall notify the Authorized Inspection Agency prior to starting a repair/replacement activity and keep the Inspector informed of progress so that necessary inspections may be performed.

IWA-4180 DOCUMENTATION

(a) The reports and records required by Article IWA-6000 shall be completed for all repair/replacement activities.

(b) Documents shall be retained in accordance with IWA-6300.

(c) The following records shall be maintained current with respect to the item's design and configuration:

(1) Design Specifications

(2) Design Report or analysis that demonstrates compliance with the Construction Code or the Owner's Requirements

(3) Overpressure Protection Reports

(d) Revisions or updates to existing reports, records, specifications, and evaluations, as required by (c) or IWA-4311, shall be traceable to and from the original record or report to provide a record of the current status of the item. The review and certification requirements for technical revisions or updates shall be in accordance with the Owner's Requirements and the Construction Code [see IWA-4222(a)(1)].

IWA-4190 APPLICATION OF SECTION XI CODE CASES

(a) Cases shall be applicable, as indicated in the Applicability Index for Section XI Cases found in the *Code Cases: Nuclear Components* book, to the Edition specified for the repair/replacement activity.

(b) The use of any Case and revisions to previously approved Cases are subject to acceptance by the regulatory and enforcement authorities having jurisdiction at the plant site.

(c) Cases shall be in effect at the time of the repair/replacement activity except as provided in (d).

(d) Cases that are superseded at the time of the repair/replacement activity, but acceptable to the regulatory and enforcement authorities having jurisdiction at the plant site, may be used.

IWA-4200 ITEMS FOR REPAIR/REPLACEMENT ACTIVITIES

IWA-4210 GENERAL REQUIREMENTS

In the course of preparation.

IWA-4220 CODE APPLICABILITY

IWA-4221 Construction Code and Owner's Requirements

(a) An item to be used for repair/replacement activities shall meet the Owner's Requirements. Owner's Requirements may be revised, provided they are reconciled in accordance with IWA-4222. Reconciliation documentation shall be prepared.

(b) An item to be used for repair/replacement activities shall meet the Construction Code specified in accordance with (1), (2), or (3) below.

(1) When replacing an existing item, the new item shall meet the Construction Code to which the original item was constructed.

(2) When adding a new component to an existing system, the Owner shall specify a Construction Code that is no earlier than the earliest Construction Code used for construction of the system or of any originally installed component in that system.

(3) When adding a new system, the Owner shall specify a Construction Code that is no earlier than the earliest Construction Code used for other systems that perform a similar function.

(c) As an alternative to (b) above, the item may meet all or portions of the requirements of different Editions and Addenda of the Construction Code, or Section III when the Construction Code was not Section III, provided the requirements of IWA-4222 through IWA-4226, as applicable, are met. Construction Code Cases may also be used. Reconciliations required by this Article shall be documented. All or portions of later different Construction Codes may be used as listed below:

(1) Piping, piping subassemblies, and their supports: B31.1 to B31.7 to Section III.

(2) Pumps, valves, and their supports: from B31.1 to Draft Code for Pumps and Valves for Nuclear Power to Section III.

(3) Vessels and their supports: Section VIII to Section III.

(4) Atmospheric and 0 psig to 15 psig (0 kPa to 100 kPa) storage tanks and their supports: Section VIII, API 620, or API 650 to Section III.

IWA-4222 Reconciliation of Code and Owner's Requirements

(a) Code Requirements and Owner's Requirements may be technical or administrative.

(1) Only technical requirements that could affect materials, design, fabrication, or examination, and affect the pressure boundary, or core support or component support function, need to be reconciled.

(2) Administrative requirements, i.e., those that do not affect the pressure boundary or core support or component support function, need not be reconciled.[9] Examples of such requirements include quality assurance, certification, application of the ASME Certification Mark and appropriate Designator, Data Reports, and Authorized Inspection.

(b) The administrative requirements of either the Construction Code of the item being replaced or the Construction Code of the item to be used for replacement shall be met.

IWA-4223 Reconciliation of Components

(a) Reconciliation of later Editions or Addenda of the Construction Codes or alternative Codes as permitted by IWA-4221 is not required. The Owner shall evaluate any changes in weight, configuration, or pressure-temperature rating in accordance with IWA-4311.

(b) An earlier Edition and Addenda of the same Construction Code may be used, provided all technical requirements of the earlier Construction Code are reconciled.

IWA-4224 Reconciliation of Material

IWA-4224.1 Identical Material Procured to a Later Edition or Addenda of the Construction Code, Section III, or Material Specification.

(a) Materials, including welding and brazing materials, may meet the requirements of later dates of issue of the material specification and later Editions and Addenda of the same Construction Code or Section III when the Construction Code was not Section III, provided the materials are the same specification, grade, type, class, or alloy, and heat-treated condition, as applicable.

(b) Differences in the specified material tensile and yield strength shall be compared. If the replacement material has a lower strength, a comparison shall be made of the allowable stresses. If the tensile or yield strength is reduced and allowable stresses are reduced, the effect of the reduction on the design shall be reconciled. For welding materials, any reduction in specified tensile strength shall be evaluated to ensure that the strength of the filler metal meets or exceeds the strength of the base materials.

IWA-4224.2 Identical Material Procured to an Earlier Construction Code Edition or Addenda or Material Specification.

(a) Materials, including welding and brazing materials, may meet the requirements of earlier dates of issue of the material specification and earlier Editions and Addenda of the same Construction Code, provided the materials are the same specification, grade, type, class, or alloy, and heat-treated condition, as applicable.

(b) Differences in the specified material tensile and yield strength shall be compared. If the replacement material has a lower strength, a comparison shall be made of the allowable stresses. If the tensile or yield strength is lower and allowable stresses are lower, the effect of the reduction on the design shall be reconciled. For welding materials, a lower specified tensile strength shall be evaluated to ensure that the strength of the filler metal meets or exceeds the strength of the base materials.

(c) Material examination and testing requirements shall be reconciled to the Construction Code requirements of the item.

IWA-4224.3 Use of a Different Material.

(a) Use of materials of a specification, grade, type, class, or alloy, and heat-treated condition, other than that originally specified, shall be evaluated for suitability for the specified design and operating conditions in accordance with IWA-4311.

(b) Material examination and testing requirements shall be reconciled to the Construction Code requirements of the item.

IWA-4224.4 Substitution of Material Specifications.

(a) When an SA or SB Specification is identified as being identical, or identical except for editorial differences, to the corresponding ASTM A or B Specification, either specification may be used.

(b) When an SFA Specification is identified as being identical, or identical except for editorial differences, to the corresponding AWS specification, either specification may be used.

IWA-4225 Reconciliation of Parts, Appurtenances, and Piping Subassemblies

(a) Parts, appurtenances, and piping subassemblies may be fabricated to later Editions and Addenda of the Construction Code and later different Construction Codes, as permitted by IWA-4221(c), provided materials are reconciled in accordance with IWA-4224. The Owner shall evaluate any changes in weight, configuration, or pressure–temperature rating in accordance with IWA-4311.

(b) An earlier Edition and Addenda of the same Construction Code may be used, provided all technical requirements of the earlier Construction Code are reconciled to the Construction Code requirements of the component or appurtenance into which the replacement item is installed, provided materials are reconciled in accordance with IWA-4224.

IWA-4226 Reconciliation of Design Requirements

IWA-4226.1 Design to All Requirements of a Later Edition or Addenda of the Construction Code. When an item is designed to all requirements of a later Edition or Addenda of the Construction Code, reconciliation beyond the design-related issues defined in IWA-4223, IWA-4224, and IWA-4225 is not required.

IWA-4226.2 Design to Portions of the Requirements of a Later Edition or Addenda of the Construction Code. When an item is designed to portions of the requirements of a later Edition or Addenda of the Construction Code, the following reconciliation, beyond the design-related issues defined in IWA-4223, IWA-4224, and IWA-4225, shall be performed.

(a) Material, fabrication, and examination requirements (e.g., NX-2000, NX-4000, and NX-5000 of Section III) shall be reviewed to reconcile the details applicable to design with the design of the replacement item.

(b) All design requirements related to the later portions shall be met, or any differences between the later design provisions and the previous design shall be reconciled.

(c) Later Editions or Addenda of the Construction Code may specify higher allowable stress values. These higher values may be used with design formulas, joint configurations, and fabrication and examination requirements of earlier Code Editions and Addenda, provided material properties are reconciled in accordance with IWA-4224.

IWA-4226.3 Design to All or Portions of a Different Construction Code. When an item is designed to all or portions of a different Construction Code, the following reconciliation, beyond the design-related issues defined in IWA-4223, IWA-4224, and IWA-4225, shall be performed.

(a) Material, fabrication, and examination requirements (e.g., NX-2000, NX-4000, and NX-5000 of Section III) shall be reviewed to reconcile the details applicable to design with the design of the replacement item.

(b) When an item is designed to portions of a different Construction Code, differences between the new design provisions and the previous design shall be reconciled.

IWA-4230 HELICAL-COIL THREADED INSERTS, CLASSES 1, 2, AND 3

Internal threads in pressure-retaining items may be replaced with helical-coil threaded inserts in accordance with the following requirements.

(a) Helical-coil threaded inserts shall satisfy the design requirements of the Construction Code for the specified loading to be applied to the threaded connection. For materials not listed in the Construction Code, primary stresses shall not exceed the lesser of two-thirds of the minimum specified yield strength or one-fourth of the minimum specified tensile strength of the applicable material.

(b) Helical-coil threaded inserts shall be purchased in accordance with the Owner's or Repair/Replacement Organization's Quality Assurance program meeting the requirements of IWA-4142.

(c) Helical-coil threaded inserts shall be supplied with a Certified Material Test Report that provides traceability to the item, material specification, chemical composition, grade or class, and mechanical properties and heat-treated condition prior to final forming.

(d) Helical-coil threaded inserts shall be installed in accordance with the manufacturer's instructions.

IWA-4300 DESIGN

IWA-4310 GENERAL REQUIREMENTS

IWA-4311 Material, Design, or Configuration Changes

When a physical change is made to the design or configuration of a pressure-retaining item or support, including material substitution, or for rerating (see IWA-4330), the change shall meet the following requirements:

(a) When an analysis of the item or system prior to the change is available, the change shall be evaluated and documented to demonstrate that the existing analysis is bounding for all design conditions. If the existing analysis does not bound all design conditions for the change, a reanalysis shall be performed. The evaluation may show that reanalysis is not required. The evaluation or reanalysis shall document that the proposed change meets the Owner's Requirements, and the Construction Code or alternative provisions of this Division. The evaluation or reanalysis shall be traceable in accordance with IWA-4180(d).

(b) When an analysis of the item or system prior to the change is unavailable (e.g., proprietary design, standard B16.5 flanges or fittings, standard B16.34 valve), an evaluation or a new analysis shall be performed to document that the proposed change meets the Owner's Requirements and the Construction Code or alternative provisions of this Division. The evaluation may show that an analysis is not required. The evaluation or new analysis shall be maintained in the same manner as a Design Report in accordance with (a) and IWA-4180(d).

(c) Later Editions and Addenda of the Construction Code or a later different Construction Code, in accordance with IWA-4221(c), either in its entirety or portions thereof, and Code Cases, may be used, provided the requirements of IWA-4226 are met.

(d) Analyses shall be reviewed and certified in accordance with the requirements of the Construction Code and Owner's Requirements. Evaluations shall be certified as required for analyses.

(e) For any design or configuration change that deviates from the Owner's Requirements, Design Specification, or Design Report, the affected documents shall be revised or updated in accordance with IWA-4180(d).

IWA-4320 MECHANICAL JOINTS

The type of piping joint used shall be suitable for the Design Loadings and shall be selected with consideration of joint tightness, mechanical strength, and the nature of the fluid handled. Piping joints shall conform to the requirements of the Construction Code, with leak tightness being a consideration in selection and design of joints for piping systems to satisfy the Owner's Requirements. Sleeve-coupled and other patented piping joints may be

designed to later editions of the Construction Code or Section III. In addition to the Construction Code and Owner's requirements, the following shall be met:

(a) Threaded joints in which the threads provide the only seal shall not be used for Class 1 applications. If a seal weld is employed as the sealing medium, the stress analysis of the joint shall include the stresses in the weld resulting from the relative deflections of the mated parts.

(b) Expanded joints shall not be used in Class 1 applications.

IWA-4330 RERATING

The provisions of this paragraph shall apply for rerating whether or not there is accompanying physical work.

IWA-4331 General Requirements

(a) The applicable design requirements of the Construction Code and Owner's Requirements shall be met. Later Editions and Addenda of the Construction Code or a later, different Construction Code, either in its entirety or portions thereof, and Code Cases may be used, provided the requirements of IWA-4221 are met.

(b) Overpressure protection shall be evaluated in accordance with the Construction Code and Owner's Requirements.

(c) The rerating shall be evaluated or analyzed in accordance with IWA-4311. The Owner's Requirements shall be reviewed and revised or updated when necessary.

(d) Form NIS-2 shall be completed for rerating, except for rerating component supports.

(e) If a nameplate with pressure or temperature rating is attached to the item or piping system, the Owner or the Owner's designee shall attach a new nameplate as close as practicable to the original nameplate. This nameplate shall contain the revised ratings and a reference to the rerating documentation.

(f) An ASME Certificate of Authorization is not required.

IWA-4332 Evaluation of Flaws

Inservice flaws that were previously evaluated and accepted by the evaluation provisions of Article IWB-3000, Article IWC-3000, Article IWD-3000, Article IWE-3000, Article IWF-3000, or Article IWL-3000, or known wall thinning, shall be evaluated or analyzed in accordance with IWA-4311.

IWA-4333 Examination

If rerating results in a design condition for which the Construction Code or Owner's Requirements requires a different examination than was originally performed, that examination shall be performed.

IWA-4334 Pressure Test Requirements

Rerated items shall be subjected to a system leakage test in accordance with Article IWA-5000 for the new service condition if the resulting test pressure would be higher than the pressure of previous pressure tests.

IWA-4340 MITIGATION OF DEFECTS BY MODIFICATION

Modification of items other than Class 1 may be performed to contain or isolate a defective area without removal of the defect, provided the following requirements are met.

(a) These requirements shall apply to physical modifications only.

(b) The alternative provisions of IWA-4131 may be applied to any portion of the mitigation performed in accordance with IWA-4340 only if the item containing the flaw meets the limitations of IWA-4131.1(b) or IWA-4131.1(c).

(c) These requirements shall not be applied when implementing IWA-4133, IWA-4411(h), or Cases that contain provisions for modification of items containing a defect.

(d) The defect shall be characterized using nondestructive examination and evaluated to determine its cause and projected growth.

(e) The modification shall provide for the structural integrity of the item such that it no longer relies on the defective area, including its projected growth, for the expected life of the item. The modification shall meet the Construction Code and Owner's Requirements for the item in accordance with IWA-4220.

(f) Welds and bolting used in the modification shall be added to the inspection plan and examined as required by IWA-4530. Following the modification, examination of the defective area in accordance with IWA-4530 is not required.

(g) In addition to meeting IWA-4160, the Owner shall perform an examination during each of the next two refueling outages to detect propagation of the flaw into the material credited for structural integrity of the item and, for high energy items, shall perform an examination to validate the projected flaw growth of (d) above. For all other items, validation of the projected flaw growth by examination shall be performed, if practicable. Projected or actual flaw growth into material credited for the structural integrity of the item shall be unacceptable. The examination used to validate flaw growth shall be the same method used to characterize the defect, or a volumetric examination in accordance with Mandatory Appendix I shall be performed.

(h) Unless the projected flaw growth is validated during the first or a subsequent examination, or the growth rate has been validated in prior Owner or industry experiences with the same conditions (e.g., system, base

material, degradation mechanism, and working fluid), the examination of (g) shall be repeated every refuel outage until the flaw is removed.

(i) If the flaw growth is validated in accordance with (g) or (h), the modification shall be examined in accordance with (g) once per interval, except as required by IWA-4160.

(j) Examinations in accordance with (h) and (i) are not required if the modification bounds the maximum possible extent of flaw growth such that the structural integrity of the item cannot be compromised.

(k) The examinations of (g) through (i) are not required if the original defect is removed and the modification is left in place.

(l) A system pressure test of the modification in accordance with Article IWA-5000 shall be performed. New welds, brazed joints, and mechanical connections, made in the course of the repair/replacement activity, shall be subjected to the required test pressure. The acceptance criteria for leakage at mechanical connections shall be established by the Owner.

(m) Modifications shall not be repeated at locations where the defect has propagated into material credited for the structural integrity of the modified item.

IWA-4400 WELDING, BRAZING, METAL REMOVAL, FABRICATION, AND INSTALLATION

IWA-4410 GENERAL REQUIREMENTS

Welding, brazing, defect removal, metal removal by thermal methods, fabrication, and installation performed by a Repair/Replacement Organization shall be performed in accordance with the requirements of this subarticle. Mechanical metal removal not associated with defect removal is not within the scope of this subarticle.

IWA-4411 Welding, Brazing, Fabrication, and Installation

Welding, brazing, fabrication, and installation shall be performed in accordance with the Owner's Requirements and, except as modified below, in accordance with the Construction Code of the item.

(a) Later editions and addenda of the Construction Code, or a later different Construction Code, either in its entirety or portions thereof, and Code Cases may be used provided the substitution is as listed in IWA-4221(c). Filler metal requirements shall be reconciled, as required, in accordance with IWA-4224.

(b) Revised Owner's Requirements may be used, provided they are reconciled in accordance with IWA-4222.

(c) The requirements of IWA-4440 shall be used for qualification of welding and brazing procedures, welders, and brazers. Welders and brazers include welding and brazing operators unless otherwise specified.

(d) The requirements of IWA-4500 shall be used for examination and testing of welds and brazes.

(e) The requirements of IWA-4600(b) may be used when welding is to be performed without the postweld heat treatment required by the Construction Code.

(f) The requirements of IWA-4660 may be used for underwater welding.

(g) The requirements of IWA-4700 shall be used for tube plugs and sleeves in Class 1 heat exchangers. The requirements of IWA-4700 may be used for welded installation of tube plugs and sleeves in Class 2 and Class 3 heat exchangers.

(h) Classes 1, 2, and 3 austenitic stainless steel pipe weldments may be repaired in accordance with Nonmandatory Appendix Q. If Nonmandatory Appendix Q is used, all requirements of Nonmandatory Appendix Q shall be met, and IWA-4520 and IWA-4530 do not apply.

(i) Welding electrodes and flux, and other welding and brazing filler material shall be stored and handled in accordance with a written procedure. Absorption of moisture by welding fluxes and cored, fabricated, or coated electrodes shall be minimized. When electrode storage and baking conditions are not specified by this Division, the precautions and recommendations of the electrode manufacturer shall be followed. Alternative electrode welding material control procedures may be used if accepted by the Inspector. Procedures for welding and brazing filler material control shall be included in the Repair/Replacement Program.

IWA-4412 Defect Removal

Defect removal shall be accomplished in accordance with the requirements of IWA-4420.

IWA-4413 Metal Removal by Thermal Methods

Metal removal by thermal methods shall be accomplished in accordance with the requirements of IWA-4461.

IWA-4420 DEFECT REMOVAL REQUIREMENTS

IWA-4421 General Requirements

Defects shall be removed in accordance with the following requirements:

(a) Defect removal by mechanical processing[10] shall be in accordance with IWA-4462.

(b) Defect removal by thermal methods shall be in accordance with IWA-4461.

(c) Defect removal by welding or brazing shall be in accordance with IWA-4411.

(1) Defect removal may include removal of all or a portion of the defective item, accompanied by installation of new material, either in accordance with the existing configuration or in a new configuration. Design or configuration changes shall meet IWA-4311.

(2) Welding or brazing to restore the minimum required material thickness may be considered defect removal. In this case, IWA-4422 does not apply.

IWA-4422 Defect Evaluation and Examination

IWA-4422.1 Defect Evaluation.

(a) A defect is considered removed when it has been reduced to an acceptable size. If the resulting section thickness is less than the minimum required thickness, the component shall be corrected by repair/replacement activities in accordance with this Article.

(b) Alternatively, the defect removal area and any remaining portion of the defect may be evaluated and the component accepted in accordance with the appropriate NDE evaluation or analytical evaluation provisions of Section XI, or the design provisions of the Owner's Requirements and either the Construction Code or Section III.

IWA-4422.2 Nondestructive Examination.

IWA-4422.2.1 Defect Removal Without Welding or Brazing.

(a) After removal of defects detected by visual or surface examination, surface examination of the defect removal area shall be performed.

(b) After removal of defects detected by volumetric examination, volumetric examination of the defect removal area shall be performed. The volumetric examination method that detected the defect shall be used.

(c) The acceptance criteria of either the Construction Code or Section XI shall be met.

(d) Indications detected as a result of excavation that are not associated with the defect being removed shall be evaluated for acceptability in accordance with the Construction Code or Section XI.

IWA-4422.2.2 Defect Removal Followed by Welding or Brazing.

(a) Surface examination of the defect removal area is required prior to welding, except as provided below.

(1) A surface examination is not required when the defect is eliminated by removing the full cross-section of the weld or base material.

(2) When surface examination of the excavation cannot be performed or will not provide meaningful results, surface examination of the excavation is not required. The acceptability of any remaining portion of the defect may be established by evaluation in accordance with IWA-4422.1(b) in lieu of the surface examination. Alternative NDE methods may be used to characterize any remaining portion of the defect.

(3) If final volumetric examination will be performed on the completed repair, the final volumetric examination method is the same as the method used to detect the defect, and the volume to be examined includes the location of the original defect, surface examination of the defect removal area is not required.

(b) The acceptance criteria of either the Construction Code or Section XI shall be used for the excavation.

(c) Surface examination of defect removal areas is not required for brazed joints.

(d) Indications detected as a result of excavation that are not associated with the defect being removed shall be evaluated for acceptability in accordance with the Construction Code or Section XI.

(e) Examination following welding or brazing shall be in accordance with IWA-4520.

IWA-4440 WELDING AND BRAZING QUALIFICATIONS (25)

(a) All welding and brazing shall be performed in accordance with Welding or Brazing Procedure Specifications that have been qualified by the Owner or Repair/Replacement Organization in accordance with the requirements of the codes specified in the repair/replacement plan.

(b) As an alternative to Section IX, QW-201 or QB-201, a procedure qualification record (PQR) qualified by one Owner or Repair/Replacement Organization may be used by another Owner or Repair/Replacement Organization. The Owner or Repair/Replacement Organization that performed the procedure qualification test shall provide documented certification that the procedure qualification was performed in accordance with Section IX and was conducted in accordance with a Quality Assurance Program that satisfies the requirements of IWA-4142.

(1) The Owner or Repair/Replacement Organization accepting the completed PQR shall be responsible for obtaining any additional supporting information needed for WPS or BPS development.

(2) The Owner or Repair/Replacement Organization accepting the completed PQR shall document, on each resulting WPS or BPS, the parameters applicable to welding or brazing. Each WPS or BPS shall be supported by all necessary PQRs.

(3) The Owner or Repair/Replacement Organization accepting the completed PQR shall accept responsibility for the PQR by documenting the Owner's or Repair/Replacement Organization's approval of each WPS or BPS that references the PQR.

(4) The Owner or Repair/Replacement Organization accepting the completed PQR shall demonstrate technical competence in application of the received PQR by completing a performance qualification using the parameters of a resulting WPS or BPS.

(5) The Owner or Repair/Replacement Organization may accept and use a PQR only when it is received directly from the Owner or Repair/Replacement Organization that certified the PQR.

(c) All welders and brazers shall be qualified by the Repair/Replacement Organization in accordance with the requirements of the codes specified in the Repair/Replacement Plan. Alternatively, a welder or brazer qualified by one Owner or Repair/Replacement Organization may be used by another Owner or Repair/Replacement Organization, if the following requirements are met:

(1) The Owner or Repair/Replacement Organization that performed the qualification test shall certify, by signing the record of Performance Qualification (WPQ or BPQ), that testing was performed in accordance with Section IX.

(2) The Owner or Repair/Replacement Organization that performed the qualification test shall certify, in writing, that the qualification was conducted in accordance with a Quality Assurance Program that satisfies the requirements of IWA-1400.

(3) The Owner or Repair/Replacement Organization accepting the WPQ or BPQ shall obtain any necessary supporting information to satisfy Section IX, QW-301.4 (e.g., Welding Procedure Specification, type of tests).

(4) The Owner or Repair/Replacement Organization accepting the WPQ or BPQ shall require each welder or brazer to demonstrate proficiency by completing a renewal qualification test in accordance with Section IX, QW-322.2(a) or QB-322(b).

(-a) If WPQ or BPQ transfer involves prior groove tests, the renewal test shall use a groove configuration.

(-b) When WPQ or BPQ transfer involves prior fillet tests, the renewal tests may use either a groove or a fillet configuration.

(5) The Owner or Repair/Replacement Organization accepting the WPQ or BPQ shall accept responsibility for the Performance Qualification Test and shall document acceptance on the WPQ or BPQ for the renewal test. This WPQ or BPQ shall reference the WPQ or BPQ supplied by the Owner that performed the qualification.

(6) The Owner or Repair/Replacement Organization accepting the WPQ or BPQ shall accept responsibility for compliance with Section IX, QW-322.

(7) The Owner or Repair/Replacement Organization may accept and use a WPQ or BPQ only if it is received directly from the Owner or Repair/Replacement Organization that performed the qualification.

(8) The Owner or Repair/Replacement Organization accepting the WPQ or BPQ shall comply with the Quality Assurance requirements of IWA-4142.

(d) Welders and brazers need not be employed directly by the Repair/Replacement Organization, provided the use of such welders and brazers is controlled by the Quality Assurance Program of the Repair/Replacement Organization. This Program shall include the following:

(1) requirements for complete and exclusive administration and technical supervision of all welders and brazers by the Repair/Replacement Organization;

(2) requirements for contractual control that provides the necessary authority to assign and remove welders and brazers at the discretion of the Repair/Replacement Organization;

(3) evidence that the Quality Assurance Program is acceptable to the Owner's Authorized Nuclear Inservice Inspector.

IWA-4460 METAL REMOVAL PROCESSES

IWA-4461 Thermal Removal Processes

Thermal removal processes include oxyacetylene cutting, carbon arc gouging, plasma cutting, metal disintegration machining (MDM), and electrodischarge machining (EDM).

IWA-4461.1 P-No. 1. When thermal removal processes are used on P-No. 1 materials, surface oxides shall be removed by mechanical processing prior to welding on cut surfaces.

IWA-4461.2 P-Nos. 3, 4, 5A, 5B, 5C, 6, 7, 9A, 9B, 9C, 10A, 10B, 10C, 10E Through 10K, and 11A Materials.

(a) When preheat is less than that specified in Table IWA-4461.1-1, material shall be removed by a mechanical method from all thermally processed areas, in accordance with the following:

(1) When welding is to be performed, at least $^{1}/_{32}$ in. (1 mm) of material shall be removed from the cavity to be welded.

(2) When welding is not to be performed, at least $^{1}/_{16}$ in. (1.5 mm) of material shall be removed and the area shall be faired into the surrounding area.

(3) Resulting irregularities shall be removed to a smooth surface by a mechanical method. This surface shall show no visual evidence of irregularities. The depth of material to be removed as required by (1) or (2) shall be measured from the smooth surface.

(b) When preheat is applied in accordance with Table IWA-4461.1-1, material shall be removed to bright metal by a mechanical method.

IWA-4461.3 All Other Materials. If thermal removal processes are used on materials other than those listed in IWA-4461.1 and IWA-4461.2, at least $^{1}/_{16}$ in. (1.5 mm) of material shall be mechanically removed from the thermally processed area.

IWA-4461.4 Alternatives to Mechanical Processing. Mechanical processing of thermally cut surfaces is not required if the thermal metal removal process is qualified as follows:

(a) The qualification test assembly for all ferrous materials, other than austenitic stainless steel or nickel base materials, shall consist of two coupons comparable to those to be cut in production as follows:

(1) The test coupon material shall be of the same P-No. and Group Number as the material to be cut in production.

(2) Alternatively, when the work piece does not have an associated P-No., the test coupon material shall have a carbon equivalence (CE) equal to or greater than the material to be cut in production. The CE shall be determined using Figure IWA-4663.1-1.

(b) The qualification test assembly for austenitic stainless steel or nickel base materials shall consist of two coupons comparable to those to be cut in production as follows:

Table IWA-4461.1-1
Minimum Preheat Temperature, °F (°C)

P-No. 3, and P-No. 11A	P-No. 4 and P-Nos. 9A, 9B, and 9C	P-Nos. 5A, 5B, and 5C, and P-No. 6	P-No. 7	P-Nos. 10A, 10B, 10C, and 10E Through 10K
200 (95)	250 (120)	300 (150)	None required	200 (95) [Note (1)]

NOTE:
(1) Applies only to material with a nominal section thickness of $^{3}/_{4}$ in. (19 mm) and greater.

(1) The test coupon material shall be of the same P-No. and grade as the material to be cut in production.

(2) Alternatively, when the work piece does not have an associated P-No., the test coupon material shall be the same material type or grade as the material to be cut in production.

(c) The qualification coupons shall be cut using the maximum heat input to be used in production.

(d) The thermally cut surface of each coupon shall be visually examined at 10X magnification and shall be free of cracks. The Owner shall specify surface roughness acceptable for the application and shall verify that the qualification coupon meets that criterion.

(e) Each qualification coupon shall be cross sectioned, and the exposed surfaces shall be polished, etched, and visually examined at 10X magnification. All sectioned surfaces shall be free of cracks.

(f) Corrosion testing of the thermally cut surface and heat-affected zone shall be performed if the cut surface is to be exposed to corrosive media. Alternatively, corrosion resistance of the thermally cut surface may be evaluated. The Owner shall specify the acceptance criteria.

IWA-4462 Mechanical Defect Removal Processes

(a) If a mechanical removal process is used for defect excavation and removal where welding is not to be performed, the area shall be faired into surrounding area.

(b) Where cavity welding is to be performed, the cavity shall be ground smooth and clean with beveled sides and edges rounded such that the cavity is suitable for welding.

IWA-4500 EXAMINATION AND TESTING

IWA-4510 GENERAL REQUIREMENTS

IWA-4511 NDE Personnel Qualification

Personnel performing nondestructive examination required by the Construction Code shall be qualified and certified in accordance with the Construction Code identified in the repair/replacement plan or IWA-2300. When using IWA-2300, personnel performing visual examinations shall be qualified for performance of VT-1 visual examinations and shall have received additional training in examination of weldments for fabrication conditions, including dimensional requirements and fabrication flaws.

IWA-4512 Use of Section V

For Section V examination methodologies referenced by the Construction Code, the Edition and Addenda of Section V shall be the same as the Edition and Addenda of the Construction Code. Alternatively, Articles from later Editions and Addenda of Section V may be used, provided related requirements of those Articles are met.

IWA-4520 EXAMINATION (25)

(a) Welding or brazing areas and welded joints made for fabrication or installation of items by a Repair/Replacement Organization shall be examined in accordance with the Construction Code identified in the Repair/Replacement Plan, with the following exceptions:

(1) Base metal repairs on Class 3 items are not required to be volumetrically examined when the Construction Code does not require that full-penetration butt welds in the same location be volumetrically examined.

(2) When welding or brazing is performed in accordance with IWA-4600 or IWA-4700, the examination requirements of IWA-4600 or IWA-4700, respectively, shall be met in lieu of examinations required by the Construction Code or Section III.

(b) Except as required by (a)(2) above, when (a) above requires surface or volumetric examinations to be performed on pressure-retaining installation (but not fabrication) welds or welds made for correction of flaws or defects, the Owner may authorize use of the personnel qualifications, methods, techniques, and acceptance criteria of Section XI, in lieu of those of the Construction Code, provided the following requirements are met:

(1) The surface examination methods shall be limited to those permitted by the Construction Code.

(2) If the Construction Code requires radiographic examination, the Owner may instead authorize use of ultrasonic examination in accordance with Nonmandatory Appendx AA for ferritic or austenitic pipe welds that are part of a repair/replacement activity.

(3) All other examination requirements of the Construction Code, including surface area requirements and timing of examinations, shall be met.

(4) The weld or braze material deposited as part of the repair/replacement activity shall meet the preservice acceptance standards of Section XI. If Section XI does not

provide preservice acceptance standards, the acceptance criteria of the Construction Code or Section III shall be met.

(5) Acceptability of remaining flaws that existed prior to the repair/replacement activity shall be established using the provisions of Article IWA-3000.

(c) These examinations may be performed concurrently with the preservice inspections required by IWA-4530 and shall be completed prior to returning the system to service.

IWA-4530 PRESERVICE INSPECTION

When portions of items requiring preservice or inservice inspection are affected by repair/replacement activities, or for items being fabricated or installed, including welded or brazed joints made for fabrication or installation of items, preservice inspections shall be performed in accordance with IWB-2200, IWC-2200, IWD-2200, IWE-2200, IWF-2200, or IWL-2200 prior to return of the system to service. The preservice inspection may be performed either prior to or following the pressure test required by IWA-4540.

IWA-4540 PRESSURE TESTING OF CLASS 1, 2, AND 3 ITEMS FOLLOWING REPAIR/ REPLACEMENT ACTIVITIES

(a) No pressure testing is required for the following repair/replacement activities or associated items:

(1) components or connections NPS 1 (DN 25) or smaller

(2) bolts, studs, nuts, and washers

(3) threaded or bolted connections

(4) non-pressure-retaining items, such as supports, mechanical attachments, pump shafts, or valve stem seals

(5) valve discs or seats

(6) heat exchanger tube plugging and sleeving

(b) Replacement components and appurtenances shall be pressure tested in accordance with the Construction Code selected for use in accordance with IWA-4221.

(c) Unless exempted by (a) or (d) or addressed by (f), repair/replacement activities performed by welding or brazing on a pressure-retaining item shall include a pressure test in accordance with Article IWA-5000 after completion of the welding or brazing and prior to, or as part of, returning to service. Only brazed joints and welds made in the course of a repair/replacement activity within the boundaries of IWB-5222(b), IWC-5222, or IWD-5222, require pressurization and VT-2 visual examination during the test.

(d) The following repair/replacement activities performed by welding or brazing on a pressure-retaining item are exempt from any pressure test:

(1) cladding

(2) welding or brazing that does not penetrate through the full thickness of the pressure-retaining material

(3) flange seating surface when less than half the flange axial thickness is removed and replaced

(4) tube-to-tubesheet welds when such welds are made on the cladding

(5) seal welds

(6) welded or brazed joints between non-pressure-retaining items and the pressure-retaining portion of the components

(7) Class 2 and Class 3 welds that are examined by a volumetric or surface method satisfying the applicable requirements of the Construction Code and Owner's Requirements

(e) Brazed joints and welds in pressure-retaining replacement parts and piping subassemblies, other than valve discs or seats, fabricated by the Repair/Replacement Organization, or fabricated in accordance with the Construction Code without a hydrostatic or pneumatic pressure test, shall be pressure tested as required by (c).

(f) Repair/replacement activities performed by welding or brazing on piping, including isolation valves, designated Class 2, that penetrates a containment vessel and where the balance of the piping system inside and outside the containment is not within the scope of Section XI, a 10 CFR 50, Appendix J Type C test, system leakage test in accordance with IWA-5211(a), or pneumatic test in accordance with IWA-5211(c) shall be performed. If there is detectable leakage during the Appendix J test, the brazed joints or welds shall be tested to confirm there is no leakage through the brazed joints or welds.

IWA-4550 CLASS MC AND METALLIC PORTIONS OF CLASS CC CONTAINMENTS

Items subjected to repair/replacement activities shall be tested in accordance with Article IWE-5000.

IWA-4600 ALTERNATIVE WELDING METHODS

(a) When welding under water, the alternative requirements of IWA-4660 may be used in lieu of the welding requirements of the Construction Code or Section III.

(b) When postweld heat treatment is not to be performed, the following provisions may be used.

(1) The welding methods of IWA-4620, IWA-4630, IWA-4640, IWA-4670, or IWA-4680 may be used in lieu of the welding and nondestructive examination requirements of the Construction Code or Section III, provided the requirements of IWA-4610 are met. Existing temper bead Welding Procedure Specifications and Procedure Qualification Records made in accordance with IWA-4610 and IWA-4620, IWA-4630, or IWA-4640 from the 1989 Edition or later editions or addenda may still be used without requalification.

(2) For welding of Class MC metal containments and their integral attachments and metallic liners of Class CC containments and their integral attachments, the

provisions of IWA-4620, IWA-4670, or IWA-4680 may be used, provided the requirements of IWA-4610 are met. Existing temper bead Welding Procedure Specifications and Procedure Qualification Records made in accordance with IWA-4610 and IWA-4620 from the 1989 Edition or later editions or addenda may be used without requalification. Alternatively, existing Welding Procedure Specification and Procedure Qualification Records made in accordance with the butter bead provisions of IWA-4650, 1989 Edition or later editions or addenda through the 2015 Edition, may be used without requalification.

IWA-4610 GENERAL REQUIREMENTS FOR TEMPER BEAD WELDING

(a) The area to be welded shall be preheated and maintained as specified in IWA-4620, IWA-4630, IWA-4640, IWA-4670, or IWA-4680, as applicable. Except as permitted by IWA-4672(c), thermocouples and recording instruments shall be used to monitor the process temperatures. Their attachment and removal shall be in accordance with Section III.

(b) The welding procedure and the welders or welding operators shall be qualified in accordance with Section IX and the additional requirements of this subarticle.

(1) Procedure Qualification

(-a) The test assembly material for the welding procedure qualification test shall be of the same P-Number and Group Number. Prior simulated postweld heat treatment on the procedure qualification test assembly is neither required nor prohibited. However, if used, the simulated postweld heat treatment shall not exceed the time or temperature already applied to the base material to be welded.

(-b) Consideration shall be given to the effects of welding in a pressurized environment. If they exist, they shall be bounded in the test assembly within the limits of Table IWA-4662.1-1.

(-c) If qualifying ambient temperature temper bead procedures of IWA-4670 or IWA-4680, the maximum interpass temperature for the first three layers of the procedure qualification test assembly shall be 150°F (66°C).

(-d) Temper bead welding procedures used in IWA-4620, IWA-4630, IWA-4640, IWA-4670, or IWA-4680 shall be qualified in accordance with Section IX, QW-290. For cladding procedures, the impact test essential variables of Section IX, QW-290.4 shall apply; however, impact qualification testing and hardness testing of the procedure qualification test assembly are not required. For all other procedures, the impact test essential variables of Section IX, QW-290.4 shall apply, and the following impact test requirements for the procedure qualification shall be met:

(-1) The test assembly base material for the welding procedure qualification shall meet the impact test requirements of the Construction Code and Owner's Requirements. If such requirements are not in the Construction Code and Owner's Requirements, the impact properties shall be determined by Charpy V-notch impact tests of the procedure qualification base material at or below the lowest service temperature of the item to be repaired. For all qualification tests, the base metal Charpy V-notch specimens shall be taken from approximately the same depth as the HAZ specimens and should be aligned in the same manner as the HAZ specimens. The location and orientation of the test specimens shall be as specified in (-3) below but shall be in the base metal. Impact testing of austenitic materials (nickel-based P-No. 4X and stainless steel P-No. 8) is not required.

As an alternative to the requirements in the preceding paragraph, the ferritic test assembly base material may be tested by Charpy V-notch testing in accordance with the requirements of (+a) and (+b). Drop weight testing, when required by the Construction Code, need not be performed.

(+a) The Charpy V-notch test temperature shall be determined from (+1), (+2), or (+3) and shall be in the transition temperature range of the base material.

(+1) a full Charpy V-notch transition temperature curve provided in the Certified Material Test Report for the test assembly base material

(+2) a full Charpy V-notch transition temperature curve developed by impact testing of the test assembly base material

(+3) one or more Charpy V-notch tests of the test assembly base material where test specimens exhibit lateral expansion values of 35 mils to 50 mils (0.89 mm to 1.3 mm)

(+b) The location and orientation of the test specimens shall be as specified in (-4) but shall be in the base metal.

(-2) Charpy V-notch tests of weld metal of the procedure qualification shall meet the requirements as determined in (-1) above. Drop weight tests, when required for the weld metal by the Construction Code in (-1), need not be performed.

(-3) Charpy V-notch tests of the heat-affected zone (HAZ) shall be performed at the same temperature as the base metal test of (-1) above. Number, location, and orientation of test specimens shall meet the requirements of (-4) below.

(-4) The specimens shall be removed from a location as near as practicable to a depth of one-half the thickness of the deposited weld metal. The coupons for HAZ impact specimens shall be taken transverse to the axis of the weld and etched to define the HAZ. The notch of the Charpy V-notch specimen shall be cut approximately normal to the material surface in such a manner as to include as much HAZ as possible in the resulting fracture. If the material thickness permits, the axis of a HAZ specimen shall be inclined to allow the root of the notch to align parallel to the fusion line.

(-5) If the test material is in the form of a plate or a forging, the axis of the weld shall be oriented parallel to the principal direction of rolling or forging.

(-6) Charpy V-notch tests shall be performed on the weld metal, the heat-affected zone, and unaffected base metal in accordance with SA-370. Specimens shall be in accordance with SA-370, Figure 11, Type A. A test shall consist of a set of three full-size 10 mm × 10 mm specimens. The lateral expansion, percentage shear, absorbed energy, test temperature, orientation, and location of all test specimens shall be reported in the Procedure Qualification Record.

(-7) The average lateral expansion value of the three HAZ Charpy V-notch specimens shall be equal to or greater than the average lateral expansion value of the three unaffected base metal specimens. However, if the average lateral expansion value of the HAZ Charpy V-notch specimens is less than the average value for the unaffected base metal specimens and the procedure qualification meets all other requirements, then either of the following shall be performed:

(+a) The welding procedure shall be requalified.

(+b) An Adjustment Temperature or lateral expansion value for the procedure qualification shall be determined and applied in accordance with the applicable provisions of NB-4335.2 of the 2004 Edition or later.

(2) Performance Qualification. If the weld is to be performed where physical obstructions impair the welder's ability to perform, the welder shall also demonstrate the ability to deposit sound weld metal in the positions required, using the same parameters and simulated physical obstructions as are involved in the repair/replacement activity.

(c) VT-1 visual examinations required by IWA-4620, IWA-4630, IWA-4670, or IWA-4680 shall meet the following:

(1) VT-1 visual examination shall be performed using a procedure that meets the requirements of IWA-2210.

(2) VT-1 visual examination personnel shall be qualified in accordance with IWA-2300 and shall receive additional training in examination of weldments for fabrication conditions, including dimensional requirements and fabrication flaws.

(3) Visual examination acceptance standards shall comply with the following:

(-a) Linear indications are indications in which the length is more than 3 times the width. Rounded indications are circular or elliptical with length equal to or less than 3 times the width.

(-b) Only indications with major dimensions greater than $^{1}/_{16}$ in. (1.5 mm) shall be considered relevant. The following relevant indications are unacceptable:

(-1) any cracks or linear indications

(-2) rounded indications with major dimensions greater than $^{3}/_{16}$ in. (5 mm)

(-3) four or more rounded indications in a line separated by $^{1}/_{16}$ in. (1.5 mm) or less edge-to-edge

(-4) ten or more rounded indications in any 6 in.^{2} (4 000 mm^2) of surface with major dimension of this area not to exceed 6 in. (150 mm) with the area taken in the most unfavorable location relative to the indication being evaluated

(d) Temper bead welding shall not be used for repair of materials from inside the reactor vessel within the beltline region or on vessel internals within the beltline region, under the following conditions:

(1) ferritic material where fast neutron fluence exposure is greater than 1×10^{17} n/cm^2 ($E > 1$ MeV)

(2) nickel-base material where thermal neutron fluence exposure is greater than 1×10^{17} n/cm^2 ($E < 0.5$ eV)

(3) austenitic stainless steel (P-No. 8), where thermal neutron fluence exposure is greater than 1×10^{17} n/cm^2 ($E < 0.5$ eV), and measured or calculated helium concentration in the P-No. 8 material is greater than 0.1 APPM.[11]

(e) For repairs on the outside of the reactor vessel shell on ferritic material where fast neutron fluence exposure is indeterminate or greater than 1×10^{17} n/cm^2 ($E > 1$ MeV), the applicable examinations of IWA-4624.1(c), IWA-4634.1(b), IWA-4673(b), or IWA-4683(b) shall also include the adjacent vessel base material as follows:

(1) The surface examination shall include $^{1}/_{2}$ in. (13 mm) of the reactor vessel base material beyond the deposited weld metal.

(2) If practicable, the volumetric examination shall include the following:

(-a) the heat-affected zone below the weld deposit

(-b) the reactor vessel base material adjacent to the deposited weld metal to a distance of $^{1}/_{2}$ in. (13 mm) and to a depth of $^{3}/_{16}$ in. (5 mm)

IWA-4611 Defect Removal

IWA-4611.1 General Requirements.

(a) Defects shall be removed in accordance with IWA-4422.1. A defect is considered removed when it has been reduced to an acceptable size.

(b) Examination of defect removal areas shall comply with IWA-4624, IWA-4634, and IWA-4644, as applicable.

(c) Metal removal by thermal methods shall comply with IWA-4413.

IWA-4611.2 Examination Following Defect Removal.

(a) After final processing, the affected surfaces, including surfaces of cavities prepared for welding, shall be examined by the magnetic particle or liquid penetrant method to ensure that the indication has been reduced to an acceptable size in accordance with IWB-3500, IWC-3500, or Article IWD-3000, as applicable. For supports and containment vessels, the provisions of IWA-4422.1(b) may be used. No examination of the defect removal area is required when defect elimination

removes the full thickness of the weld and the back side of the weld joint is not accessible for removal of examination materials.

(b) Indications detected as a result of the excavation that are not associated with the defect being removed shall be subject to an NDE evaluation for acceptability in accordance with Article IWA-3000.

IWA-4620 TEMPER BEAD WELDING OF SIMILAR MATERIALS

IWA-4621 General Requirements

(a) Repair/replacement activities on P-Nos. 1 and 3[12] base materials and associated welds may be performed without the specified postweld heat treatments, provided the requirements of (b), (c), (d), IWA-4623, and IWA-4624 are met.

(b) The maximum area of an individual weld based on the finished surface shall be 500 in.^{2} (325 000 mm^2), and the depth of the weld shall not be greater than one-half of the base metal thickness.

(c) Weld metal and heat-affected zones may be peened to control distortion. Peening shall not be used on the final weld surfaces, except as permitted in (d) below.

(d) Peening demonstrated to reduce residual surface tensile stresses is permitted on the final weld surfaces after any required surface examinations are completed. A VT-1 visual examination in accordance with IWA-4610(c) shall be performed after this peening.

IWA-4623 Welding Procedure

IWA-4623.1 Shielded Metal-Arc Welding. The procedure shall include the requirements of (a) through (f):

(a) Welding electrodes shall meet the requirements for supplemental designators *R*, indicating a moisture-resistant coating, and "H4," indicating that they are low in diffusible hydrogen (<4 mL/100 g), as defined in the applicable specifications in Section II, Part C. Welding electrodes shall be supplied in unopened, hermetically sealed containers or vacuum-sealed packages.

(b) Electrodes shall be used directly from vacuum-sealed packages or hermetically sealed containers, or shall be placed in storage at 225°F to 350°F (110°C to 180°C) prior to use.

(c) Electrodes not consumed within 8 hr for E70XX electrodes or 4 hr for E80XX and E90XX after removal from vacuum-sealed packages, hermetically sealed containers, or storage at 225°F to 350°F (110°C to 180°C) shall not be used for temper bead welding. The use of reheated or rebaked electrodes is not permitted.

(d) The area to be welded plus a band around the area of at least 1.5 times the component thickness or 5 in. (125 mm), whichever is less, shall be preheated and maintained at a minimum temperature of 350°F (175°C). The maximum interpass temperature shall be 450°F (230°C).

(e) Weld the cavity in accordance with the qualified Section IX, QW-290 WPS described in IWA-4610(b).

(f) The weld area shall receive a postweld hydrogen bakeout by maintaining it at 450°F to 550°F (230°C to 290°C) for a minimum of 2 hr after completion of the weld in P-No. 1 materials. For P-No. 3 materials, the holding time shall be a minimum of 4 hr.

IWA-4623.2 Gas Tungsten-Arc Welding. The procedure shall include the requirements of (a) through (d):

(a) The weld metal shall be deposited by the automatic or machine gas tungsten-arc weld process using cold wire feed.

(b) The area to be welded plus a band around the area of at least 1.5 times the component thickness or 5 in. (125 mm), whichever is less, shall be preheated and maintained at a minimum temperature of 300°F (150°C). The maximum interpass temperature shall be 450°F (230°C).

(c) Weld the cavity in accordance with the qualified Section IX, QW-290 WPS described in IWA-4610(b).

(d) The weld area shall receive a postweld hydrogen bakeout by maintaining it at 450°F to 550°F (230°C to 290°C) for a minimum of 2 hr after completion of the weld repair in P-No. 1 materials. For P-No. 3 materials, the holding time shall be a minimum of 4 hr.

IWA-4624 Examination

IWA-4624.1 Examination Criteria.

(a) Prior to welding, surface examination shall be performed on the area to be welded. Surface examination and acceptance criteria shall comply with IWA-4611.2

(b) The initial layer shall be examined by the magnetic particle method after grinding or machining. Each subsequent layer shall be examined by the magnetic particle method if a final volumetric examination will not be performed.

(c) Nondestructive examinations shall be performed after the completed weld has cooled to ambient temperature. The nondestructive examination of the welded region shall include both volumetric [except as permitted in (b)] and surface examination.

(d) Areas from which weld attached thermocouples have been removed shall be ground and examined by a surface examination method.

IWA-4624.2 Acceptance Criteria. Acceptance criteria for examinations required by IWA-4624.1(b) and IWA-4624.1(c) shall be in accordance with the Construction Code or Section III.

IWA-4630 TEMPER BEAD WELDING OF DISSIMILAR MATERIALS

IWA-4631 General Requirements

(a) Repair/replacement activities on welds that join P-No. 8 or P-No. 43 material to P-Nos. 1 and 3[12] material may be made without the specified postweld heat treatment, provided the requirements of (b), (c), (d), IWA-4633 and IWA-4634 are met.

(b) Repair/replacement activities in accordance with this paragraph are limited to those along the fusion line of a nonferritic weld to ferritic base material where $\frac{1}{8}$ in. (3.2 mm) or less of nonferritic weld deposit exists above the original fusion line after defect removal. If the defect penetrates into the ferritic base material, welding of the base material may be performed in accordance with IWA-4633 provided the depth of the weld in the base material does not exceed $\frac{3}{8}$ in. (9.5 mm). The repair/replacement activity performed on a completed joint shall not exceed one-half the joint thickness. The surface of the completed weld in the ferritic material shall not exceed 500 in.^{2} (325 000 mm^2).

(c) Weld metal and heat-affected zones may be peened to control distortion. Peening shall not be used on the final weld surfaces, except as permitted in (d) below.

(d) Peening demonstrated to reduce residual surface tensile stresses is permitted on the final weld surfaces after any required surface examinations are completed. A VT-1 visual examination in accordance with IWA-4610(c) shall be performed after this peening.

IWA-4633 Welding Procedure

(25) **IWA-4633.1 Shielded Metal-Arc Welding.** The procedure shall include the requirements of (a) through (g).

(a) The weld metal shall be deposited using A-No. 8 weld metal (Section IX, Table QW-442) for P-No. 8 to P-No. 1 or P-No. 3 weld joints or F-No. 43 weld metal (Section IX, Table QW-432) for either P-No. 8 or P-No. 43 to P-No. 1 or P-No. 3 weld joints.

(b) Welding electrodes shall be supplied in unopened, hermetically sealed containers or vacuum-sealed packages.

(c) Electrodes shall be used directly from vacuum-sealed packages or hermetically sealed containers, or shall be placed in storage at 225°F to 350°F (110°C to 180°C) prior to use.

(d) Electrodes not consumed within 8 hr after removal from vacuum-sealed packages, hermetically sealed containers, or storage at 225°F to 350°F (110°C to 180°C) shall not be used for temper bead welding. The use of reheated or rebaked electrodes is not permitted.

(e) The area to be welded plus a band around the area of at least 1.5 times the component thickness or 5 in. (125 mm), whichever is less, shall be preheated and maintained at a minimum temperature of 350°F (175°C). The maximum interpass temperature shall be 450°F (230°C).

(f) Weld the cavity in accordance with the qualified Section IX, QW-290 WPS described in IWA-4610(b).

(g) When at least $\frac{3}{16}$ in. (5 mm) of weld metal has been deposited, the balance of the welding, if any, may be performed using ambient temperature preheat and maximum interpass temperature of 350°F (180°C).

(25) **IWA-4633.2 Gas Tungsten-Arc Welding.** The procedure shall include the requirements of (a) through (e).

(a) The weld shall be made using A-No. 8 weld metal (Section IX, Table QW-442) for P-No. 8 to P-No. 1 or P-No. 3 weld joints or F-No. 43 weld metal (Section IX, Table QW-432) for either P-No. 8 or P-No. 43 to P-No. 1 or P-No. 3 weld joints.

(b) The weld metal shall be deposited by the automatic or machine gas tungsten arc weld process using cold wire feed.

(c) The area to be welded plus a band around the area of at least 1.5 times the component thickness or 5 in. (125 mm), whichever is less, shall be preheated and maintained at a minimum temperature of 300°F (150°C). The maximum interpass temperature shall be 450°F (230°C).

(d) Weld the cavity in accordance with the qualified Section IX, QW-290 WPS described in IWA-4610(b).

(e) When at least $\frac{3}{16}$ in. (5 mm) of weld metal has been deposited, the balance of the welding, if any, may be performed using ambient temperature preheat and maximum interpass temperature of 350°F (180°C).

IWA-4634 Examination

IWA-4634.1 Examination Requirements.

(a) Prior to welding, surface examination shall be performed on the area to be welded. Surface examination and acceptance criteria shall comply with IWA-4611.2.

(b) Nondestructive examinations shall be performed after the completed weld has cooled to ambient temperature. The examination of the welded region shall include both volumetric and surface examination.

IWA-4634.2 Acceptance Criteria. Acceptance criteria for examinations required by IWA-4634.1(b) shall be in accordance with the Construction Code or Section III.

IWA-4640 TEMPER BEAD WELDING OF CLADDING

IWA-4641 General Requirements

(a) Repair/replacement activities on austenitic stainless steel and nickel base cladding on P-No. 1 and 3[12] base materials when the ferritic material is within $\frac{1}{8}$ in. (3 mm) of being exposed may be performed by welding without the specified postweld heat treatments provided the requirements of IWA-4643 and IWA-4644 are met.

(b) The maximum area of an individual cladding repair based on the finished surface shall be 500 in.^{2} (325 000 mm^2), and the depth of the weld into the ferritic material shall not be greater than $\frac{1}{4}$ in. (6 mm) or 10% of the base metal thickness, whichever is less.

IWA-4643 Welding Procedure

(25) **IWA-4643.1 Shielded Metal-Arc Welding.** The procedure shall include the requirements of (a) through (g).

(a) The welds shall be made using A-No. 8 weld metal (Section IX, Table QW-442) for austenitic stainless steel cladding or F-No. 43 weld metal (Section IX, Table QW-432) for either austenitic stainless steel or nickel base cladding.

(b) Welding electrodes shall be supplied in unopened, hermetically sealed containers or vacuum-sealed packages.

(c) Electrodes shall be used directly from vacuum-sealed packages or hermetically sealed containers, or shall be placed in storage at 225°F to 350°F (110°C to 180°C) prior to use.

(d) Electrodes not consumed within 8 hr after removal from vacuum-sealed packages, hermetically sealed containers, or storage at 225°F to 350°F (110°C to 180°C) shall not be used for temper bead welding. Use of reheated or rebaked electrodes is not permitted.

(e) The area to be welded plus a band around the area of at least 1.5 times the component thickness or 5 in. (125 mm), whichever is less, shall be preheated and maintained at a minimum temperature of 350°F (175°C). The maximum interpass temperature shall be 450°F (230°C).

(f) Weld the cavity in accordance with the qualified Section IX, QW-290 WPS described in IWA-4610(b).

(g) When at least $^{3}/_{16}$ in. (5 mm) of weld metal has been deposited, the balance of the welding, if any, may be performed using ambient temperature preheat and maximum interpass temperature of 350°F (180°C).

(25) **IWA-4643.2 Gas Tungsten-Arc Welding.** The procedure shall include the requirements of (a) through (e).

(a) The welds shall be made using A-No. 8 weld metal (Section IX, Table QW-442) for austenitic stainless steel cladding or F-No. 43 weld metal (Section IX, Table QW-432) for either austenitic stainless steel or nickel base cladding.

(b) The weld metal shall be deposited by the automatic or machine gas tungsten-arc weld process using cold wire feed.

(c) The area to be welded plus a band around the area of at least 1.5 times the component thickness or 5 in. (125 mm), whichever is less, shall be preheated and maintained at a minimum temperature of 300°F (150°C). The maximum interpass temperature shall be 450°F (230°C).

(d) Weld the cavity in accordance with the qualified Section IX, QW-290 WPS described in IWA-4610(b).

(e) When at least $^{3}/_{16}$ in. (5 mm) of weld metal has been deposited, the balance of the welding, if any, may be performed using ambient temperature preheat and maximum interpass temperature of 350°F (180°C).

IWA-4644 Examination

IWA-4644.1 Examination Requirements.

(a) Prior to welding, surface examination shall be performed on the area to be welded. Examination and acceptance criteria shall comply with IWA-4611.2.

(b) Nondestructive examinations shall be performed after the completed weld has cooled to ambient temperature. The examination of the welded region shall include both volumetric and surface examination.

IWA-4644.2 Acceptance Criteria. Acceptance criteria for examinations required by IWA-4644.1(b) shall be in accordance with the Construction Code or Section III.

IWA-4660 UNDERWATER WELDING

IWA-4661 Scope and General Requirements

(a) These requirements[13] are for dry or wet underwater welding.

(b) The terms and definitions of ANSI/AWS D3.6M, "Underwater Welding Code," shall be used.

(c) Welding of P-No. 1, P-No. 8, and P-No. 4X materials may be performed under water provided the welding procedures and welders or welding operators are qualified in accordance with Section IX as modified by IWA-4662 or IWA-4663, as applicable.

(d) Dry underwater welding may be performed with GMAW, GTAW, LBW, PAW, SMAW, or a combination of these processes.

(e) Wet underwater welding may be performed with GMAW (FCAW-type only), LBW, SMAW, or a combination of these processes.

(f) IWA-4660 may not be used for welding of the following materials:

(1) P-No. 1 material exposed to fast neutron fluence greater than 1×10^{17} n/cm^2 (E > 1 MeV)

(2) P-No. 8 material exposed to thermal neutron fluence greater than 1×10^{17} n/cm^2 (E < 0.5 eV) and containing measured or calculated helium content exceeding 0.1 APPM[11]

(3) P-No. 4X material exposed to thermal neutron fluence greater than 1×10^{17} n/cm^2 (E < 0.5 eV)

IWA-4662 Additional Variables for Dry Underwater Welding

IWA-4662.1 Procedure Qualification. Welding procedure specifications for dry underwater welding shall be qualified in accordance with the requirements of Section IX and applicable impact testing requirements of the Construction Code for groove welds. The following variables also apply.

(a) Additional essential variables:

(1) A change in the method for underwater transport and storage of filler material (e.g., from sealed packages to exposed).

(2) Addition or deletion of waterproof or supplementary coatings for the filler metal or a change in the type of any waterproof or supplementary coatings.

(3) A change in depth beyond that qualified in accordance with Table IWA-4662.1-1.

(4) A change in the nominal background gas composition.[14]

(5) For SMAW and FCAW, use of a larger diameter electrode than that used in qualification.

Table IWA-4662.1-1
Depth Limitations for Underwater Welding Qualification

Type of Welding	Max. Depth Qualified [Note (1)]	Min. Depth Qualified [Note (2)]
Dry Welding	*D* plus 33 ft (10 m)	*D* minus 33 ft (10 m)
Wet Welding with A-No. 8 Filler Metals	*D* plus 10 ft (3 m)	*D* minus 33 ft (10 m)
Wet Welding with F-No. 4X Filler Metals	*D*	*D* minus 33 ft (10 m)
Wet Welding with Other Than A-No. 8 and F-No. 4X Filler Metals	*D* plus 33 ft (10 m)	*D* minus 33 ft (10 m) [Note (3)]

GENERAL NOTE: *D* is qualification test depth.

NOTES:
(1) For the maximum depth qualified, depth shall be measured from the lower extremity of the test weldment with a tolerance of plus or minus 9 in. (230 mm).
(2) For the minimum depth qualified, depth shall be measured from the upper extremity of the test weldment with a tolerance of plus or minus 9 in. (230 mm).
(3) Welds at depths less than 10 ft (3 m) require qualification at the production weld minimum depth.

(6) For P-No. 1 material, a decrease in the minimum distance from the point of welding to the wetted surface in any direction, when the minimum distance is less than 6 in. (150 mm)

(7) For P-No. 1 material, the supplementary essential variables of Section XI apply to nonimpact-tested base metal when the minimum distance from the point of welding to the wetted surface in any direction is less than 6 in. (150 mm)

(b) Additional nonessential variables:

(1) For SMAW and FCAW, an increase in time of electrode exposure to the underwater environment.

(2) A change in the method of protecting, removing moisture from, or otherwise conditioning bare filler metal and bare electrodes in the underwater environment.

IWA-4662.2 Performance Qualification. Welders and welding operators for dry underwater welding shall be qualified in accordance with Section IX and the variables listed below. When a welder or welding operator has not welded with a process in a dry underwater environment for at least six months, the qualifications for that underwater process shall expire.

(a) A change in welding mode (i.e., dry chamber, dry spot, or habitat).

(b) A change in the SFA specification AWS filler metal classification, or if not conforming to an AWS filler metal classification, a change in the manufacturer's trade name for the electrode or filler metal.

(c) Addition or deletion of supplementary coatings for the filler metal or a change in the type of any supplementary coatings.

(d) A change in depth beyond that qualified in accordance with Table IWA-4662.1-1.

(e) For SMAW and GMAW, use of a larger diameter electrode than that used during performance qualification.

IWA-4663 Additional Variables for Wet Underwater Welding

IWA-4663.1 Procedure Qualification. Welding procedure specifications for wet underwater welding shall be qualified to the requirements of Section IX for groove welds, except that for P-No. 1 base metals, the supplementary essential variables of Section IX apply to both impact-tested and non-impact-tested base metal. The impact test requirements of the Construction Code shall apply for qualification of welds joining materials required by the Construction Code to be impact tested. The following variables shall also apply:

(a) Additional essential variables:

(1) A change in the method for underwater transport and storage of filler material (e.g., from sealed packages to exposed).

(2) Addition or deletion of waterproof or supplementary coatings for the filler metal or a change in the type of any waterproof or supplementary coatings.

(3) A change in electrode diameter beyond the range used in qualification.

(4) A change in depth beyond that qualified in accordance with Table IWA-4662.1-1.

(5) A change in the SFA specification AWS filler metal classification, or, if not conforming to an AWS filler metal classification, a change in the manufacturer's trade name for the electrode or filler metal.

(6) Addition of welding positions other than those qualified in accordance with Table IWA-4662.1-2.

(7) A change from upward to downward, or vice versa, in the progression specified for any pass of a vertical weld.

(8) A change from the stringer bead technique to the weave bead technique, or vice versa. For P-No. 8 and P-No. 4X base metals, this variable applies only to the vertical position.

(9) A change from ac to dc, or vice versa, and, in dc welding, a change from electrode negative (straight polarity) to electrode positive (reverse polarity), or vice versa.

(10) A change from wet backside to dry backside for backing thickness less than $\frac{1}{4}$ in. (6 mm).

Table IWA-4662.1-2
Procedure and Performance Qualification — Position Limitations

Qualification Test Weld	Plate or Pipe Positions	Position and Type of Weld Qualified [Note (1)]			
		Plate		Pipe	
		Groove	Fillet	Groove	Fillet
Plate-groove	1G	F	F	F	F
	2G	H	H	H	H
	3G	V	V	...	...
	4G	O	O	...	...
Pipe-groove	1G	F	F	F	F
	2G	H	H	H	H
	5G	F, V, O	F, V, O	F, V, O	F, V, O
	6G	All	All	All	All

NOTE:
(1) Positions of welding:
F = Flat
H = Horizontal
V = Vertical
O = Overhead

(11) For P-No. 1 base metal carbon equivalents as calculated in accordance with Figure IWA-4663.1-1, an increase in the carbon equivalent beyond that of the procedure qualification test coupon.

(12) An increase in the time of electrode exposure to water at qualification depth.

(13) For P-No. 1 base materials, a change from multipass per side to single pass per side.

(b) Additional nonessential variable: a decrease in included angle, a decrease in root opening, or an increase in root face.

IWA-4663.2 Performance Qualification. Welders and welding operators for wet underwater welding shall be qualified in accordance with Section IX and the variables listed below. For all base metals, bend testing shall be performed in accordance with requirements of Section IX, QW-302.1. Alternatively, testing may be by radiographic examination in accordance with Section IX, QW-302.2. When a welder or welding operator has not welded with a process in a wet underwater environment for at least six months, the qualifications for welding with that process underwater shall expire.

(a) A change in the SFA specification AWS filler metal classification, or, if not conforming to an AWS filler metal classification, a change in the manufacturer's trade name for the electrode or filler metal.

(b) Addition or deletion of waterproof or supplementary coating for the filler metal or a change in the type of any waterproof or supplementary coatings.

(c) A change from salt or borated water to fresh water.

(d) Use of a larger diameter electrode than that used during performance qualification.

(e) A change in depth beyond that qualified in accordance with Table IWA-4662.1-1.

(f) Addition of welding positions other than those qualified in accordance with Table IWA-4662.1-2.

(g) A change in polarity or type of power source (e.g., rectifier, motor-generator, inverter).

(h) A change from stringer bead to weave technique.

(i) A change in the welder's view from beneath to above the water surface.

(j) A decrease in the included angle, a decrease in root opening, or an increase in the root face.

Figure IWA-4663.1-1
Carbon Equivalency Calculation

$$CE = C + \frac{Mn + Si}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

GENERAL NOTE: The chemical analysis for carbon equivalent calculations for the production base material may be obtained from the mill test certificate or chemical analysis. If chemical analysis is not available for Cr, Mo, V, Ni, and Cu, the carbon equivalent may be determined by using 0.1 for the term $\left[\frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15}\right]$.

IWA-4664 Filler Metal Qualification

(a) Filler metal qualification testing in accordance with (b), (c), and (d) is required for the following:

(1) each heat and lot of filler metal used for wet welding

(2) each heat and lot of flux-coated or flux-cored electrode used for dry welding

(3) each waterproof coating type

(4) each supplementary coating type

(b) An all-weld-metal coupon and a weld pad shall be prepared using the production welding procedure at a depth such that the depth of the production weld will be within the depth limitations of Table IWA-4662.1-1.

(1) For material that conforms to an SFA specification, the coupons shall be prepared in accordance with the applicable SFA specification.

(2) For material that does not conform to an SFA specification, the coupons shall be prepared in accordance with the SFA specification most nearly matching that material (e.g., for ferritic covered electrodes, SFA-5.1).

(c) The coupons shall be tested as follows.

(1) The ferrite number shall be directly measured from the weld pad for austenitic stainless steel, Section IX, Table QW-442, A-No. 8 filler metal.

(2) One all-weld-metal specimen shall be tension tested.

(3) As-deposited chemical composition shall be determined from the weld pad in accordance with the applicable SFA specification or the SFA specification most nearly matching the material.

(4) For ferritic weld metal, Charpy V-notch absorbed energy shall be determined in accordance with IWA-4665 and, if applicable, the Construction Code.

(d) The qualification testing acceptance criteria shall be as follows.

(1) The ferrite number shall meet the requirements of the Construction Code.

(2) The ultimate tensile strength shall meet the minimum tensile strength specified for either of the base metals to be joined.

(3) The chemical composition shall meet the applicable SFA specification requirements for the as-deposited chemical composition. For material that does not conform to an SFA specification, the chemical composition shall meet the requirements specified in the WPS.

(4) Charpy V-notch absorbed energy shall meet the requirements of IWA-4665(b) and, if applicable, the Construction Code.

IWA-4665 Charpy V-Notch Testing Requirements

(a) Charpy V-notch tests of the weld metal shall be performed at 32°F (0°C). Number, location, and orientation of the test specimens shall be as follows.

(1) The specimens shall be removed from a location as near as practicable to a depth of one-half the thickness of the deposited weld metal.

(2) The Charpy V-notch test shall be performed in accordance with SA-370. Specimens shall be in accordance with SA-370, Figure 11, type A. A test shall consist of a set of three full-size 10 mm × 10 mm specimens. The absorbed energy and the test temperature, as well as the orientation and location of the tests performed, shall be reported in the Procedure Qualification Record.

(b) The averages of the three weld metal impact tests shall be not less than 25 ft-lb (34 J).

(c) Charpy V-notch tests of the weld metal are not required for austenitic (A-No. 8) or nickel-base (F-No. 4X) filler material.

IWA-4666 Examination

The examination requirements of the Construction Code or Section III shall be met for completed welds. When the nondestructive examinations required by this Division or the Construction Code cannot be performed or will not provide meaningful results because of the underwater environment, the following alternative requirements apply.

IWA-4666.1 Surface Examination. In lieu of any required surface examination, the following apply:

(a) A surface examination shall be conducted with an ultrasonic or eddy current surface examination procedure qualified for the underwater environment.

(b) If ultrasonic and eddy current methods cannot be performed or will not provide meaningful results, the surface shall be VT-1 visually examined with a procedure meeting the requirements of IWA-2200.

(c) An NDE evaluation of the ultrasonic, eddy current, and visual surface indications shall be performed using the surface examination acceptance criteria of the Construction Code, Section III, or this Division.

(d) Personnel performing visual examinations shall be qualified in accordance with IWA-2300 for performance of VT-1 visual examinations and shall have received additional training in examination of weldments for fabrication conditions, including dimensional requirements and fabrication flaws.

IWA-4666.2 Volumetric Examination. In lieu of any required volumetric examination, the following apply:

(a) A volumetric examination shall be conducted with an ultrasonic examination procedure. The ultrasonic examination shall be conducted in accordance with Section V, Article 4. An NDE evaluation of indications shall be performed using the volumetric acceptance criteria of the Construction Code, Section III, or this Division.

(b) If the ultrasonic method cannot be performed or will not provide meaningful results, a surface examination shall be performed on the root pass and on the finished weld in accordance with IWA-4666.1.

IWA-4670 AMBIENT TEMPERATURE TEMPER BEAD WELDING USING GAS TUNGSTEN ARC WELDING

Ambient temperature preheat may be used for welding similar materials, dissimilar materials, inlays, onlays, and overlays, with the additional requirements in IWA-4671 through IWA-4673.

IWA-4671 General Requirements

(a) Repair/replacement activities are limited to P-Nos. 1 and 3[12] materials, and their associated welds, and welds joining P-No. 8 or P-No. 43 materials to P-Nos. 1 and 3[12] materials.

(b) The maximum area of an individual weld based on the finished surface over the ferritic material shall be 1,000 in.^{2} (650 000 mm^2) for full circumferential weld overlays and 500 in.^{2} (325 000 mm^2) for all other applications, and, except as permitted in (1), the depth of the weld shall not be greater than one-half of the ferritic base metal thickness.

(1) Through-wall circumferential welds are permitted if the following requirements are met:

(-a) For repair/replacement activities associated with existing welds, the existing weld (including any associated buttering) shall be removed in its entirety.

(-b) Temper bead buttering shall be applied across the entire face of the weld preparation area on the base materials requiring tempering and shall extend around the full circumference of the joint.

(c) Repair/replacement activities on a dissimilar-metal weld are limited to those along the fusion line of a nonferritic weld to ferritic base material on which $^1/_8$ in. (3 mm) or less of nonferritic weld deposit exists above the original fusion line.

(d) If a defect penetrates into the ferritic base material, repair of the base material, using a nonferritic weld filler material, may be performed, provided the depth of repair in the base material does not exceed $^3/_8$ in. (10 mm).

(e) Prior to welding, the area to be welded and a band around the area of at least 1$^1/_2$ times the component thickness or 5 in. (130 mm), whichever is less, shall be at least 50°F (10°C).

(f) Weld metal and heat-affected zones may be peened to control distortion. Peening shall not be used on the final weld surfaces, except as permitted in (g) below.

(g) Peening demonstrated to reduce surface tensile stresses is permitted on the final weld surfaces after any required surface examinations are completed. A VT-1 visual examination in accordance with IWA-4610(c) shall be performed after this peening.

IWA-4672 Welding Procedure Requirements

The procedure shall include the following requirements:

(a) The weld metal shall be deposited using the automatic or machine GTAW process.

(b) The maximum interpass temperature for field applications shall be 350°F (180°C) for all weld layers, regardless of the interpass temperature used during qualification. The interpass temperature limitation of Section IX, QW-406.3 need not be applied.

(c) The interpass temperature shall be determined by direct measurement (e.g., pyrometers, temperature-indicating crayons, thermocouples) during welding. If direct measurement is impracticable (e.g., because of geometric limitations or radiological reasons), interpass temperature shall be determined in accordance with the following:

(1) heat flow calculations, including the following variables:

(-a) welding heat input

(-b) initial base material temperature

(-c) configuration, thickness, and mass of the item being welded

(-d) thermal conductivity and diffusivity of the materials being welded

(-e) time per weld pass and delay time between each pass

(-f) time to complete the weld

(2) Measurement of the actual interpass temperature on a test coupon not thicker than the item to be welded. The maximum heat input of the welding procedure shall be used in the welding of the test coupon.

(d) Particular care shall be given to ensure that the weld region is free of potential sources of hydrogen. The surfaces to be welded, filler metal, and shielding gas shall be suitably controlled.

IWA-4673 Examination

Except as permitted in (a), the following examinations shall be performed in accordance with the Construction Code or Section III:

(a) Prior to repair welding, surface examination shall be performed on the area to be welded. If surface examination materials cannot be cleaned from crevices in the area to be welded (e.g., trapped in crevices remaining after removal of the full thickness of a partial penetration or fillet weld), VT-1 visual examination shall be performed, provided the requirements of IWA-4610(c) are met.

(b) Examination of the welded region shall include both volumetric and surface examination methods. If ferritic materials are used, the weld shall be nondestructively examined after the completed weld has been at ambient temperature for at least 48 hr. Ultrasonic examination shall be performed using procedures qualified at least in accordance with the low rigor requirements of Section V, Article 14.

(c) Areas from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method.

(d) Acceptance criteria for surface and volumetric examination shall be in accordance with the Construction Code or Section III.

IWA-4680 AMBIENT TEMPERATURE TEMPER BEAD WELDING USING SHIELDED METAL ARC WELDING

Ambient temperature preheat may be used for welding similar materials and dissimilar materials, with the following additional requirements.

IWA-4681 General Requirements

(a) Repair/replacement activities are limited to P-Nos. 1 and 3[12] materials and their associated welds and welds joining P-No. 8 or P-No. 43 materials to P-Nos. 1 and 3[12] materials.

(b) The maximum area of an individual weld based on the finished surface over the ferritic material shall be 500 in.^{2} (325 000 mm^2), and except as permitted in (1), the depth of the weld shall not be greater than one-half of the ferritic base metal thickness.

(1) Through-wall circumferential welds are permitted if the following restrictions are met:

(-a) For repair/replacement activities associated with existing welds, the existing weld (including any associated buttering) shall be removed in its entirety.

(-b) Temper bead buttering shall be applied across the entire face of the weld preparation area on the base materials requiring tempering, and shall extend around the full circumference of the joint.

(c) Repair/replacement activities on a dissimilar-metal weld are limited to those along the fusion line of a nonferritic weld to ferritic base material on which $^1/_8$ in. (3 mm) or less of nonferritic weld deposit exists above the original fusion line.

(d) If a defect penetrates into the ferritic base material, repair of the base material, using a nonferritic weld filler material, may be performed provided the depth of repair in the base material does not exceed $^3/_8$ in. (10 mm).

(e) Prior to welding, the area to be welded and a band around the area of at least 1$^1/_2$ times the component thickness or 5 in. (130 mm), whichever is less, shall be at least 50°F (10°C).

(f) Weld metal and heat-affected zones may be peened to control distortion. Peening shall not be used on the final weld surfaces, except as permitted in (g) below.

(g) Peening demonstrated to reduce residual surface tensile stresses is permitted on the final weld surfaces after any required surface examinations are completed. A VT-1 visual examination in accordance with IWA-4610(c) shall be performed after this peening.

IWA-4682 Welding Procedure Requirements

The procedure shall include the requirements of (a) through (f).

(a) The weld metal shall be deposited using the manual SMAW process.

(b) Ferritic weld metal used shall meet the following additional requirements:

(1) Welding electrodes shall meet the requirements for supplemental designators *R*, indicating a moisture-resistant coating, and "H4," indicating that they are low in diffusible hydrogen (<4 mL/100 g), as defined in the applicable specifications in Section II, Part C. Welding electrodes shall be supplied in unopened, hermetically sealed containers or vacuum-sealed packages.

(2) Electrodes shall be used directly from vacuum-sealed packages or hermetically sealed containers, or shall be placed in storage at 225°F to 350°F (110°C to 180°C) prior to use.

(3) Electrodes not consumed within 8 hr for E70XX electrodes or 4 hr for E80XX and E90XX after removal from vacuum-sealed packages, hermetically sealed containers, or storage at 225°F to 350°F (110°C to 180°C) shall not be used for temper bead welding. Use of reheated or rebaked electrodes is not permitted.

(c) Austenitic or nickel-based weld metal used shall meet the following requirements:

(1) Welding electrodes shall be supplied in unopened, hermetically sealed containers or vacuum-sealed packages.

(2) Electrodes shall be used directly from vacuum-sealed packages or hermetically sealed containers, or shall be placed in storage at 225°F to 350°F (110°C to 180°C) prior to use.

(3) Electrodes not consumed within 8 hr after removal from vacuum-sealed packages, hermetically sealed containers, or storage at 225°F to 350°F (110°C to 180°C) shall not be used for temper bead welding. Use of reheated or rebaked electrodes is not permitted.

(d) The maximum interpass temperature for field applications shall be 350°F (180°C) for all weld layers, regardless of the interpass temperature used during qualification. The interpass temperature requirements of Section IX, QW-406.3 need not be met.

(e) The interpass temperature shall be determined by direct measurement (e.g., pyrometers, temperature-indicating crayons, thermocouples) during welding.

(f) Particular care shall be given to ensure that the weld region is free of potential sources of hydrogen. The surfaces to be welded and filler metal shall be suitably controlled.

IWA-4683 Examination

Except as permitted in (a), the following examinations shall be performed in accordance with the Construction Code or Section III.

(a) Prior to repair welding, surface examination shall be performed on the area to be welded. When surface examination materials cannot be cleaned from crevices in the area to be welded (e.g., trapped in crevices remaining after removal of the full thickness of a partial penetration or fillet weld), VT-1 visual examination may be performed, provided the requirements of IWA-4610(c) are met.

(b) Examination of the welded region shall include both volumetric and surface examination methods. If ferritic materials are used, the weld shall be nondestructively examined after the completed weld has been at ambient temperature for at least 48 hr. Ultrasonic examination shall be performed using procedures qualified at least in accordance with the low rigor requirements of Section V, Article 14.

(c) Areas from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method.

(d) Acceptance criteria for surface and volumetric examination shall be in accordance with the Construction Code or Section III.

IWA-4700 HEAT EXCHANGER TUBING

IWA-4710 PLUGGING

IWA-4711 Explosive Welding

If explosive welding is used to weld plugs to Class 1 heat exchanger tubes or heat exchanger tubesheet bore holes, the requirements of IWA-4711.1 through IWA-4711.4 shall be met. These requirements may be used for Class 2 and Class 3 heat exchangers.

IWA-4711.1 General Requirements.

(a) Material used in manufacturing plugs shall be produced in compliance with requirements of a SA or SB material specification or any other material specification that has been approved for Section III.

(b) Each plug shall be traceable to a Certified Material Test Report that indicates the mechanical properties and chemistry.

(c) Records shall be maintained by the Owner, and shall include the following:

(1) plugging procedure

(2) welding procedure qualifications

(3) welding operator performance qualifications

(4) material certifications

(5) location of all plugged tubes or holes

(6) results of heat exchanger examinations required by this Subparagraph

(7) specific tubes or holes plugged by each welding operator

(d) Records of the procedure and welder qualification shall include the results of all tests required by IWA-4711.2, and shall be certified by the Repair/Replacement Organization. The Procedure Qualification Records shall include a description of all essential and nonessential variables [IWA-4711.2.1(a) and IWA-4711.2.1(b)]. The operator performance qualification record shall also list the procedure number and revision that was used for testing; the record of operator experience shall be kept current.

IWA-4711.2 Welding Qualification.

IWA-4711.2.1 Procedure Qualifications. The Welding Procedure Specification for plugging shall be qualified as a new procedure specification and shall be completely requalified if any of the essential variables listed below are changed. Nonessential variables may be changed without requalification, provided the Welding Procedure Specification is amended to show these changes.

(a) Essential Variables

(1) a change in the P-Number classification (Section IX, Table QW/QB-422) of any of the materials being joined. This includes the tube, plug, tubesheet, or tubesheet cladding. If the plug is to be joined to any part of the tubesheet cladding, this cladding must be duplicated in the procedure qualification. Materials not listed under a P-Number require separate qualification.

(2) a decrease in the nominal design tube wall thickness of 10% or more (if the plug is welded to the tube).

(3) a change in the tubesheet hole pattern.

(4) a decrease in the proximity of two simultaneously detonated parts.

(5) any increase in the number of plugs to be simultaneously detonated.

(6) a change in detail controlling explosive densities and charge-to-mass ratios.

(7) a change in the type of explosive.

(8) a change of 10% or more in the explosive charge mass.

(9) a decrease of 15% or more in the tubesheet ligament.

(10) the deletion of cleaning of the tube, plug, or hole contact surfaces, or a change in the cleanliness requirements (including surface oxide removal) for such surfaces prior to explosive welding.

(11) a change of whether or not the tubes had been expanded into contact with the tubesheets in the areas where bonding occurs.

(12) any change in the nominal plug configuration.

(13) a change of 10% or more in the clearance (stand-off) between the tube or hole and the plug in the bonding area.

(b) Nonessential Variables

(1) a change in the P-Number of tubesheet material for tube plugging (when plug is not joined to tubesheet)

(2) a change in the tubesheet cladding (when the plug is not joined to the cladding) when the explosive charge is installed within one tube diameter of the cladding metal

(3) for tube plugging, a change in the tube-to-tubesheet seal welding procedure when the explosive charge is installed within one tube diameter of the tube-to-tubesheet seal weld [see (c)(3)]

(c) Test Assembly

(1) The procedure qualification shall be made on a test assembly that simulates the conditions to be used in production with respect to position, tube hole pattern, and the essential variables listed in this Subparagraph.

(2) The test assembly tubesheet thickness shall be as thick as the production tubesheet, except that it need not be 1 in. greater than the length of the explosive plug.

(3) When the explosive charge in the heat exchanger is to be placed less than one tube diameter from cladding or a tube-to-tubesheet weld, the qualification test assembly shall also contain cladding or tube-to-tubesheet welds, as applicable.

(4) The minimum number of explosive welds required for procedure qualification shall be 10 welds made consecutively.

(d) Examination of Test Assembly

(1) When cladding or welds are required per (c)(3), such cladding and tube-to-tubesheet welds shall be examined by the liquid penetrant method and shall comply with the acceptance standards of Article NB-5000.

(2) Each plug weld and tube-to-tubesheet weld (when applicable) shall be sectioned longitudinally to reveal four cross-sectional faces, 180-deg apart. After polishing and etching the four faces, each explosive weld joint area shall be metallographically examined at 50X or greater magnification for the length of the explosive bond. The bonding shall be considered acceptable if there is a minimum of five times the nominal tube wall thickness of continuous bond between the plug and tube or tubesheet on each cross-sectioned face. Each tube-to-tubesheet weld examination (if applicable) shall be considered acceptable if it is free from explosively produced cracks as determined visually using 10X magnification.

(3) Ligament distortion caused by explosive welding is unacceptable when the adjacent tube I.D. is reduced below the diameter of the tube plug.

(4) The procedure shall be considered qualified if all 10 of the required, consecutively made explosive welds are found to be acceptable.

IWA-4711.2.2 Performance Qualifications. Tube plugging by explosive welding shall be performed by welding operators who have first been qualified in accordance with the following requirements.

(a) Required Tests. The welding operator shall prepare (if applicable), install, and detonate consecutively a minimum of five plugs in conformance with an explosive plug Welding Procedure Specification. Acceptance of these plug welds qualifies the operator for welding with all other explosive plug welding procedures.

(b) Examination of Test Assembly. The five plugs shall be examined in accordance with the requirements of IWA-4711.2.1(d). All five welds must meet these acceptance standards for performance qualification to be accepted.

(c) Renewal of Qualification. Renewal of qualification of an explosive plug welding operator's performance is required when the operator has not used the process for six months or longer, or when there is specific reason to question the individual's ability to make quality welds in accordance with the PPS. Renewal of qualification shall be identical to the initial qualification, except that only one tube plug explosive weld needs to be made.

IWA-4711.3 Plugging Procedure Specification. The written plugging procedure specification shall delineate all the requirements of the repair/replacement activity, including the following:

(a) safety requirements

(b) plug material, dimensions, and certification requirements

(c) essential and nonessential variables of the explosive welding process

(d) preparation or cleaning of the plug, tube, and tubesheet bore hole, if required

(e) detonation of the charge

(f) nondestructive examination

(g) method of verifying that both ends of the same tube or tubesheet bore hole are to be plugged

IWA-4711.4 Examination. The final examination shall be a VT-1 visual examination in accordance with IWA-2200, looking for proper installation and correct location.

IWA-4712 Fusion Welding

The requirements of IWA-4712.1 through IWA-4712.5 shall be met when manual, machine, or automatic welding is used to join plugs to Class 1 heat exchanger tubes of P-Nos. 8 and 4X material or tubesheet holes of austenitic stainless steel or nickel base material. These requirements may be used for Classes 2 and 3 heat exchangers.

IWA-4712.1 Material Requirements.

(a) Material shall be in accordance with the requirements of an SA, SB, SFA, or any other material specification accepted for use by Section III. Material produced to a weld filler metal chemistry shall meet the filler material requirements of Article NB-2000.

(b) Material shall be traceable to a Certified Material Test Report (CMTR).

IWA-4712.2 Welding Qualifications. Welding Procedure Specifications (WPS) and welders or welding operators shall be qualified in accordance with Section IX and the additional requirements and exceptions of this Subparagraph.

(a) Procedure Qualification

(1) Welds shall be made using the shielded metal arc welding (SMAW), gas tungsten arc welding (GTAW), or gas metal arc welding (GMAW) process. Short-circuiting arc GMAW shall not be used.

(2) A separate qualification is required for any change in the P-Number, A-Number, or F-Number of the plug, tube, sleeve, filler metal, or cladding. A separate qualification is also required when the material has no P-Number, A-Number, or F-Number.

(3) If the plug is welded to the cladding, the cladding shall be considered as base material. The qualification test coupon may simulate the cladding by either of the following:

(-a) Cladding with $^{3}/_{16}$ in. (5 mm) thickness shall be deposited using any qualified WPS that results in the chemical analysis of the deposited cladding nominally matching the chemical analysis of the cladding on the item to be welded.

(-b) Wrought material shall be used. A-No. 8 cladding may be simulated by P-No. 8 material. F-No. 4X cladding may be simulated by similar P-No. 4X material.

(4) The following essential variables, in addition to those specified by Section IX, apply and shall be listed on the WPS:

(-a) a change of more than $^{1}/_{16}$ in. (1.5 mm) in the extension or recess of either the tube relative to the tubesheet or the plug relative to the material being joined (tube, sleeve, or tubesheet) (see Figure IWA-4712.2-1)

(-b) 10% change in the plug thickness at the weld location

(-c) 10% change in the nominal wall thickness of the tube or sleeve, when the plug is welded to the tube or sleeve

(-d) decrease of 10% or more in the specified width of the ligament between tube holes when the specified width is less than $^{3}/_{8}$ in. (10 mm) or three times the specified tube wall thickness, whichever is greater

(5) The tubesheet in the test assembly shall be at least as thick as the production tubesheet, but need not exceed $1^{1}/_{2}$ in. (38 mm).

(6) In lieu of the examination and test requirements of Section IX, five consecutive welds of the test assembly shall be examined using a liquid penetrant method in accordance with IWA-2200 and shall meet the acceptance standards of NB-5350. These welds shall then be cross sectioned longitudinally through the center of each plug. The thickness of the assembly may be reduced to facilitate sectioning. One section of each plug shall be polished, etched, and visually examined at 10X magnification. The weld throat and minimum leakage path shall not be less than that required by the Construction Code and Owner's Requirements. The welds shall be free of cracks and lack of fusion. Porosity shall not reduce the weld throat below the required minimum thickness in the leakage path.

(b) Performance Qualification

(1) The test assembly for performance qualification for welders and welding operators shall be the same as for any welding procedure qualification in accordance with the requirements of (a).

(2) For welders and welding operators, five consecutive acceptable welds shall be made and examined in accordance with (a)(6). The performance qualification shall be made in accordance with a WPS that has been qualified in accordance with the requirements of (a).

(3) Welders and welding operators shall be tested under conditions that simulate the weld area access. Such simulated conditions shall include radiation protection gear.

(4) In addition to the preceding requirements, only the following Section IX essential variables for welders apply:

(-a) a change from one welding process to any other welding process

(-b) a change in F-number of filler material

(-c) a change in P-number of either of the base materials

(-d) an addition or deletion of preplaced metal inserts

(-e) addition of welding positions other than those already qualified

(5) Essential variables for welding operators shall be in accordance with Section IX, QW-360.

(6) Renewal of qualification is required when the welder or welding operator has not used the process for 6 months or longer, or when there is a specific reason to question the individual's ability to make quality welds in accordance with the WPS. Renewal of qualification shall be identical to the initial qualification, except that only one weld needs to be made.

IWA-4712.3 Plugging Procedure. Each plug operation shall be performed in accordance with a procedure delineating the requirements of the complete repair/replacement activity, including the following:

(a) plug material, dimensions, and material certification requirements

(b) the preparation necessary for the joint to be plugged, including examination requirements and a means for removal of surface oxide

(c) requirements for preparation (sizing) of the tube or tubesheet hole I.D. prior to setting plugs, including examination requirements

(d) requirements for inserting the plug into position for welding, including examination requirements

(e) the qualified WPS

(f) requirements for final examination

IWA-4712.4 Examination. Final examination of heat exchanger plugs and welds shall consist of a VT-1 visual examination.

IWA-4712.5 Records. Records shall be maintained by the Owner in accordance with Article IWA-6000, and shall include the following:

(a) Welding Procedure Specification (WPS)

(b) Procedure Qualification Record (PQR)

(c) performance qualification records

(d) Certified Material Test Reports (CMTR)

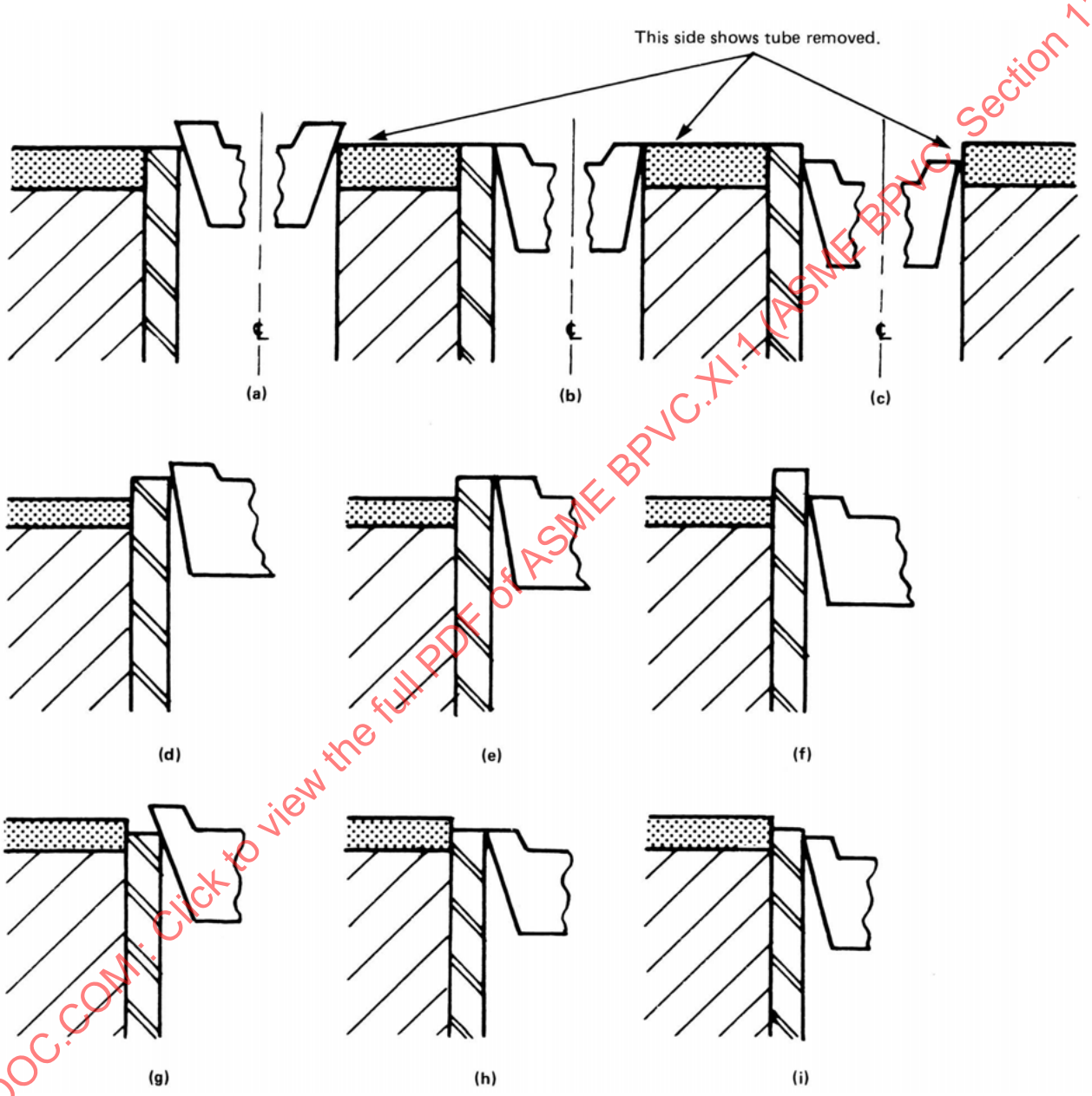
(e) location of plugged tubes or tubesheet holes

(f) results of examinations required by IWA-4712

IWA-4713 Heat Exchanger Tube Plugging by Expansion

If the mechanical roll or mechanical expander expansion method is used to expand plugs into Class 1 heat exchanger tubes in tubesheets, such that the plug is permanently deformed and the attachment depends upon friction or interference at the interface, the requirements of IWA-4713.1 through IWA-4713.5 shall be met.

Figure IWA-4712.2-1
Examples of Extension and Recess of Tube and Plug



GENERAL NOTE: When tubes have been sleeved, the plugs may be welded to the sleeve, tube, or cladding.

IWA-4713.1 General Requirements.

(a) Plugs shall meet the requirements of IWA-4200.

(b) Prior to installation, plug material shall be traceable to a Certified Material Test Report.

(c) Specimens representing the expanded plug attachment to a tube shall be corrosion tested or analyzed to assess the expected life of the plug.

IWA-4713.2 Plugging Procedure Specification. Each plugging operation shall be performed in accordance with a Plugging Procedure Specification (PPS). This specification shall delineate requirements of the plug installation, including the following:

(a) plug and tube materials and dimensions

(b) preparation of the plug and tube prior to insertion of the plug, including any specified examination requirements and acceptance criteria

(c) the essential variables of IWA-4713.3 and the expansion process used

(d) inserting the plug into position prior to final expanding

(e) plug expansion acceptance criteria

(f) final acceptance criteria

(g) the sequence of operations

(h) pre- and post-installation performance checks of the installation equipment

IWA-4713.3 Plug and Procedure Qualification.

(a) The plug design and PPS shall be tested in accordance with the following requirements:

(1) General Test Requirements

(-a) Testing used to qualify the plug design and PPS shall be conducted using the essential variables specified in (b).

(-b) The test plan shall include:

(-1) test temperatures and pressures

(-2) acceptance criteria

(-3) essential variables

(-4) number of test specimens

(-5) external loading (e.g., incurred by tube stabilizer)

(-6) test configuration

(-7) surface condition (including acceptance criteria)

(-c) For each required test, five specimens shall be tested; each specimen shall meet the acceptance criteria in (2) and (3).

(-d) Following installation of each test specimen, the condition of the adjacent bores shall be evaluated to verify that ligament distortion will not prohibit access for NDE or repair/replacement activities.

(-e) The test assembly shall simulate production conditions with respect to the essential variables in (b). The minimum test assembly tubesheet thickness shall be the lesser of the length of the plug attachment joint plus $^{1}/_{2}$ in. (13 mm) or the production tubesheet thickness.

(2) Cyclic Test

(-a) The specimens shall be pressure tested and thermally cycled to simulate the effects of heat exchanger heat-up and cool-down for the expected life of the plug. Test temperatures and pressures shall envelope service conditions. Alternatively, the need to perform an equivalent number of thermal test cycles to simulate the effects of heat exchanger heat-up and cool-down for the expected life of the plug is not necessary if all of the following are met:

(-1) A similar plug has been qualified in accordance with IWA-4713.3 for the expected number of thermal cycles for the life of the plug. In this context, a plug is considered similar if it has all the same essential variables listed in (b) with the exception of the variables in (b)(3) and (b)(4).

(-2) The specimens required by (1)(-c) shall be thermally cycled at least ten times. The thermal cycles shall simulate the effects of heat exchanger heat-up and cool-down.

(-3) An evaluation shall be performed and documented to ensure that the number of thermal cycles performed in (-2) is adequate to ensure the plug satisfies the acceptance criteria in (-b) for the expected life of the plug.

(-b) The test results shall meet leakage and plug movement acceptance criteria specified by the Owner.

(3) Proof Test

(-a) The specimens shall be proof tested at the higher of the following pressures:

(-1) 1.43 times the maximum differential pressure during accident conditions; or

(-2) 3.0 times the maximum differential pressure across the tubesheet during normal operating conditions.

(-b) The test may be conducted at any temperature.

(-c) There shall be no plug ejection.

(4) General Design Considerations

(-a) Testing or an evaluation shall demonstrate that the plug attachment can withstand the specific external loadings (e.g., those incurred by tube stabilizers) and meet the acceptance criteria.

(-b) An evaluation shall be performed to assess the potential for and consequences of increased pressure caused by heating of static fluid in a plugged tube.

(b) The PPS shall be requalified if any of the essential variables listed below are changed.

(1) specified material and heat treatment condition of the plug

(2) a change of plug, tube, or tubesheet material that results in a change of 10% or more in the material thermal expansion coefficient

(3) the pre-expanded plug nominal diameter and nominal wall thickness in the effective attachment joint length

(4) the nominal tube diameter

(5) a change of more than 5% in the nominal tube wall thickness

(6) cleaning method prior to plug insertion

(7) the expansion method (i.e., roll or expander)

(8) the specified effective attachment joint length

(9) whether or not the tube has been expanded into contact with the tubesheet in the area where plug expansion occurs

(10) a design change in the expanded interface between the plug and the tube

(11) for mechanical roll expansion

(-a) joint rolling torque outside the minimum and maximum values used in qualification

(-b) a change in roll expander geometry, material, or design from those used in qualification testing

(-c) a change of roll lubricant

(12) for mechanical expander expansion

(-a) a reduction in minimum pull load or expander travel

(-b) a change in expander or plug inside taper

(-c) a change of expander material or hardness

(-d) a change of expander lubricant

(c) When an essential variable is changed following a completed qualification in accordance with IWA-4713.3, the following alternative requirements may be used in lieu of repeating the testing and evaluations required by (a)(2) and (a)(3).

An evaluation may be performed to show the acceptability of the PPS for the design change being considered, provided the following requirements are met:

(1) Test data that isolate the essential variable and meet the acceptance criteria of (a)(1)(-b)(-2) shall be available.

(2) Cyclic and proof test data shall demonstrate compliance with (a)(2) and (a)(3) respectively, with the revised essential variable.

(3) A changed essential variable shall be evaluated with respect to all other essential variables to ensure that the original acceptance criteria of (a)(1)(-b)(-2) are still met.

IWA-4713.4 Plugging Performance Qualification. Tube plugging by expansion shall be performed by individuals who have demonstrated their ability to expand plugs in accordance with the PPS. At least one test is required for performance qualification.

(a) For manual installation, the installer shall be qualified under conditions simulating the restricted access to the production joint.

(b) Renewal of the performance qualification is required when the expansion plugging equipment operator has not used the process for more than twelve months or when there is reason to question their ability to install plugs in accordance with the PPS. Renewal of qualification shall be identical to the initial qualification.

IWA-4713.5 Records. The following records, in addition to those required by Article IWA-6000, shall be maintained by the Owner:

(a) Plugging Procedure Specifications

(b) record of procedure qualification for the plugging method, including the essential variables and results of all tests required by IWA-4713.3

(c) record of performance qualification for each individual, including the PPS number and revision

(d) Certified Material Test Report for installed plugs

(e) location of all plugged tubes

(f) results of post-installation examinations and evaluations

(g) evaluations performed in accordance with IWA-4713.3(a)(4)

IWA-4720 SLEEVING

IWA-4721 General Requirements

IWA-4721.1 Sleeves. The sleeves shall meet the requirements of IWA-4200. The exemptions of IWA-4130 shall not apply.

The requirements of IWA-4721 through IWA-4724 shall be used for Class 1 heat exchanger tube sleeving. These requirements may be used for Classes 2 and 3 heat exchangers.

IWA-4721.2 Sleeving Procedure Specification. Each sleeving operation shall be performed in accordance with a sleeving procedure specification (SPS) that defines the following:

(a) sleeve and tube materials and dimensions

(b) requirements for preparation of the tube inside surface prior to insertion of the sleeve, including examination requirements and acceptance criteria

(c) requirements for inserting the sleeve into position, including examination requirements and acceptance criteria

(d) the essential and nonessential variables of IWA-4721.3 and the welding or brazing process used

(e) required sleeve attachment dimensions

(f) requirements for final examination and acceptance criteria

(g) the sequence of operations

IWA-4721.3 Qualification.

IWA-4721.3.1 Sleeving Procedure Specification Qualification. The SPS shall be qualified in accordance with this Subsubparagraph, and shall be requalified for any change in an essential variable. Nonessential variables may be changed without requalification provided the SPS is amended to show the changes.

(a) The following essential variables apply to all sleeve installation processes, in addition to those listed for each sleeve attachment process in IWA-4723, IWA-4724, and IWA-4725:

(1) a change in the P-Number classification of any of the materials being joined. This includes the tube, sleeve, tubesheet, or equivalent P-Number for tubesheet cladding. Materials not having a P-Number classification require a separate qualification.

(2) a change of 10% or more in nominal tube or sleeve design wall thickness in the area of the joint.

(3) deletion of tube cleaning prior to sleeve insertion.

(4) a change in sleeve attachment location from within the tubesheet to beyond the tubesheet or vice versa.

(5) a change in sleeve attachment location from within the sludge pile to beyond the sludge pile or vice versa.

(6) the addition or deletion of postweld or postbraze heat treatment.

(7) a change of more than 10% in the nominal tube or sleeve diameter.

(b) The following nonessential variable applies to all sleeve installation processes, in addition to those listed for each sleeve attachment process in IWA-4723, IWA-4724, and IWA-4725: a change in the method of tube cleaning prior to sleeve insertion.

IWA-4721.3.2 Sleeving Performance Qualification.

(a) Sleeve attachment processes shall be performed by welders, brazers, or equipment operators that have been qualified in accordance with this subsubarticle.

(b) Manual process qualification shall be performed under conditions simulating the restricted access of the production joint.

(c) Renewal of performance qualification is required when the welder, brazer, or equipment operator has not used the process for more than 6 months, or when there is any reason to question the individual's ability to make quality attachments in accordance with SPS. Renewal of qualifications shall be identical to the initial qualification except that only one sleeve attachment needs to be made.

IWA-4721.4 Sleeving by a Combination of Processes. If a combination of processes is used for sleeve installation, either at opposite ends of a single sleeve or as a sequence of processes in a single attachment, IWA-4723, IWA-4724, or IWA-4725, as applicable, apply to each process used. The SPS shall require that the processes used during production sleeving be performed in the same sequence as used during qualification.

IWA-4721.5 Records. The following records, in addition to those required by Article IWA-6000, shall be maintained by the Owner:

(a) SPS

(b) procedure qualification for the attachment process

(c) performance qualification for each welder, brazer, and equipment operator

(d) location records of all sleeved tubes and sleeves

(e) results of all required sleeve installation examinations

IWA-4723 Fusion Welding

IWA-4723.1 General Requirements. When fusion welding is used for sleeve attachment, the requirements of IWA-4723.1.1 through IWA-4723.4 shall be met.

IWA-4723.1.1 Procedure Qualification. Welds shall be made using the gas tungsten arc welding (GTAW), gas metal arc welding (GMAW), or laser beam welding (LBW) process.

IWA-4723.2 Fusion Welding Qualification.

IWA-4723.2.1 Procedure Qualification.

(a) Essential Variables

(1) for sleeve welds within the tubesheet, when the ligament thickness between the holes is $^{3}/_{8}$ in. (10 mm) or less, a reduction in ligament thickness of 10% of the ligament thickness or three times the specified wall thickness, whichever is less

(2) a change in any essential variable listed for the specific welding process in Section IX, QW-250

(b) Test Assembly. The procedure shall be qualified using a test assembly that simulates the conditions that will be encountered in production with respect to the essential variables.

(c) Test Assembly Within Tubesheet. The test assembly tubesheet thickness shall be at least as thick as the production tubesheet except that it need not be more than 1 in. (25 mm) greater than the length of the sleeve attachment.

(d) Examination of Test Assembly

(1) Five consecutive welds shall be examined by a liquid penetrant method in accordance with IWA-2200 and shall meet the acceptance standards of NB-5350. Welds inaccessible for liquid penetrant examination may be sectioned longitudinally through the center of the sleeve prior to performing the liquid penetrant examination.

(2) The five consecutive welds shall also be sectioned longitudinally through the center of each sleeve. The thickness of the assembly may be reduced to facilitate sectioning.

(3) The two faces of a single half-section shall be polished, etched, and visually examined at 10X magnification. The weld throat and minimum leakage path shall not be less than that required by the Construction Code and Owner's Requirements. The weld shall be free of cracks and lack of fusion. Porosity shall not reduce the weld throat thickness below the required minimum leakage path.

IWA-4723.2.2 Performance Qualification. Welding shall be performed by welders and welding operators that have been qualified in accordance with the following:

(a) The test assembly for the performance qualification for welders and welding operators shall be the same as for any welding procedure qualification in accordance with the requirements of IWA-4723.2.1.

(b) The essential variables for welders and welding operators shall be in accordance with Section IX, QW-350 and QW-360, respectively, for the process to be employed.

(c) For welders, five consecutive acceptable welds shall be made and examined in accordance with IWA-4723.2.1(d). For welding operators, one acceptable weld shall be made and examined in accordance with IWA-4723.2.1(d). The performance qualification shall be made in accordance with a SPS qualified in accordance with IWA-4723.2.1.

(d) Welders shall be tested under simulated access conditions. The qualification test mock-up shall effectively simulate the conditions that will be encountered in production with respect to the essential variables.

(e) Retest shall be performed as required by Section IX, QW-320.

IWA-4723.3 Sleeving Procedure Specification. The SPS shall delineate all the requirements of the fusion welding process, including the variables of Section IX, QW-250.

IWA-4723.4 Examination. The welded sleeve attachment shall be examined to confirm that the attachment is in the correct location and conforms to the Construction Code and Owner's Requirements.

IWA-4724 Brazing

IWA-4724.1 General Requirements. When brazing is used for sleeve attachment, IWA-4724.2 through IWA-4724.4 shall be met.

IWA-4724.2 Brazing Qualification.

IWA-4724.2.1 Procedure Qualification. The brazing procedure shall be qualified as required by Section IX, QB-200 and the following:

(a) An additional essential variable is a change in the designed sleeve installation from free tubes to tubes that are locked to the tube support plate.

(b) Test Assembly. The procedure shall be qualified using a test assembly that simulates the conditions that will be encountered in production with respect to the essential variables.

(c) Test Assembly Within Tubesheet. The test assembly tubesheet thickness shall be at least as thick as the production tubesheet except that it need not be more than 1 in. (25 mm) greater than the length of the sleeve attachment.

(d) Examination of Test Assembly

(1) Each test specimen shall be examined to confirm that the braze bond area conforms to the Construction Code and Owner's Requirements.

(2) The minimum number of braze joints required for procedure qualification shall be five braze joints made consecutively.

IWA-4724.2.2 Performance Qualification. Each brazer and brazing operator shall be qualified as required by Section IX, QB-300, and each test specimen shall be examined to confirm that the braze bond area conforms to the Construction Code and Owner's Requirements.

IWA-4724.3 Sleeving Procedure Specification. The SPS shall delineate all the requirements of the brazing process, including the variables of Section IX, QB-200.

IWA-4724.4 Examination. A final examination of the brazed sleeve attachment shall confirm that the attachment is in the correct location and conforms to the Construction Code and Owner's Requirements.

IWA-4725 Expansion

IWA-4725.1 General Requirements. When a sleeve is expanded against a tube by a mechanical or hydraulic process so that the sleeve is permanently deformed and the attachment depends upon friction or interference at the interface, IWA-4725.2 through IWA-4725.4 shall be met.

IWA-4725.2 Expansion Qualification.

IWA-4725.2.1 Procedure Qualification.

(a) Essential Variables

(1) a change in the basic expansion process

(2) a change of 10% or more in sleeve material yield strength

(3) a change in the expansion length

(4) a change that results in an expansion diameter outside the range of sleeve or tube expansion diameters qualified. The range of sleeve or tube expansion diameters qualified shall be the expansion diameters between the minimum and maximum expansion diameters obtained in qualification tests.

(5) for mechanical expansion:

(-a) a reduction in the minimum rolling torque

(-b) a change in expansion roller geometry

(-c) a reduction in the minimum expansion pressure if expansion is controlled by hydraulic pressure only

(b) Test Assembly. The procedure shall be qualified using a test assembly that simulates the conditions that will be encountered in production with respect to the essential variables.

(c) Test Assembly Within Tubesheet. The test assembly tubesheet thickness shall be at least as thick as the production tubesheet except that it need not be more than 1 in. (25 mm) greater than the length of the sleeve attachment.

(d) Qualification of Test Assembly. Specimens representing the expanded sleeve attachment to a tube shall be cyclic tested in accordance with Section III Appendices, Mandatory Appendix II. This fatigue test shall demonstrate that the sleeve attachment can withstand the specified design loadings without exceeding the specified design leakage limit.

IWA-4725.2.2 Performance Qualification. The expansion operator shall demonstrate the ability to expand sleeve attachments in accordance with the SPS.

IWA-4725.3 Sleeving Procedure Specification. The SPS shall delineate the requirements for mechanical expansion. These requirements shall conform to the Construction Code and Owner's Requirements.

IWA-4725.4 Examination. The expanded sleeve attachment shall be examined to confirm that the attachment is in the correct location and conforms to the requirements of the Construction Code and Owner's Requirements.

ARTICLE IWA-5000
SYSTEM PRESSURE TESTS

IWA-5100 GENERAL

IWA-5110 PERIODIC SYSTEM PRESSURE TESTS

(a) System pressure tests shall be conducted in accordance with the Examination Categories identified in Tables IWB-2500-1 (B-P), IWC-2500-1 (C-H), and IWD-2500-1 (D-B).

(b) The pressure testing requirements for Class MC and CC components are identified in Subsections IWE and IWL, respectively.

IWA-5120 PERIODIC SYSTEM PRESSURE TEST EXEMPTIONS

The following systems and components are exempt from the periodic pressure test requirement:

(a) piping that penetrates a containment vessel when the piping and isolation valves perform a containment function and the balance of the piping system is outside the scope of this Division or is not required to be tested in accordance with Article IWC-5000 or Article IWD-5000

(b) ventilation systems, except those designed to remove explosive gases from plant structures

(c) sample lines that carry compressible fluids, other than steam

(d) those portions of pneumatic components and systems statically pressurized and continuously monitored or alarmed for pressure loss[15]

(e) those portions of pneumatic components and systems periodically tested for leakage, or that demonstrate the necessary leak tightness, by programs required by plant Technical Specifications[16] or the regulatory authority having jurisdiction at the plant site

IWA-5200 SYSTEM TEST REQUIREMENT

IWA-5210 TEST

IWA-5211 Test Description

Pressure-retaining components within each system boundary shall be subject to the following applicable system pressure tests under which conditions a VT-2 visual examination is performed in accordance with IWA-5240 to detect leakage:

(a) a system leakage test conducted while the system is in operation, during a system operability test, or while the system is at test conditions using an external pressurization source;

(b) a system hydrostatic test[17] conducted while the system or portion of the system is at an elevated test pressure as specified in IWB-5230, IWC-5230, or IWD-5230; and

(c) a system pneumatic test conducted in lieu of either of the above system pressure tests for Class 2 or Class 3 components as permitted by Article IWC-5000 or Article IWD-5000. The requirements for system leakage and hydrostatic tests are applicable to pneumatic tests.

IWA-5212 Pressure and Temperature (25)

(a) System leakage tests and system hydrostatic tests shall be conducted at the pressure and temperature specified in Article IWB-5000, Article IWC-5000, and Article IWD-5000. The system hydrostatic test pressure shall not exceed the maximum allowable test pressure of any component within the system pressure test boundary.

(b) When conducting a system leakage test or a system pneumatic test in lieu of a system leakage test, system pressure shall be verified by normal system instrumentation, test instrumentation, or through performance of the system operating or surveillance procedure.

(c) The system test conditions shall be maintained during the course of the visual examination, except as provided in IWA-5243.1(a) and IWA-5245.

(d) When conducting a system hydrostatic test or a system pneumatic test in lieu of a system hydrostatic test, the requirements of IWA-5260 shall be met.

(e) A system hydrostatic test [see IWA-5211(b)] and accompanying visual examination are acceptable in lieu of the system leakage test [see IWA-5211(a)] and visual examination.

(f) The system test pressure and temperature may be obtained by using any means that comply with the plant Technical Specifications.

IWA-5213 Test Condition Holding Time (25)

The holding time after pressurization to test conditions, before the visual examinations commence, shall be as follows.

(a) For the system leakage tests required by Table IWB-2500-1 (B-P), Table IWC-2500-1 (C-H), or Table IWD-2500-1 (D-B), the following shall be met.

(1) For Class 1 components [see Table IWB-2500-1 (B-P)], no holding time is required after attaining test pressure.

(2) For Class 2 [see Table IWC-2500-1 (C-H)] and Class 3 [see Table IWD-2500-1 (D-B)] components in standby systems (or portions of standby systems) that are not operated routinely except for testing, a 10-min holding time is required after attaining test pressure.

(3) For Class 2 [see Table IWC-2500-1 (C-H)] and Class 3 [see Table IWD-2500-1 (D-B)] components operated continuously or routinely during normal plant operation, cold shutdown, or refueling operations, no holding time is required, provided the system has been in operation for at least 4 hr for insulated components or 10 min for noninsulated components.

(4) For Class 2 [see Table IWC-2500-1 (C-H)] and Class 3 [see Table IWD-2500-1 (D-B)] components connected directly to the Class 1 system that are pressurized and examined as part of the Class 1 system leakage test, no holding time is required after attaining test pressure.

(b) For system pressure tests required by IWA-4540, the following shall be met:

(1) For PWRs and BWRs, except as provided in (2), a 10-min holding time for noninsulated components, or 4 hr for insulated components, is required after attaining test pressure. For Class 1 system leakage tests, if during the holding time the pressure drops below the required test pressure, the initial holding time need not be restarted but shall be extended by an amount equal to the time the required test pressure was not met.

(2) For a BWR using the reduced pressure alternative of IWB-5221(b)(3), a 15-min holding time for noninsulated components, or 6 hr for insulated components, is required after attaining test pressure.

(c) For system pneumatic tests, a 10-min holding time is required after attaining test pressure.

IWA-5214 Preservice Test

A preservice system pressure test is not required by this Article, except following repair/replacement activities as required by IWA-4540.

IWA-5220 TEST PRESSURIZATION BOUNDARIES[18]

IWA-5221 System Leakage Test Boundary

The boundary subject to test pressurization during a system leakage test [see IWA-5211(a)] includes the pressure-retaining components to be tested in accordance with IWB-5222, IWC-5222, and IWD-5222.

IWA-5222 System Hydrostatic Test Boundary

(a) The boundary subject to test pressurization during a system hydrostatic test [see IWA-5211(b)] shall be defined by the system boundary (or each portion of the boundary) within which the components have the same minimum required classification and are designed to the same pressure rating as governed by the system function and the internal fluid operating conditions, respectively.

(b) Systems which share safety functions for different modes of plant operation, and within which the component classifications differ, shall be subject to separate system hydrostatic tests of each portion of the system boundary having the same minimum required design pressure ratings.

(c) Systems designed to operate at different pressures under several modes of plant operation or post-accident conditions shall be subject to a system hydrostatic test within the test boundary defined by the operating mode with the higher pressure.

(d) Where the respective system design pressure ratings on the suction and discharge sides of system pumps differ, the system hydrostatic test boundary shall be divided into two separate boundaries (such as suction side and discharge side test boundaries). In the case of positive displacement pumps, the boundary interface shall be considered as the pump. In the case of centrifugal pumps, the boundary interface shall be the first shutoff valve on the discharge side of the pump.

IWA-5240 VISUAL EXAMINATION

IWA-5241 Insulated and Noninsulated Components (25)

(a) The VT-2 visual examination shall be conducted by examining the accessible external exposed surfaces of pressure-retaining components for evidence of leakage.

(b) The sources of leakage detected during the conduct of a system pressure test shall be identified.

(c) For components whose external surfaces are inaccessible for direct VT-2 visual examination, only the examination of the surrounding area (including floor areas or equipment surfaces located underneath the components) for evidence of leakage shall be required.

(d) Components within rooms, vaults, etc., where access cannot be obtained may be examined using installed leakage detection systems.

(e) Essentially vertical surfaces need only be examined at the lowest elevation where leakage may be detected.

(f) Essentially horizontal surfaces of insulation shall be examined at each insulation joint if accessible for direct VT-2 examination.

(g) When examining insulated components, the examination of the surrounding area (including floor areas or equipment surfaces located underneath the components) for evidence of leakage, or other areas to which such leakage may be channeled, shall be required.

(h) For components located in a portion of a system that is borated for the purpose of controlling reactivity, the requirements of IWA-5243.1 shall also be met.

(i) Corrective actions for borated water leakage or accumulated boron residue identified during performance of VT-2 visual examinations shall comply with IWA-5243.2.

(j) For Class 2 and Class 3 buried components not surrounded by an annulus, examination and testing shall be conducted in accordance with IWA-5244.

(k) For Class 2 and Class 3 components surrounded by an annulus, a VT-2 visual examination shall be performed at each end of the annulus and at low-point drains for evidence of leakage. If there is no low-point drain and the annulus is enclosed, access for visual examination shall be obtained through any existing means, such as cover plates and inspections ports.

(25) ## IWA-5242 Pneumatic Components

(a) For systems and components that contain a compressible fluid, excluding steam, during normal plant operation, a leakage test using one of the following techniques shall be performed in lieu of a VT-2 visual examination:

(1) bubble test—direct pressure technique

(2) bubble test—vacuum box technique

(3) halogen diode detector probe test

(4) helium mass spectrometer test—detector probe technique

(5) helium mass spectrometer test—tracer probe technique

(6) pressure change test

(b) The test procedures for (a) leakage tests shall comply with the requirements for leak testing defined in ASME Section V, Article 10 and shall include methods for detection and location of through-wall leakage from components of the system tested.

(c) The Owner shall specify the acceptance criteria for the examinations and tests of (a), which shall be based on system design and operational requirements.

(d) The personnel qualification shall be in accordance with IWA-2318.

(e) Pneumatic components with leakage in excess of the acceptance criteria of IWA-5242(c) shall be corrected by repair/replacement activity or corrective measures, as required to satisfy the acceptance criteria.

(25) ## IWA-5243 Borated Water Systems

IWA-5243.1 Systems Borated for Reactivity Control. In addition to the requirements of IWA-5241, the following requirements are applicable for components located in a portion of a system that is borated for the purpose of controlling reactivity:

(a) For insulated components, insulation shall be removed from pressure-retaining bolted connections for VT-2 visual examination. Insulation removal and VT-2 visual examination of insulated bolted connections may be deferred until the system is depressurized. When corrosion-resistant bolting material with a chromium content of at least 10%, such as SA-564 Grade 630 H1100, SA-453 Grade 660, SB-637 Type 718, or SB-637 Type 750, is used, it is permissible to perform the VT-2 visual examination without insulation removal.

(b) If leakage is identified at a bolted connection, the following requirements shall be met:

(1) The leakage shall be stopped, and the bolting and component material shall be evaluated for joint integrity.

(2) If the leakage is not stopped, the Owner shall evaluate the structural integrity of the joint, the consequences of continuing operation, and the effect on system operability of continued leakage.

(3) The evaluation required by (1) or (2) shall determine the susceptibility of the bolted connection to corrosion and failure. The evaluation shall include analysis of the following:

(-a) the number and service age of the bolts or studs

(-b) bolt or stud and component material

(-c) corrosiveness of process fluid

(-d) leakage location and system function

(-e) leakage history at the connection or other system components

(-f) visual evidence of corrosion at the assembled connection

(c) As an alternative to (b), one of the bolts or studs shall be removed, VT-3 visually examined, and evaluated in accordance with IWA-3100. The bolt or stud selected shall be the one closest to the source of leakage. When the removed bolt or stud has evidence of degradation, all remaining bolts or studs in the connection shall be removed, VT-3 examined, and evaluated in accordance with IWA-3100. If all bolts or studs in the connection are replaced in accordance with Article IWA-4000, no visual examination of the removed bolts or studs is required.

IWA-5243.2 Corrective Actions for Borated Water Leakage.

(a) When VT-2 visual examinations identify evidence of borated water leakage or accumulated boron residue on surfaces of components, insulation, or adjacent floor areas, the following measures shall be required:

(1) The sources of leakage detected during the conduct of a system pressure test shall be located and evaluated by the owner for corrective action, in accordance with established procedures.

(2) Borated water leakage or any resulting corrosion on pressure-retaining or load-bearing surfaces shall be compared to the acceptance criteria of IWB-3522.1, IWC-3516.1, or IWD-3511.1, as applicable.

(b) Components with local areas of general corrosion that reduce the wall thickness by more than 10% shall be evaluated to determine whether the component may be acceptable for continued service or whether repair/replacement activities will be performed.

IWA-5244 Buried Components

(a) Buried Class 2 and Class 3 components shall be pressure tested as required by Tables IWC-2500-1 (C-H) and IWD-2500-1 (D-B). In lieu of pressure testing

portions of Class 2 and Class 3 buried components that are open ended, a test to confirm that flow during operation is not impaired shall be performed once every 2 yr.

(b) Buried components fabricated from the following types of materials[19] are exempt from examination and testing:

(1) stainless steel, provided the local soil conditions (determined by soil analysis) would not potentially cause stress corrosion cracking

(2) titanium alloy, super austenitic steel, duplex cast austenitic stainless steel, or nickel alloy

(3) copper alloy, provided the local soil conditions (determined by soil analysis) would not potentially cause an accelerated rate of material loss due to the presence of anaerobic sulfide-reducing bacteria, a high concentration of ammonia (NH_3), or a pH less than 6.0

(4) high-density polyethylene

(c) Class 2 and Class 3 buried components shall be pressure tested in accordance with one or more of the methods described in (1) through (3). Acceptance criteria and personnel qualifications shall be determined by the Owner. Different test and examination methods may be used for subsequent periodic pressure tests.

(1) pressure decay test: a test that determines the rate of pressure loss within a specified boundary for detecting leakage. For this type of test, the test boundary isolation valves shall be capable of being leak tight.

(2) inventory reduction test: a test in which a reduction in inventory could be indicative of leakage from the pressure boundary (e.g., suction line from a tank). The Owner shall determine the required test parameters, with consideration for level instrument accuracy, normal inventory level or range, expected inventory loss from other than pressure boundary leakage (e.g., evaporation from a spray pond), and duration of the test, to detect potential leakage that could adversely affect the system safety function. The Owner shall account for makeup sources to the system during the test to ensure that detection of potential buried component pressure boundary leakage is not adversely affected by inventory increases.

(3) ground surface visual examination: a test method consisting of a visual examination conducted on the ground surface while the buried component below is pressurized. The visual examination is to identify evidence of leakage on ground surfaces near the buried components and in areas where leakage might be channeled or accumulated. The examination shall include other areas to which leakage is likely to be channeled or in which leakage is likely to be accumulated (e.g., storm drain catch basins, other ponding areas). The ground surface examination method shall not be used in areas where the component is buried beneath an impermeable material, is encased in concrete, or where leakage would be expected to flow toward areas where it cannot be detected (e.g., leakage that would be expected to flow to the groundwater table, into an aquifer, or into a surface body of water). Additionally, the pressurization hold time shall be established in accordance with the following. If the system pressure during the test is at least 90% of the accident pressure of the system, the examination shall be performed after the buried component has been operating at the system pressure continuously for at least 30 days. Alternatively, the Owner may determine a period of operation shorter than 30 days, or a lower system test pressure, provided leakage would be projected to permeate to the ground surface within the specified hold time at the system test pressure. The basis for the shorter period of operation shall be documented in accordance with IWA-6340(k).

(d) Alternatively, if it is impracticable to test the buried components in accordance with (c), and if the component is coated, wrapped, or not located in a harsh environment, a test to confirm that flow during operation is not impaired shall be performed every 2 yr, provided the following conditions are met. The basis for a pressure test being impracticable shall be documented in accordance with IWA-6340(k). The environment shall be considered harsh if cathodic protection is not functional, the component is within the groundwater table, or soil testing using methods like AWWA C105, Table A.1 results in a point value greater than 10. If soil testing is not performed, the environment shall be considered harsh.

IWA-5245 Elevated Temperature Tests

The visual examination of system components requiring a test temperature above 200°F (95°C) during the system pressure test may be conducted after the pressure holding period of IWA-5213 is satisfied, and the pressure is lowered to the level corresponding with a temperature of 200°F (95°C), in accordance with allowable cooldown rates established by fracture prevention criteria.

IWA-5246 Reactor Vessel Head Flange Seal Leak Detection

In lieu of the requirements of IWB-5220, IWC-5220, or IWD-5220, the Class 1, 2, or 3 portion of the reactor vessel head flange seal leak detection system shall be examined using the VT-2 visual examination method. The test shall be conducted at ambient conditions after the refueling cavity has been filled to its normal refueling water level for at least 4 hr.

IWA-5250 CORRECTIVE ACTION (25)

DELETED

IWA-5260 INSTRUMENTS FOR SYSTEM HYDROSTATIC TESTS

IWA-5261 Type

Any pressure measuring instrument or sensor, analog or digital, including the pressure measuring instrument of the normal operating system instrumentation (such as control room instruments), may be used, provided the requirements of IWA-5260 are met.

IWA-5262 Accuracy

The pressure measuring instrument or sensor used in hydrostatic testing shall provide results accurate to within 0.5% of full scale for analog gages and 0.5% over the calibrated range for digital instruments.

IWA-5263 Calibration

All pressure measuring instruments shall be calibrated against a standard deadweight tester or calibrated master gage. The test gages shall be calibrated before each test or series of tests. A series of tests is a group of tests that use the same pressure measuring instruments and that are conducted within a period not exceeding 2 weeks.

IWA-5264 Ranges

(a) Analog pressure gages used in testing shall have dials graduated over a range of at least 1.5 times, but not more than 4 times, the intended maximum test pressures.

(b) Digital pressure measuring instruments used in testing shall be selected such that the intended maximum test pressure shall not exceed 70% of the calibrated range of the instrument.

IWA-5265 Location

(a) When testing an isolated component, the pressure measuring instrument or sensor shall be connected close to the component.

(b) When testing a group of components or a multicomponent system, the pressure measuring instrument or sensor shall be connected to any point within the pressure boundary of the components or system such that the imposed pressure on any component, including static head, will not exceed 106% of the specified test pressure for the system; even though the specified test pressure may not be achieved at the highest elevations in the system.

IWA-5300 TEST RECORDS

The record of the visual examination conducted during a system pressure test shall include the procedure documenting the system test condition and system pressure boundary. Any source of leakage or other relevant conditions shall be itemized, and the location and corrective action shall be documented.

ARTICLE IWA-6000
RECORDS AND REPORTS

IWA-6100 SCOPE

This Article provides the requirements for the preparation, submittal, and retention of records and reports.

IWA-6200 REQUIREMENTS

IWA-6210 RESPONSIBILITIES

IWA-6211 Owner's Responsibilities

(a) The Owner shall prepare plans and schedules for preservice and inservice examinations and tests to meet the requirements of this Division.

(b) The Owner shall prepare records of examinations, tests, and repair/replacement activities.

(c) The Owner shall complete the Owner's Activity Report, Form OAR-1, for preservice and inservice examination of pressure-retaining components and their supports, and core support structures. Form OAR-1 shall be completed as required by IWA-6230 for the following:

(1) preservice examinations performed prior to placement of the unit into commercial service.

(2) preservice and inservice examinations performed following placement of the unit into commercial service. Form OAR-1 shall include records of examinations, tests, and repair/replacement activities completed since certification of the preceding Form OAR-1.

(d) The Owner shall prepare the Owner's Repair/Replacement Certification Record, Form NIS-2, upon completion of all required activities associated with the repair/replacement plan necessary to place the item in service.

(e) All Form NIS-2s associated with repair/replacement activities performed since certification of the preceding Form OAR-1 shall be completed prior to the completion of Form OAR-1.

(f) When the Owner contracts a Repair/Replacement Organization to perform repair/replacement activities, the Owner shall require the Repair/Replacement Organization to provide a document certifying its repair/replacement activities. Nonmandatory Appendix T[20] provides a report form that may be used for contracted repair/replacement activities and that will assist the Owner in completing and filing Form NIS-2.

IWA-6212 Contracted Repair/Replacement Organization's Responsibilities

A contracted Repair/Replacement Organization shall prepare a document, acceptable to the Owner, certifying its repair/replacement activities. Nonmandatory Appendix T[20] provides a report form that may be used for contracted repair/replacement activities and that will assist the Owner in completing and filing Form NIS-2.

IWA-6220 OWNER'S REPAIR/REPLACEMENT CERTIFICATION RECORD (25)

(a) A repair/replacement plan shall be prepared in accordance with IWA-4150 for all repair/replacement activities, including rerating, and shall be given a unique identification number.

(b) Upon completion of all required activities associated with the repair/replacement plan, the Owner shall complete Form NIS-2, as shown in Mandatory Appendix II.

(c) Form NIS-2 shall be completed after satisfying all Section XI requirements necessary to place the item in service and prior to completion of Form OAR-1.

(d) Form NIS-2 shall be certified by the Owner and presented to the Inspector for the required signature.

(e) The certified Form NIS-2 shall be retained by the Owner in accordance with IWA-6350.

(f) The Owner shall maintain an index of repair/replacement plans.

IWA-6230 OWNER'S ACTIVITY REPORT

(a) Form OAR-1 for the preservice examinations shall be completed prior to the date of placement of the unit into commercial service.

(b) For preservice and inservice examinations performed following placement of the unit into commercial service, Form OAR-1, as shown in Mandatory Appendix II, shall be processed as specified below within 120 calendar days of the completion of each refueling outage.

(1) A listing of the items with flaws or relevant conditions that exceeded the acceptance criteria of Division 1 and that required evaluation for continued service in accordance with IWB-3132.3, IWC-3122.3, IWE-3122.3, IWL-3112, IWL-3212, or IWL-3222 shall be documented on Form OAR-1, Table 1. This information is required whether or not the flaw or relevant condition was discovered during a scheduled examination or test.

(2) An abstract for the repair/replacement activities that were required due to an item containing a flaw or relevant condition that exceeded Section XI, Division 1 acceptance criteria shall be provided with the information and format of Form OAR-1, Table 2. This information is required even if the discovery of the flaw or relevant condition that necessitated the repair/replacement activity did not result from an examination or test required by Section XI, Division 1. If the acceptance criteria for a particular item is not specified in Section XI, Division 1, the provisions of IWA-3100(b) shall be used to determine which repair/replacement activities are required to be included in the abstract.

(3) For Articles IWE-2000 andIWL-2000 examinations, the following information concerning the acceptability of inaccessible areas, if unacceptable conditions are found to exist that could indicate the presence of, or result in, degradation, shall be included with Form OAR-1:

(-a) a description of the type and estimated extent of the degradation and the conditions that led to the degradation

(-b) the results of engineering evaluations for each affected area

(-c) a description of each corrective action

(4) If there are multiple inspection plans with different intervals, periods, or Section XI, Division 1 Editions or Addenda, the different inspection intervals, periods, Editions, or Addenda shall be identified on Form OAR-1.

(5) Form OAR-1 shall be certified by the Owner and presented to the Inspector for the required signature.

(6) The completed Form OAR-1 shall be submitted to the regulatory and enforcement authorities having jurisdiction at the plant site, if required by these authorities.

IWA-6300 RETENTION

IWA-6310 MAINTENANCE OF RECORDS

(a) The Owner shall retain records and reports identified in IWA-6330, IWA-6340, and IWA-6350. The records and reports shall be filed and maintained in a manner that will allow access by the Inspector. The Owner shall provide suitable protection from deterioration and damage for all records and reports, in accordance with the Owner's Quality Assurance Program, for the service lifetime of the component or system. Storage shall be at the plant site or at another location that will meet the access and Quality Assurance Program requirements.

(b) The Owner shall provide reasonable protection from deterioration for radiographic film that the Owner has classified as a record for the lifetime of the item. However, deterioration of radiographic film is to be expected and is not a violation of the requirement to provide suitable protection. If radiographic film has deteriorated, it need no longer be maintained as a lifetime record, as determined by the Owner.

IWA-6320 REPRODUCTION, DIGITIZATION, AND MICROFILMING

(a) Records and reports shall be either the original, including a digitally generated original, or a reproduced, legible copy. Records may be maintained in an electronic (i.e., digital) format using magnetic, optical, or equivalent storage media. Hard-copy records may be digitized. The Owner's Quality Assurance Program shall include a system for verifying accuracy and monitoring image legibility, storage, retrievability, and reproduction quality.

(b) Radiographs may be microfilmed or digitally reproduced. Digital reproduction shall be in accordance with Section V, Article 2, Mandatory Appendix VI, including Supplement A. The Owner's Quality Assurance Program shall include a system for monitoring the accuracy of the reproduction process so that the reproduction will provide the same information retrieval capability as the original radiograph. The accuracy of the reproduction process includes the exposure (or multiple exposures for density coverage), focusing, contrast, and resolution. The Quality Assurance Program shall also provide a system for identifying film or reproduction artifacts that might appear as material discontinuities in the reproduction.

IWA-6330 CONSTRUCTION RECORDS

Records designated by the Owner in accordance with the Construction Code, and Owner's Requirements, as applicable, shall be retained.

IWA-6340 INSERVICE INSPECTION RECORDS (25)

The Owner shall designate the records to be maintained. Such records shall include the following, as applicable:

(a) record index

(b) preservice and inservice inspection plans and schedules

(c) preservice and inservice inspection reports

(d) records of evaluations performed to accept flaws or relevant conditions that exceeded acceptance standards

(e) records of regions in ferritic Class 1 components with modified acceptance standards

(f) nondestructive examination procedures

(g) nondestructive examination records, including identification of calibration blocks used

(h) pressure test procedures

(i) pressure test records

(j) for Class CC

(1) tendon force and elongation measurement records (IWL-2522)

(2) free water documentation (IWL-2524.2)

(3) corrosion protection medium and free water analysis results (IWL-2525)

(k) records of evaluations to determine the practicability of conducting pressure testing of buried components in accordance with IWA-5244(d) or to determine a hold time and test pressure in accordance with IWA-5244(c)(3).

IWA-6350 REPAIR/REPLACEMENT ACTIVITY RECORDS

The following records prepared in performance of a repair/replacement activity shall be retained:

(a) evaluations required by IWA-4160(a), IWA-4160(b), and IWA-4311

(b) Repair/Replacement Program and plans

(c) records and reports of repair/replacement activities

(d) reconciliation documentation

(e) Form NIS-2

(f) documents certifying repair/replacement activities by contracted Repair/Replacement Organizations

(25)

ARTICLE IWA-9000
GLOSSARY

analytical evaluation: a quantitative process to determine the acceptability of postulated flaws, or flaws that exceed the applicable acceptance standards, including predicted future growth, to determine whether a component is acceptable for continued service without a repair/replacement activity.

applied stress (σ): a stress resolvable into membrane and bending components and including pressure, thermal, discontinuity, and residual effects acting at the flaw location.

appurtenance: an item to be attached to a stamped component that has work performed on it requiring verification by an Inspector (for items that are to be attached to components fabricated in accordance with Section III).

assess: to determine by evaluation of data compared with previously obtained data such as operating data or design specifications.

audit: a planned and documented activity performed to determine by investigation, examination, or evaluation of objective evidence; the adequacy of, and compliance with, established procedures; instructions, drawings, and other applicable documents; and the effectiveness of implementation. An audit should not be confused with the surveillance or inspection activities performed for the sole purpose of process control of product acceptance.

Authorized Inspection Agency: an organization that is empowered by an enforcement authority to provide inspection personnel and services as required by this Section.

Authorized Nuclear Inservice Inspector: a person who is employed and qualified by an Authorized Inspection Agency and who will perform the duties of the Inspector in accordance with the requirements of this Section.

Authorized Nuclear Inservice Inspector Supervisor: a person who is employed by an Authorized Inspection Agency to supervise Authorized Nuclear Inservice Inspectors and who is qualified as an Authorized Nuclear Inservice Inspector.

Authorized Nuclear Inspector: an employee of an Authorized Inspection Agency who has been qualified in accordance with Section III, Subsection NCA, Article NCA-5000.

beltline region: the region of the reactor vessel (shell material including welds, heat-affected zones, and plates or forgings) that directly surrounds the effective height of the active core and adjacent regions of the reactor vessel that are predicted to experience sufficient neutron radiation damage to be considered in the selection of the most limiting material with regard to radiation damage.

bending stress (σ_b): component of primary stress proportional to distance from centroid of cold section. It excludes discontinuity stresses and stress concentrations.

bobbin coil: a circular inside diameter eddy current coil wound such that the coil is concentric with the tube during examination.

buried component or support: a component or support that is buried in direct contact with soil or backfill, or encased in concrete.

Certificate Holder: an organization holding a Certificate of Authorization or Certificate of Accreditation issued by the Society.

Certificate of Authorization: a document issued by the Society that authorizes the use of an ASME Certification Mark and appropriate Designator for a specified scope of activity.

clad or cladding: a layer, usually an austenitic alloy, on the surface of a component to minimize corrosion.

cold shutdown: See plant technical specifications.

commercial service: nuclear power plant operation commencing with the date the power unit is determined by the Owner to be available for the regular production of electricity.

component: a vessel, concrete containment, pump, valve, storage tank, piping system, or core support structure.

component curvature (R_i/t): ratio of inside radius to wall thickness.

component standard support: a support consisting of one or more generally mass-produced units usually referred to as catalog items.

component support: a metal support designed to transmit loads from a component to the load-carrying building or foundation structure. Component supports include piping supports and encompass those structural elements relied upon to either support the weight or provide structural stability to components.

constant load type support: spring type support that produces a relatively constant supporting force throughout a specified deflection.

construction: an all-inclusive term comprising materials, design, fabrication, examination, testing, inspection, and certification required in the manufacture and installation of items.

Construction Code: nationally recognized Codes, Standards, and Specifications (e.g., ASME, ASTM, USAS, ANSI, API, AWWA, AISC, MSS, AWS) including designated Cases, providing construction requirements for an item.

coplanar flaws: two or more flaws that are oriented in the through-wall direction of a component lying in the same plane. The flaws may be defined as surface or subsurface, continuous or discontinuous, depending on their proximity. (See Figure IWA-3380-1.)

core support structures: those structures or parts of structures that are designed to provide direct support or restraint of the core (fuel and blanket assemblies) within the reactor pressure vessel.

corrective action: action taken to resolve flaws and relevant conditions, including supplemental examinations, analytical evaluations, other evaluations, repair/replacement activities, and corrective measures.

corrective measures: actions (such as maintenance) taken to resolve relevant conditions, but not including supplemental examinations, analytical evaluations, other evaluations, and repair/replacement activities.

crack arrest fracture toughness (K_{Ia}): the critical value of the stress intensity factor (K_I) for crack arrest as a function of temperature.

crack tip: the extremity of the flaw. The boundary between the flaw and the adjacent material at the intersection of the two flaw faces.

critical flaw size: the flaw size that will cause failure under a specified load calculated using fracture mechanics. The minimum critical flaw size for normal or upset conditions (Service Levels A and B) is a_c; the minimum critical initiation flaw size for emergency and faulted conditions is a_i.

cumulative fatigue crack growth: the total incremental growth of a flaw over a period of time determined through use of the design transients.

defect: a flaw (imperfection or unintentional discontinuity) of such size, shape, orientation, location, or properties as to be rejectable.

design life: the period of time for which a component is designed to meet the criteria set forth in the Design Specification.

design lifetime: See *design life*.

Design Report: the design document which shows that the allowable limits stated in the construction code are not exceeded for the loadings specified in the design specification.

Design Specification: a document prepared by the Owner or Owner's Designee which provides a complete basis for construction in accordance with the construction code.

discontinuity: a lack of continuity or cohesion; an interruption in the normal physical structure of material or a product.

discontinuity stress: the stress distribution through a component wall resulting from gross structural discontinuities such as head-to-shell junctions where net bending and membrane forces are produced.

dissimilar metal weld: a weld between
(a) carbon or low alloy steels to high alloy steels,
(b) carbon or low alloy steels to high nickel alloys, or
(c) high alloy steels to high nickel alloys.

elastic–plastic fracture mechanics: the analytical procedure that relates the stress-field magnitude and distribution, and plastic deformation in the vicinity of a crack tip, resulting from the normal stress applied to the structure, to the size of a crack in an elastic–plastic (ductile) material.

Emergency Conditions: those operating conditions which have a low probability of occurrence (Service Level C).

end-of-evaluation-period flaw size: the maximum size (depth, a_f, and length, ℓ_f) to which a detected flaw is calculated to grow in a specified time period, such as the next scheduled examination of the component or until end of component life.

end-of-life irradiation: the predicted fluence at the end of component life.

end-of-period irradiation: the predicted fluence at the end of evaluation period.

enforcement authority: a national, regional, or local governing body, such as a Country, State, or Municipality, empowered to enact and enforce Boiler and Pressure Vessel Code legislation.

engineering evaluation: an evaluation of indications that exceed allowable acceptance standards to determine if the margins required by the Design Specifications and Construction Code are maintained.

examination category: a grouping of items to be examined or tested.

explosive welding: a solid state welding process wherein coalescence is produced by the application of pressure by means of an explosive.

fabrication: actions by Repair/Replacement Organizations such as forming, machining, assembling, welding, brazing, heat treating, examination, testing, and inspection, but excluding design, required to manufacture parts, appurtenances, piping subassemblies, or supports.

failure assessment diagram: analytical procedure that considers brittle and elastic–plastic fracture, and limit load failure, for piping containing flaws exceeding the acceptance standards of IWB-3500, IWC-3500, or IWD-3500, using a graphical approach to determine acceptability for continued service to the next inspection or to the end of the evaluation period.

fatigue crack growth rate (da/dN): the incremental crack extension per cycle as a function of the applied stress intensity factor range.

fatigue crack growth threshold (ΔK_{th}): the value of the range of applied stress intensity factor, ΔK_I, below which fatigue crack growth is negligible.

Faulted Conditions: those operating conditions associated with extremely low probability postulated events (Service Level D).

flaw: an imperfection or unintentional discontinuity that is detectable by nondestructive examination.

flaw (crack) initiation: the onset of flaw extension due to an increase in component loading.

flaw (crack) penetration: the ratio of crack depth to component thickness: $2a/t$ for subsurface flaws and a/t for surface flaws.

flaw acceptance criteria: the equations or bases for acceptance by fracture mechanics analytical evaluations of flaws of a size exceeding the flaw acceptance standards.

flaw acceptance standards: specified values of flaw length, depth, depth-to-component thickness ratio, or areas as specified in IWA-3100 for comparison with examination results.

flaw aspect ratio (a/ℓ): the ratio of flaw depth (a) for surface flaws, or one-half of the flaw depth ($2a$) for subsurface flaws, to the length of the flaw (ℓ), where a, $2a$, and ℓ are the dimensions of the rectangle circumscribing the flaw. (See Figures IWA-3310-1 through IWA-3390-1.)

flaw characterization: the process of circumscribing a flaw in a rectangle parallel to the component surface or in the plane of the wall perpendicular to the component surface for comparison with flaw acceptance standards.

flaw depth: the depth is the maximum through-thickness dimension (a or $2a$) of the rectangle circumscribing the flaw when drawn normal to the surface of the component.

flaw length: the length, ℓ, of the rectangle circumscribing the flaw when drawn parallel to the surface of the component.

flaw location: the site of a flaw (radial, axial, circumferential position) in the wall of a component.

flaw orientation: the position of the plane of the flaw with respect to the plane perpendicular to the maximum principal stress direction. For purpose of analysis, the flaw plane is projected onto the perpendicular plane.

flow stress (σ_f): the average of the yield and ultimate tensile strengths.

fracture initiation: level at which the applied stress intensity (K_I) is equal to or exceeds the fracture toughness (K_{Ic}).

fracture toughness: the material toughness property measured in terms of the stress intensity factor, K_I, that will lead to nonductile crack propagation.

general corrosion: an approximately uniform wastage of a surface of a component, through chemical or electrochemical action, free of deep pits or cracks.

hanger: an item that carries the weight of components or piping from above with the supporting members being mainly in tension.

high energy items: items in systems with maximum operating conditions greater than 200°F (93°C) or 275 psig (1.9 MPa).

hot functional testing: a series of preoperational tests, prior to reactor criticality, to ensure that the equipment meets the design parameters at normal system temperatures and pressures.

hot standby: See plant technical specifications.

imperfection: a condition of being imperfect; a departure of a quality characteristic from its intended condition.

indication: the response or evidence from the application of a nondestructive examination.

infinitely long flaw: a flaw whose depth-to-length ratio, a/ℓ, is very small or approaching zero.

inservice examination: the process of visual, surface, or volumetric examination performed in accordance with the rules and requirements of this Division.

inservice inspection: methods and actions for assuring the structural and pressure-retaining integrity of safety-related nuclear power plant components in accordance with the rules of this Section.

inservice life: the period of time from the initial use of an item until its retirement from service.

inspection: verification of the performance of examinations and tests by an Inspector.

Inspection Program: the plan and schedule for performing examinations or tests.

Inspector: an Authorized Nuclear Inservice Inspector, except for those instances where so designated as an Authorized Nuclear Inspector.

installation: those actions required to place and attach components to their supports and join items of a nuclear power system by welding or mechanical means.

irradiation effect: the change in material properties due to neutron fluence.

item: a material, part, appurtenance, piping subassembly, component, or component support.

K_I: See *stress intensity factor*.

K_{Ia}: See *crack arrest fracture toughness*.

K_{Ic}: See *plane strain fracture toughness*.

K_{Id}: dynamic initiation fracture toughness obtained under fast or rapidly applied loading conditions.

K_{IR}: the crack growth resistance (fracture toughness) expressed in units corresponding to K_I. The value of K_{IR} defined in Nonmandatory Appendix G is the lesser of K_{Ic} and K_{Ia} for the material and temperature involved.

laminar flaw: a two-dimensional flaw oriented within 10 deg of a plane parallel to the surface of the component. (See Figure IWA-3360-1.)

limit load: failure mode associated with fully plastic collapse.

linear elastic fracture mechanics: the analytical procedure that relates the stress-field magnitude and distribution in the vicinity of a crack tip, resulting from the nominal stress applied to the structure, to the size of a crack in a linear elastic material.

linear flaw: a flaw having finite length and narrow uniform width and depth. (See Figure IWA-3400-1.)

lowest service temperature: the minimum temperature of the fluid retained by a component or, alternatively, the calculated volumetric average metal temperature expected during normal operation, whenever the pressure within the component exceeds 20% of the preoperational system hydrostatic test pressure.

material: metallic materials manufactured to an SA, SB, or SFA specification or any other material specification permitted by this Section or the Construction Code.

Material Organization (Metallic): an organization accredited by holding a Quality System Certificate issued by the Society, or qualified by an accredited Material Organization or Certificate Holder, in accordance with the requirements of Section III, Subsection NCA, NCA-3300 (previously NA-3700 or NCA-3800) or qualified by an Owner in accordance with the requirements of IWA-4140.

membrane stress (σ_m): the component of normal stress which is uniformly distributed and equal to the average value of stress across the thickness of the section under consideration.

moderate energy items: items in systems with maximum operating conditions less than or equal to 200°F (93°C) and 275 psig (1.9 MPa).

multiple flaws: two or more proximate discontinuous flaws. They may be planar, coplanar, or separate.

NDE evaluation: a process to characterize and determine the relevance of indications, and to compare the flaws and indications to acceptance standards.

neutron fluence: the number of fast neutrons per unit area received by a cross-sectional component. This is a time integral of neutron flux at a given location in a component.

nondestructive examination: an examination by the visual, surface, or volumetric method.

nonlinear stress distribution: the curvilinear stress distribution across a component wall, resulting from the algebraic addition of stresses (e.g., bending, membrane, residual). (See A-3210.)

nonplanar flaw: a flaw oriented in more than one plane. It may be curvilinear or a combination of two or more inclined planes. (See Figure IWA-3340-1.)

normal conditions: transients expected to occur during the course of system testing and operation (Service Level A).

normal operating conditions: the operating conditions during reactor startup, operation at power, hot standby, and reactor cooldown to cold shutdown conditions. Test conditions are excluded.

normal plant operation: the conditions of startup, hot standby, operation within the normal power range, and cooldown and shutdown of the plant.

normal stress: the component of stress normal to the plane of reference, also referred to as *direct stress*.

open ended: a condition of piping or lines that permits free flow to or from the environment or containment.

overpressure protection: the means by which components, or groups of components, are protected from overpressure, as required by the applicable Construction Code, by the use of pressure-relieving devices or other design provisions.

Owner: the organization legally responsible for the construction and/or operation of a nuclear facility including but not limited to one who has applied for, or who has been granted, a construction permit or operating license by the regulatory authority having lawful jurisdiction.

Owner's Requirements: those requirements prepared by or for the Owner that

(a) define the requirements for an item when a Construction Code is not specified;

(b) address plant-specific requirements of the Construction Code that must be identified by the Owner; or

(c) invoke plant-specific requirements that are in part in excess of Construction Code requirements.

part: see below.

(a) for components fabricated to Section III: an item that was attached to or became a portion of a component or support before completion and stamping of the component or support. A replacement part for use in a repair/replacement activity is an item that will become a portion of a component or support after completion and stamping of the component or support. Parts have work performed on them requiring verification by an Inspector.

(b) for components fabricated to Construction Codes other than Section III: an item intended to be installed, or that is installed, in a component comprised of one of the following:

(1) materials joined by welding with filler metal or brazing

(2) materials having hard-facing or corrosion-resistant weld metal overlay applied

(3) materials joined by any means, when the Construction Code requires that fabrication be verified by an Inspector.

piping subassembly: a section of piping system consisting of fittings, pipes, or tubes that is fabricated in a shop or in the field before being installed.

planar flaw: a two-dimensional flaw oriented in a plane more than 10 deg from parallel to the surface of the component. (See Figures IWA-3310-1 and IWA-3320-1.)

plane strain fracture toughness (K_{Ic}): the material toughness property measured in terms of the stress intensity factor, K_I, which will lead to nonductile crack propagation.

post-tensioning: a method of prestressing concrete in which the tendons are tensioned after the concrete has cured

prestressed concrete: reinforced concrete in which there have been introduced internal stresses of such magnitude and distribution that the stresses resulting from loads are counteracted to a desired degree.

primary stress: any normal stress or shear stress developed by an imposed loading that is necessary to satisfy the laws of equilibrium of external and internal forces and moments. The basic characteristic of a primary stress is that it is not self-limiting. Primary stresses that considerably exceed the yield strength will result in failure or at least gross distortion.

qualified source material: metallic products, for plants whose original Construction Code is Section III, that are produced by a Certificate Holder, Material Organization, or approved supplier in accordance with the requirements of Section III, Subsection NCA, NCA-3300 (previously NA-3700 or NCA-3800) or the output of the qualification process requirements of IWA-4142.1(a)(1).

Quality System Certificate (Materials): a certificate issued by the Society that permits an organization to perform specified Material Organization activities in accordance with Section III requirements.

R ratio (K_{min}/K_{max}): the algebraic ratio of calculated stress intensity factor (minimum and maximum) in a stress cycle.

reconciliation: the process of evaluating and justifying use of alternative Construction Code requirements or revised Owner's Requirements.

regulatory authority: a federal government agency, such as the United States Nuclear Regulatory Commission, that is empowered to issue and enforce regulations affecting the design, construction, and operation of nuclear power plants.

reinforced concrete: concrete containing reinforcement and designed so that the two materials act together in resisting force.

relevant condition: a condition observed during a visual examination that requires supplemental examination, corrective measure, correction by repair/replacement activities, or evaluation.

Repair/Replacement Organization: the organization that performs repair/replacement activities under the provisions of IWA-4142. The Owner may be the Repair/Replacement Organization.

rerating: a change to all or a portion of a component or component support by changing its design ratings (e.g., internal or external pressure or temperature), whether or not physical work is performed on the item.

residual stress: remaining tensile or compressive stresses within a material under unloaded conditions.

RT_{NDT}: the reference nil-ductility transition temperature established in NB-2330 from drop weight and Charpy V-notch tests to account for the effect of irradiation.

safety function: a function that is necessary to ensure

(a) the integrity of the reactor coolant pressure boundary,

(b) the capability to shut down the reactor and maintain it in a safe shutdown condition, or

(c) the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guideline exposures of 10 CFR 100.

seal weld: a nonstructural weld intended to prevent leakage, where the strength is provided by a separate means.

secondary stress: the normal or shear stress developed by the constraint of the structure. The basic characteristic of a secondary stress is that it is self-limiting.

source material: metallic products used for conversion to, or qualification as, material, by a Certificate Holder, Material Organization, or Owner.

stress: the intensity of the internal forces or components of forces that act on a plane through a given point. Stress is expressed in force per unit area.

stress intensity factor (K_I): a measure of the stress-field intensity near the tip of an ideal crack in a linear elastic medium when deformed so that the crack faces are displaced apart, normal to the crack plane (opening mode or mode I deformation). K_I is directly proportional to applied load and depends on specimen geometry.

structural factor: a multiplying factor applied to load or stress in the analytical evaluation of a degraded component or piping item for the purpose of maintaining structural integrity during continued operation for a defined period of time.

Structural Integrity Test: the initial or subsequent pressure test of a containment structure to demonstrate the ability to withstand the prescribed loads.

subsurface flaw: a flaw having an orientation and distance between itself and the nearest component surface as prescribed in IWA-3300.

support: see below

(a) an item used to position components, resist gravity, resist dynamic loading, or maintain equilibrium of components;

(b) an item that carries the weight of a component or piping from below with the supporting members being mainly in compression.

support part: a part or subassembly of a component support or piping support.

surface flaw: a flaw that either penetrates the surface or is less than a given distance from the surface. (See Figure IWA-3310-1.)

tearing modulus: material property determined from the slope of the J-R curve at a particular flaw depth.

tendon: an assembly of prestressing steel, anchorages, and couplings, which imparts prestressing forces to concrete.

terminal ends: the extremities of piping runs that connect to structures, components, or pipe anchors, each of which acts as a rigid restraint or provides at least 2 degrees of restraint to piping thermal expansion.

test: a procedure to obtain information through measurement or observation.

unbonded tendons: tendons in which the prestressing steel is permanently free to move relative to the concrete to which they are applying prestressing forces.

unqualified source material: source material, for plants whose original Construction Code is Section III, not produced by a Certificate Holder, Material Organization, or approved supplier in accordance with the requirements of Section III, Subsection NCA, NCA-3800 or IWA-4142.1(a)(1).

upset conditions: transients not expected to occur during the course of system testing and normal operation (Service Level B).

variable spring type support: a spring type support providing a variable supporting force throughout a specified deflection.

verify: to determine that a particular action has been performed in accordance with the rules and requirements of this Section either by witnessing the action or by reviewing records.

vibration control and sway brace: a spring type support providing a variable restraining force along its axis.

welded joint category: the location of a joint in a vessel used for specifying required examinations. The categories are designated as A, B, C, and D as defined in NE-3351.

yield strength (σ_y): the stress at which a material exhibits a specified limiting deviation from the linear proportionality of stress to strain. The deviation is expressed in terms of strain (generally 0.2%).

SUBSECTION IWB
REQUIREMENTS FOR CLASS 1 COMPONENTS OF LIGHT-WATER-COOLED PLANTS

ARTICLE IWB-1000
SCOPE AND RESPONSIBILITY

IWB-1100 SCOPE

This Subsection provides requirements for inservice inspection of Class 1 pressure-retaining components and their welded attachments in light-water-cooled plants.

IWB-1200 COMPONENTS SUBJECT TO EXAMINATION

IWB-1210 EXAMINATION REQUIREMENTS

The examination requirements of this Subsection shall apply to Class 1 pressure-retaining components and their welded attachments.

IWB-1220 COMPONENTS EXEMPT FROM EXAMINATION

The following components or portions of components are exempted from the volumetric, surface, VT-1 visual, and VT-3 visual examination requirements of IWB-2500:

(a) components that are connected to the reactor coolant system and are part of the reactor coolant pressure boundary, and that are of such a size and shape so that upon postulated rupture the resulting flow of coolant from the reactor coolant system under normal plant operating conditions is within the capacity of makeup systems that are operable from on-site emergency power. The emergency core cooling systems are excluded from the calculation of makeup capacity.

(b) See (1) through (3) below.

(1) components and piping segments NPS 1 (DN 25) and smaller, except for steam generator tubing

(2) components and piping segments with one inlet and one outlet, both of which are NPS 1 (DN 25) and smaller

(3) components[21] and piping segments with multiple inlets or multiple outlets for which the cumulative pipe O.D. cross-sectional area does not exceed the cross-sectional area defined by the O.D. of NPS 1 (DN 25) pipe

(c) reactor vessel head connections and associated piping, NPS 2 (DN 50) and smaller, made inaccessible by control rod drive penetrations.

(d) welds or portions of welds that are inaccessible due to being encased in concrete, buried underground, located inside a penetration, or encapsulated by guard pipe.

ARTICLE IWB-2000
EXAMINATION AND INSPECTION

IWB-2200 PRESERVICE EXAMINATION

(a) Examinations required by this Article (with the exception of Examination Categories B-P and B-Q, the VT-1 visual examination of Examination Categories B-G-1 and B-G-2 pressure-retaining bolting associated with Examination Categories B-L-2 and B-M-2 components, and the VT-3 visual examination of the internal surfaces of Examination Categories B-L-2 and B-M-2) shall be completed prior to initial plant startup or as required by IWA-4530. In addition, except in those components exempted from examination by IWB-1220(a), IWB-1220(b), or IWB-1220(c), these preservice examinations shall be extended to include the defined examination extent of all of the pressure-retaining welds in all Class 1 components categorized under the Item Numbers in Table IWB-2500-1 (B-A) through Table IWB-2500-1 (B-Q), regardless of the sample sizes applicable to inservice inspection. However, in the case of Examination Category B-O, the examination shall be extended to include essentially 100% of the welds in the installed peripheral control rod drive housings only.

(b) Shop and field examinations may serve in lieu of the on-site preservice examinations provided:

(1) in the case of vessels only, the examination is performed after the hydrostatic test required by the Construction Code has been completed;

(2) such examinations are conducted under conditions and with equipment and techniques equivalent to those that are expected to be employed for subsequent inservice examinations;

(3) personnel performing the shop and field magnetic particle and liquid penetrant examinations shall be qualified and certified in accordance with the requirements of the Construction Code or IWA-2300;

(4) the shop and field examination records are, or can be, documented and identified in a form consistent with those required in Article IWA-6000.

(c) If preservice volumetric examinations detect surface-connected flaws in welds susceptible to stress corrosion cracking that will be in contact with the reactor coolant environment during normal operation, the requirements of IWB-3514.8 shall be met.

IWB-2400 INSPECTION SCHEDULE

IWB-2410 INSPECTION PROGRAM

Inservice examinations and system pressure tests may be performed during plant outages such as refueling shutdowns or maintenance shutdowns.

IWB-2411 Inspection Program

(a) The required percentage of examinations in each Examination Category shall be completed in accordance with Table IWB-2411-1, with the following exceptions:

(1) Examination Categories B-N-1, B-P, and B-Q

(2) examinations that may be partially deferred to the end of an inspection interval, as allowed by Examination Categories B-A, B-D, and B-F

(3) examinations that may be deferred to the end of an inspection interval, as allowed by Examination Categories B-A, B-G-1, B-N-2, B-N-3, and B-O

(4) examinations deferred until disassembly of a component for maintenance, repair/replacement activity, or volumetric examination, as allowed by Examination Categories B-G-1, B-G-2, B-L-2, and B-M-2

(5) welded attachments examined as a result of component support deformation under Examination Category B-K

If there are less than three items or welds to be examined in an Examination Category, the items or welds may be examined in any two periods, or in any one period if there is only one item or weld, in lieu of the percentage requirements of Table IWB-2411-1.

Table IWB-2411-1
Inspection Program

Inspection Interval	Inspection Period, Calendar Years of Plant Service Within the Interval	Minimum Examinations Completed, %	Maximum Examinations Credited, %
All	3	16	50
All	7	50 [Note (1)]	75
All	10	100	100

NOTE:
(1) If the first period completion percentage for any examination category exceeds 34%, at least 16% of the required examinations shall be performed in the second period.

(b) If items or welds are added to the Inspection Program, during the service lifetime of a plant, examination shall be scheduled as follows:

(1) When items or welds are added during the first period of an interval, at least 25% of the examinations required by the applicable Examination Category and Item Number for the added items or welds shall be performed during each of the second and third periods of that interval. Alternatively, if deferral of the examinations is permitted for the Examination Category and Item Number, the second period examinations may be deferred to the third period and at least 50% of the examinations required by the applicable Examination Category and Item Number for the added items or welds shall be performed during the third period.

(2) When items or welds are added during the second period of an interval, at least 25% of the examinations required by the applicable Examination Category and Item Number for the added items or welds shall be performed during the third period of that interval.

(3) When items or welds are added during the third period of an interval, examinations shall be scheduled in accordance with (a) for successive intervals.

IWB-2420 SUCCESSIVE INSPECTIONS

(a) To the extent practicable, the sequence of component examinations established during the first inspection interval shall be repeated during each successive inspection interval. The sequence of component examinations may be modified in a manner that optimizes scaffolding, radiological, insulation removal, or other considerations, provided that the percentage requirements of Table IWB-2411-1 are maintained.

(b) If a component is accepted for continued service in accordance with IWB-3132.3, the areas containing flaws shall be reexamined during the next three inspection periods listed in the schedule of the Inspection Program of IWB-2400. Alternatively, acoustic emission may be used to monitor growth of existing flaws in accordance with IWA-2234.

(1) For vessel welds, the three successive inspections are not required if the following conditions are met:

(-a) The flaw is characterized as subsurface in accordance with Figure IWA-3320-2.

(-b) The weld containing the flaw is acceptable for continued service in accordance with IWB-3600, and the flaw is demonstrated acceptable for the intended service life of the component.

(2) For dissimilar metal butt welds in vessel nozzles and piping butt welds, the three successive inspections are not required if the following conditions are met:

(-a) The flaw shall be characterized as subsurface in accordance with Figure IWB-2420-1. Interpolation for all a/ℓ values between the curves in Figure IWB-2420-1 may be performed using the values in Table IWB-2420-1.

(-b) The NDE technique and evaluation that detected and characterized the flaw shall be documented in the flaw evaluation report.

(-c) The weld containing the flaw is acceptable for continued service in accordance with IWB-3600 for the intended service life of the component.

(-d) The flaw is not in a weld in austenitic stainless steel in a Boiling Water Reactor (BWR), in UNS N06600 or W86182 in a Pressurized Water Reactor (PWR) or BWR, or in UNS W86082 in a PWR.

(c) If a component is accepted for continued service in accordance with IWB-3142.4, successive examinations shall be performed, if determined necessary, based on an evaluation by the Owner. The evaluation shall be documented and shall include the cause of the relevant condition, if known. If the cause of the relevant condition is unknown or if the relevant condition has previously occurred, successive examinations shall be performed during each successive inspection period until the relevant condition remains essentially unchanged from the previous inspection.

(d) If the reexaminations required by (b) above reveal that the flaws remain essentially unchanged, or that the flaw growth is within the growth predicted by the analytical evaluation, for three successive inspection periods, then the component examination schedule may revert to the original schedule of successive inspections or the inspection interval defined by the analytical evaluation, whichever is limiting.

(e) If the reexaminations required by (b) or (c) above reveal new flaws or relevant conditions that exceed the applicable acceptance standards of Table IWB-3410-1, or growth of existing flaws in excess of the growth predicted by the analytical evaluation, then

(1) the entire weld, area, or part[22] shall be examined during the current outage

(2) additional examinations shall be performed in accordance with IWB-2430

(f) For steam generator tubing, the successive examinations shall be governed by the plant Technical Specification.

(g) If welded attachments are examined as a result of identified component support deformation, and the results of these examinations exceed the acceptance standards of Table IWB-3410-1, successive examinations shall be performed, if determined necessary, based on an evaluation by the Owner. The evaluation shall be documented and shall include the cause of the welded attachment damage if known. If the cause of the welded attachment damage could recur or is unknown, successive examinations shall be performed in accordance with the requirements of (b) above.

Table IWB-2420-1
Surface Proximity Rules for Successive Examinations of Piping Components

	S/t			
a/t	$a/\ell = 0$	$a/\ell = 0.1$	$a/\ell = 0.2$	$a/\ell = 0.5$
0.025	0.058	0.042	0.033	0.010
0.050	0.104	0.078	0.061	0.020
0.075	0.141	0.108	0.085	0.030
0.100	0.172	0.134	0.107	0.040
0.125	0.197	0.157	0.125	0.050
0.150	0.218	0.176	0.141	0.060
0.175	0.236	0.192	0.155	0.070
0.200	0.250	0.206	0.166	0.080
0.225	0.261	0.217	0.176	0.090
0.250	0.270	0.227	0.184	0.100

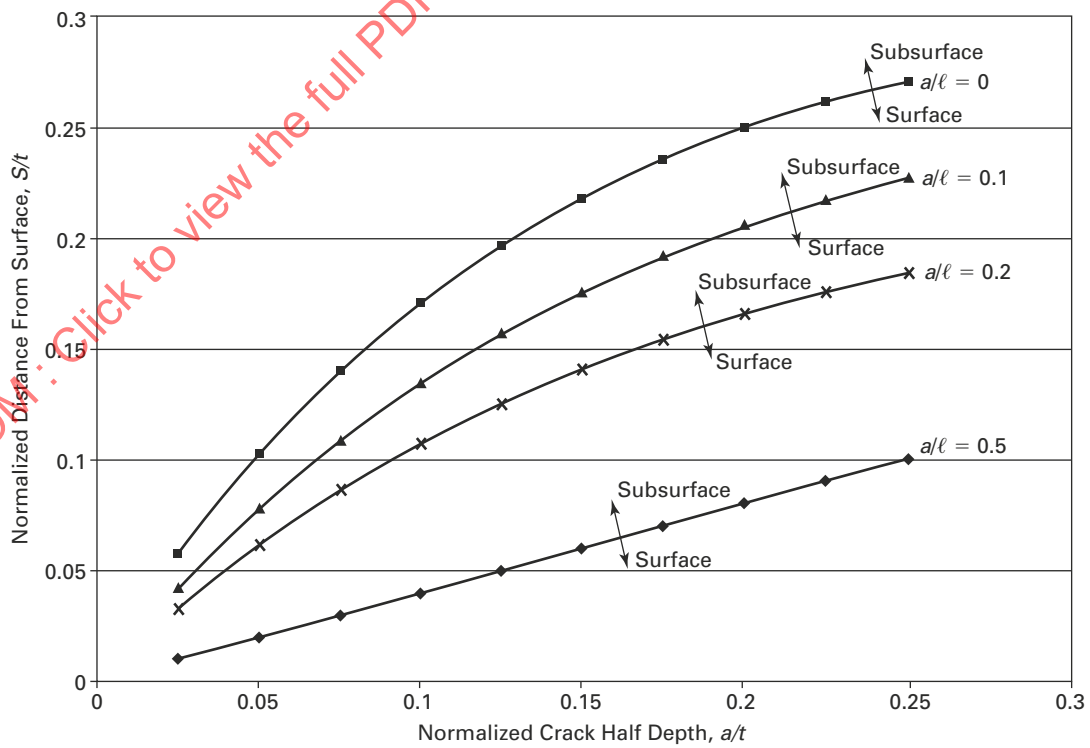
IWB-2430 ADDITIONAL EXAMINATIONS

(a) Examinations performed in accordance with Tables IWB-2500-1 (B-A) through IWB-2500-1 (B-O) and Table IWB-2500-1 (B-Q), that reveal flaws or relevant conditions exceeding the acceptance standards of Table IWB-3410-1 shall be extended to include additional examinations during the current outage in accordance with (1) or (2) below.

(1) Additional examinations shall be performed in accordance with the following requirements:

(-a) The additional examinations shall include an additional number of welds, areas, or parts[22] included in the inspection item[23] equal to the number of welds, areas, or parts included in the inspection item that were scheduled to be performed during the present inspection period. The additional examinations shall be selected from welds, areas, or parts of similar material and service.

Figure IWB-2420-1
Successive Examination Surface Proximity Rule for Piping Components



This additional selection may require inclusion of piping systems other than the one containing the flaws or relevant conditions.

(-b) If the additional examinations required by (-a) above reveal flaws or relevant conditions exceeding the acceptance standards of Table IWB-3410-1, the examinations shall be further extended to include additional examinations during the current outage. These additional examinations shall include the remaining number of welds, areas, or parts of similar material and service subject to the same type of flaws or relevant conditions.

(2) Additional examinations shall be performed in accordance with the following requirements:

(-a) An evaluation shall be performed. Topics to be addressed in the evaluation shall include the following:

(-1) a determination of the cause of the flaws or relevant conditions

(-2) an evaluation of applicable service conditions and degradation mechanisms to establish that the affected welds, areas, or parts[22] will perform their intended safety functions during subsequent operation

(-3) a determination of which additional welds, areas, or parts[22] are subject to the same service conditions and degradation mechanisms that caused the flaws or relevant conditions

(-b) Additional examinations shall be performed on all those welds, areas, or parts[22] subject to the same service conditions and degradation mechanisms that caused the flaws or relevant conditions. This additional selection might require inclusion of piping systems other than the one containing the original flaws or relevant conditions. No additional examinations are required if the evaluation concludes that

(-1) there are no additional welds, areas, or parts subject to the same service conditions that caused the flaws or relevant conditions or

(-2) no degradation mechanism exists

(-c) The evaluation shall be retained in accordance with Article IWA-6000.

(b) The examination method for additional examinations may be limited to the examination method that originally identified the flaws or relevant conditions, provided use of the method is supported by an evaluation. The evaluation shall determine the cause of the flaws or relevant conditions and the appropriate method to be used as part of the additional examination scope. The evaluation shall be retained in accordance with Article IWA-6000.

(c) For the inspection period following the period in which the examinations of (a) were completed, the examinations shall be performed as originally scheduled in accordance with IWB-2400.

(d) For steam generator tubing, additional examinations shall be governed by plant Technical Specifications.

(e) If welded attachments are examined as a result of identified component support deformation, and the results of these examinations exceed the acceptance standards of Table IWB-3410-1, additional examinations shall be performed, if determined necessary, based on an evaluation by the Owner. The evaluation shall be documented and shall include the cause of the welded attachment damage if known. If the cause of the welded attachment damage could recur or is unknown, additional examinations shall be performed in accordance with the requirements of (a) above. No additional examinations are required if either of the following applies:

(1) There are no other welded attachments subject to the same apparent or root cause conditions.

(2) The degradation mechanism no longer exists.

IWB-2500 EXAMINATION AND PRESSURE TEST REQUIREMENTS

(a) Components shall be examined and tested as specified in Tables IWB-2500-1 (B-A) through IWB-2500-1 (B-Q). The method of examination for the components and parts of the pressure-retaining boundaries shall comply with those tabulated in Tables IWB-2500-1 (B-A) through IWB-2500-1 (B-Q) except where alternate examination methods are used that meet the requirements of IWA-2240.

(b) Tables IWB-2500-1 (B-A) through IWB-2500-1 (B-Q) are organized as follows.

Examination Category	Examination Area
B-A	Pressure-Retaining Welds in Reactor Vessel
B-B	Pressure-Retaining Welds in Vessels Other Than Reactor Vessels
B-D	Full Penetration Welded Nozzles in Vessels
B-F	Pressure-Retaining Dissimilar Metal Welds in Vessel Nozzles
B-G-1	Pressure-Retaining Bolting, Greater Than 2 in. (50 mm) in Diameter
B-G-2	Pressure-Retaining Bolting, 2 in. (50 mm) and Less in Diameter
B-J	Pressure-Retaining Welds in Piping
B-K	Welded Attachments for Vessels, Piping, Pumps, and Valves
B-L-2	Pump Casings
B-M-2	Valve Bodies
B-N-1	Interior of Reactor Vessel
B-N-2	Welded Core Support Structures and Interior Attachments to Reactor Vessels
B-N-3	Removable Core Support Structures
B-O	Pressure-Retaining Welds in Control Rod Drive and Instrument Nozzle Housings
B-P	All Pressure-Retaining Components
B-Q	Steam Generator Tubing

(c) Alternatively, for Examination Categories B-F and B-J, the provisions of Nonmandatory Appendix R may be applied to all Class 1 piping or to one or more individual piping systems.

(d) In lieu of the surface examination requirements for Examination Category B-F NPS 4 (DN 100) and larger piping welds, Examination Category B-J NPS 4 (DN 100) and larger piping welds, Examination Category B-F socket

welds, and Examination Category B-J socket welds, the Owner may elect to perform a plant-specific review for welds susceptible to outside surface attack. To the extent practicable, all welds of the examination categories and within the size limitations of this subparagraph, determined by this review to be susceptible to outside surface attack, require surface examination each interval, in the same sequence, over the lifetime of the item. The plant-specific review shall be updated each interval. The requirements of IWB-2411 shall be met. Acceptance standards shall be in accordance with IWB-3514. For any socket weld connections identified as susceptible to thermal fatigue, VT-2 visual examination shall be performed at operating pressure during each refueling outage. Contributors to outside surface attack include proximity to nearby leak paths, proximity to chloride-bearing materials, existence of moisture- or salt-laden atmosphere, and existence of insulation or other coating or cover that traps moisture. Specific outside surface attack susceptibility criteria are as follows:

(1) austenitic stainless steel base metal, welds, or heat-affected zone (HAZ); operating temperature greater than 150°F (65°C); and piping outside surface within five pipe diameters of a probable leak path (e.g., valve stem) and covered with nonmetallic insulation not in compliance with U.S. NRC Regulatory Guide 1.36 (e.g., chloride content) or equivalent requirements

(2) austenitic stainless steel base metal, welds, or HAZ and piping outside surface exposed to wetting from a concentrated chloride-bearing environment (e.g., seawater, brackish water, brine) or

(3) items identified as susceptible to any mechanisms of outside surface attack other than external chloride stress corrosion cracking based on a review of plant experience and plant-specific processes and programs addressing chlorides and other contaminants

(e) For PWR stainless steel residual and regenerative heat exchangers, in lieu of the requirements of Examination Categories B-B, B-D, and B-J, VT-2 visual examinations may be performed in accordance with the following:

(1) These alternative examination requirements shall not be applied to any heat exchanger, nor to any heat exchanger design or configuration, that has experienced a through-wall leak, such as heat exchangers with an inner shell (inner barrel). The Owner shall review industry experience to determine which heat exchanger designs or configurations have leaked. If any leakage is detected, it shall be corrected in accordance with Article IWA-4000. Any subsequent use of these alternative examination requirements shall then be discontinued. The affected heat exchanger and others of the same design or configuration shall be examined in accordance with (a).

(2) Application of these alternative examination requirements is limited to those welds that are part of the as-received heat exchanger assembly. The regenerative heat exchanger assembly may be formed from multiple smaller heat exchanger subcomponents connected by sections of piping. All of the smaller heat exchanger subcomponents and the connecting piping are within the boundary of the heat exchanger assembly.

(3) All welds, other than reinforcing plate welds, shall have received at least one volumetric examination. The preservice or Construction Code volumetric examination may be used to meet this requirement. Reinforcing plate welds shall have received at least one surface examination.

(4) The component shall be VT-2 visually examined for evidence of leakage while undergoing the system leakage test as required by Examination Category B-P, to be performed every refueling outage. IWB-3522 shall be met.

(f) For BWRs, in lieu of examining all nozzles, at least 25% of nozzle inner radii and nozzle-to-shell welds, including at least one nozzle for each system and nominal pipe size, may be examined for Table IWB-2500-1 (B-D), Item Nos. B3.90 and B3.100, provided the following conditions are met:

(1) The nozzles are not feedwater nozzles or control rod drive return line nozzles.

(2) The provisions of Appendix VIII are used for examinations.

(3) The maximum RPV heatup and cooldown rates are limited to less than 115°F/hr (64°C/h).

(4) For recirculation inlet nozzles

$$(pr/t)/C_{\mathrm{RPV}} \le 1.15$$

where

C_{RPV} = 19,332 for U.S. Customary units
= 133.29 for SI units
p = the RPV normal operating pressure, psi (MPa)
r = the RPV inner radius, in. (mm)
t = the RPV wall thickness, in. (mm)

(5) For recirculation inlet nozzles

$$\left[p\left(r_o^2 + r_i^2\right) / \left(r_o^2 - r_i^2\right)\right] / C_{\mathrm{NOZZLE}} \le 1.47$$

where

C_{NOZZLE} = 1,637 for U.S. Customary units
= 11.29 for SI units
r_i = nozzle inner radius, in. (mm)
r_o = nozzle outer radius, in. (mm)

For definition of p, see (4).

(6) For recirculation outlet nozzles

$$(pr/t)/C_{\mathrm{RPV}} \le 1.15$$

where

C_{RPV} = 16,171 for U.S. Customary units
= 111.50 for SI units

For definitions of p, r, and t, see (4).

(7) For recirculation outlet nozzles

$$\left[p\left(r_o^2 + r_i^2\right) / \left(r_o^2 - r_i^2\right)\right] / C_{\text{NOZZLE}} \leq 1.59$$

where

C_{NOZZLE} = 1,977 for U.S. Customary units
= 13.63 for SI units

For definition of p, see (4); for definitions of r_i and r_o, see (5).

(8) Fluence levels do not exceed 1×10^{17} n/cm^2 on any portion of the examined component.

(9) The total number of heatup and cooldown cycles from plant startup for the component will not exceed 40 by the end of the interval. A cycle consists of both a heatup and a cooldown.

(g) VT-1 visual examination may be performed in lieu of volumetric examination required by Table IWB-2500-1 (B-D), Item Number B3.100, provided that the requirements of (1) are met for preservice examinations or the requirements of (2) are met for inservice examinations.

(1) Preservice Examination. For reactor vessel nozzles other than BWR feedwater nozzles and operational control rod drive return line nozzles, a VT-1 visual examination of the surface M-N shown in Figures IWB-2500-7(a) through IWB-2500-7(d), may be performed in lieu of the volumetric examination required by Table IWB-2500-1 (B-D), Item No. B3.100, provided the following requirements are met:

(-a) The surface M-N shown in Figures IWB-2500-7(a) through IWB-2500-7(d), shall have been examined using a surface examination method and shall have met the Section III fabrication acceptance standards at least once after the Construction Code hydrostatic test. The surface examination shall have been performed prior to the preservice VT-1 visual examination.

(-b) The appropriate surfaces shall have been prepared in accordance with IWA-2200(b) for application of a future volumetric examination in accordance with Table IWB-2500-1 (B-D).

(-c) An evaluation that includes the following shall have been performed:

(-1) review of the fabrication examination history for the nozzle inner radius region

(-2) verification that the nozzle of interest meets the requirements of Section III Appendices, Nonmandatory Appendix G

For the preservice VT-1 visual examination, components with crack-like surface flaws exceeding the acceptance criteria of Table IWB-3510-3 are unacceptable for service, unless the reactor vessel meets the requirements of IWB-3122.2 or IWB-3122.3. The component thickness, t, to be applied in calculating the allowable surface-flaw-length-to-component-thickness ratio, l/t, in Table IWB-3510-3 shall be selected as specified in Table IWB-3512-2.

(2) Inservice Examination. For reactor vessel nozzles other than BWR feedwater nozzles and operational control rod drive return line nozzles, a VT-1 visual examination of the surface M-N shown in Figures IWB-2500-7(a) through IWB-2500-7(d) may be performed in lieu of the volumetric examination required by Table IWB-2500-1 (B-D), Item No. B3.100. For the inservice VT-1 visual examination, components with crack-like surface flaws exceeding the acceptance criteria of Table IWB-3510-3 are unacceptable for continued service, unless the reactor vessel meets the requirements of IWB-3142.2, IWB-3142.3, or IWB-3142.4. The component thickness, t, to be applied in calculating the allowable surface-flaw-length-to-component-thickness ratio, l/t, in Table IWB-3510-3 shall be selected as specified in Table IWB-3512-2.

Table IWB-2500-1 (B-A)
Examination Category B-A, Pressure-Retaining Welds in Reactor Vessel

Item No.	Parts Examined	Examination Requirements/ Figure No.	Examination Method	Acceptance Standard	Extent and Frequency of Examination		Deferral of Examination to End of Interval
					First Inspection Interval	Successive Inspection Intervals	
B1.10	Shell welds						
B1.11	Circumferential	IWB-2500-1	Volumetric	IWB-3510	All welds [Note (2)]	Same as for first interval	Permissible
B1.12	Longitudinal	IWB-2500-2					
B1.20	Head welds						
B1.21	Circumferential	IWB-2500-3	Volumetric	IWB-3510	Accessible length of all welds [Note (2)]	Same as for first interval	Permissible
B1.22	Meridional						
B1.30	Shell-to-flange weld	IWB-2500-4	Volumetric	IWB-3510	Weld [Note (2)]	Same as for first interval	Permissible [Note (3)] or [Note (5)]
B1.40	Head-to-flange weld	IWB-2500-5	Volumetric and surface [Note (6)]	IWB-3510	Weld [Note (2)]	Same as for first interval	Permissible [Note (4)] or [Note (5)]
B1.50	Repair welds [Note (1)]	IWB-2500-1 and IWB-2500-2	Volumetric	IWB-3510	All weld repair areas	Same as for first interval	Permissible
B1.51	Beltline region						

NOTES:
(1) Material (base metal) weld repairs where repair depth exceeds 10% nominal of the vessel wall. If the location of the repair is not positively and accurately known, then the individual shell plate, forging, or shell course containing the repair shall be included.
(2) Includes essentially 100% of the examination volume or area.
(3) The shell-to-flange weld examination may be performed during the first and third periods, in which case 50% of the shell-to-flange weld shall be examined by the end of the first period, and the remainder by the end of third period. During the first period, the examination need only be performed from the flange face, provided this same portion is examined from the shell during the third period.
(4) During the first and second periods, the examination may be performed from the flange face, provided these same portions are examined from the head during the third period.
(5) Deferral in the first inspection interval is not permitted. Deferral in successive inspection intervals is permitted provided that
(a) no welded repair/replacement activities have been performed either on the shell-to-flange weld or head-to-flange weld; and
(b) neither the shell-to-flange weld nor the head-to-flange weld contains identified flaws or relevant conditions that require successive inspections in accordance with IWB-2420(b).
(6) After a preservice or inservice ultrasonic examination has been performed with no flaw detected that exceeds the acceptance criteria of IWB-3500, only the surface examination requirements of B1.40 need to be met.

Table IWB-2500-1 (B-B)
Examination Category B-B, Pressure-Retaining Welds in Vessels Other Than Reactor Vessels

Item No.	Parts Examined	Examination Requirements/ Figure No.	Examination Method	Acceptance Standard	Extent and Frequency of Examination		Deferral of Examination to End of Interval
					First Inspection Interval	Successive Inspection Intervals [Note (3)]	
	Pressurizer		Volumetric	IWB-3510	Figure IWB-2500-20, illustration (a)	Figure IWB-2500-20, illustration (b)	Not permissible
B2.10	Shell-to-Head						
B2.11	Circumferential	IWB-2500-1			Both welds [Note (4)]	Both welds [Note (4)]	
B2.12	Longitudinal	IWB-2500-2			1 ft (300 mm) of all welds [Note (2)]	1 ft (300 mm) of one weld [Note (2)] per head	
B2.20	Head Welds	IWB-2500-3	Volumetric	IWB-3510	All welds [Note (4)]	One weld per head	Not permissible
B2.21	Circumferential						
B2.22	Meridional						
	Steam Generators (Primary Side)	IWB-2500-3	Volumetric	IWB-3510	Figure IWB-2500-20, illustration (c) All welds [Note (4)]	Figure IWB-2500-20, illustration (d) One weld [Note (1)] per head	Not permissible
B2.30	Head Welds						
B2.31	Circumferential						
B2.32	Meridional						
B2.40	Tubesheet-to-Head Weld	IWB-2500-6	Volumetric	IWB-3510	Weld [Note (4)]	Weld [Note (1)], [Note (4)]	Not permissible
	Heat Exchangers (Primary Side) — Head	IWB-2500-1, IWB-2500-3	Volumetric	IWB-3510	Figure IWB-2500-20, illustration (e) All welds [Note (4)]	Figure IWB-2500-20, illustration (f) One weld [Note (1)] per head	Not permissible
B2.50	Head Welds						
B2.51	Circumferential						
B2.52	Meridional	IWB-2500-3					
	Heat Exchangers (Primary Side) — Shell				Figure IWB-2500-20, illustration (g)	Figure IWB-2500-20, illustration (h)	
B2.60	Tubesheet-to-Head Welds	IWB-2500-6	Volumetric	IWB-3510	Weld [Note (4)]	Weld [Note (1)], [Note (4)]	Not permissible
B2.70	Longitudinal Welds	IWB-2500-2	Volumetric	IWB-3510	1 ft of all welds [Note (2)] at each end of shell	1 ft of one weld [Note (1)], [Note (2)] at each end of shell	Not permissible
B2.80	Tubesheet-to-Shell Welds	IWB-2500-6	Volumetric	IWB-3510	Welds [Note (4)] each end	Welds [Note (1)], [Note (4)] each end	Not permissible

Table IWB-2500-1 (B-B)
Examination Category B-B, Pressure-Retaining Welds in Vessels Other Than Reactor Vessels (Cont'd)

Item No.	Parts Examined	Examination Requirements/ Figure No.	Examination Method	Acceptance Standard	Extent and Frequency of Examination		Deferral of Examination to End of Interval
					First Inspection Interval	Successive Inspection Intervals [Note (3)]	
	Core Makeup Tanks		Volumetric	IWB-3510	Figure IWB-2500-20, illustration (a)	Figure IWB-2500-20, illustration (b) [Note (1)]	Not permissible
B2.90	Shell-to-Head	IWB-2500-1					
B2.91	Circumferential				Both welds [Note (4)]	Both welds [Note (1)], [Note (4)]	
B2.92	Longitudinal	IWB-2500-2			1 ft (300 mm) of all welds [Note (2)]	1 ft (300 mm) of one weld [Note (1)], [Note (2)] per head	
B2.100	Head Welds	IWB-2500-3	Volumetric	IWB-3510	All welds [Note (4)]	One weld per head [Note (1)]	Not permissible
B2.101	Circumferential						
B2.102	Meridional						

NOTES:
(1) The examination may be limited to one vessel among the group of vessels performing a similar function.
(2) The weld selected for examination is that weld intersecting the circumferential weld.
(3) To the extent practicable, the initially selected welds are to be examined in the same sequence during successive inspection intervals.
(4) Includes essentially 100% of the examination volume.

Table IWB-2500-1 (B-D)
Examination Category B-D, Full Penetration Welded Nozzles in Vessels

Item No.	Parts Examined	Examination Requirements/ Figure No.	Examination Method	Acceptance Standard	Extent and Frequency of Examination		Deferral of Examination to End of Interval
					First Inspection Interval	Successive Inspection Intervals	
	Reactor Vessel						
B3.90	Nozzle-to-Vessel Welds	IWB-2500-7(a), IWB-2500-7(b), IWB-2500-7(c), or IWB-2500-7(d) [Note (4)]	Volumetric	IWB-3512	All nozzles [Note (1)]	Same as for 1st Interval [Note (6)]	See [Note (2)], [Note (3)], [Note (5)]
B3.100	Nozzle Inside Radius Section	IWB-2500-7(a), IWB-2500-7(b), IWB-2500-7(c), or IWB-2500-7(d) [Note (4)]	Volumetric [Note (7)]	IWB-3512 [Note (8)]	All nozzles [Note (1)]	Same as for 1st Interval [Note (6)]	See [Note (2)], [Note (5)]
	Pressurizer	IWB-2500-7(a), IWB-2500-7(b), IWB-2500-7(c), or IWB-2500-7(d) [Note (4)]					
B3.110	Nozzle-to-Vessel Welds	IWB-2500-7(a), IWB-2500-7(b), IWB-2500-7(c), or IWB-2500-7(d) [Note (4)]	Volumetric	IWB-3512	All nozzles [Note (1)]	Same as for 1st Interval	Not permissible
	Steam Generators (Primary Side)	IWB-2500-7(a), IWB-2500-7(b), IWB-2500-7(c), or IWB-2500-7(d) [Note (4)]					
B3.130	Nozzle-to-Vessel Welds	IWB-2500-7(a), IWB-2500-7(b), IWB-2500-7(c), or IWB-2500-7(d) [Note (4)]	Volumetric	IWB-3512	All nozzles [Note (1)]	Same as for 1st Interval	Not permissible
	Heat Exchangers (Primary Side)	IWB-2500-7(a), IWB-2500-7(b), IWB-2500-7(c), or IWB-2500-7(d) [Note (4)]					

Table IWB-2500-1 (B-D)
Examination Category B-D, Full Penetration Welded Nozzles in Vessels (Cont'd)

Item No.	Parts Examined	Examination Requirements/ Figure No.	Examination Method	Acceptance Standard	Extent and Frequency of Examination		Deferral of Examination to End of Interval
					First Inspection Interval	Successive Inspection Intervals	
B3.150	Nozzle-to-Vessel Welds	IWB-2500-7(a), IWB-2500-7(b), IWB-2500-7(c), or IWB-2500-7(d) [Note (4)]	Volumetric	IWB-3512	All nozzles [Note (1)]	Same as for 1st Interval	Not permissible
B3.160	Nozzle Inside Radius Section	IWB-2500-7(a), IWB-2500-7(b), IWB-2500-7(c), or IWB-2500-7(d) [Note (4)]	Volumetric	IWB-3512	All nozzles [Note (1)]	Same as for 1st Interval	Not permissible
	Core Makeup Tanks	IWB-2500-7(a), IWB-2500-7(b), IWB-2500-7(c), or IWB-2500-7(d) [Note (4)]					
B3.170	Nozzle-to-Vessel Welds	IWB-2500-7(a), IWB-2500-7(b), IWB-2500-7(c), or IWB-2500-7(d) [Note (4)]	Volumetric	IWB-3512	All nozzles [Note (1)]	Same as for 1st Interval	Not permissible

NOTES:
(1) Includes nozzles with full penetration welds to vessel shell (or head) and integrally cast nozzles, but excludes manways and handholes either welded to or integrally cast in vessel.
(2) At least 25% but not more than 50% of the nozzles shall be examined by the end of the first inspection period, and the remainder by the end of the inspection interval.
(3) If the nozzle weld is examined by the straight beam ultrasonic method from inside the nozzle bore, the remaining examinations required from the shell inside diameter may be performed at or near the end of the interval.
(4) The examination volumes shall apply to the applicable sketches shown in Figures IWB-2500-7(a) through IWB-2500-7(d). Examination of the nozzle inside radius section is required only for Items B3.100 and B3.160.
(5) For PWRs in the second and successive inspection intervals, these examinations may be deferred to the end of the interval, provided no repair/replacement activities have been performed on the examination item, and no flaws or relevant conditions requiring successive inspections in accordance with IWB-2420(b) are contained in the examination item.
(6) For BWRs, the alternative criteria in IWB-2500(f) may be used.
(7) VT-1 visual examination may be performed in accordance with IWB-2500(g) in lieu of a volumetric examination.
(8) The allowable-flaw-length criteria of Table IWB-3512-1 with a flaw aspect ratio of a/ℓ = 0.5 shall be used for VT-1 visual examination.

Table IWB-2500-1 (B-F)
Examination Category B-F, Pressure-Retaining Dissimilar Metal Welds in Vessel Nozzles

Item No.	Parts Examined	Examination Requirements/ Figure No.	Examination Method	Acceptance Standard	Extent and Frequency of Examination		Deferral of Examination to End of Interval
					First Inspection Interval	Successive Inspection Intervals	
	Reactor Vessel						
B5.10	NPS 4 (DN 100) or Larger Nozzle-to-Safe End Butt Welds	IWB-2500-8	Volumetric and surface	IWB-3514	All welds	Same as for 1st interval	See [Note (1)], [Note (2)]
B5.11	NPS 4 (DN 100) or Larger Nozzle-to-Component Butt Welds	IWB-2500-8	Volumetric and surface	IWB-3514	All welds	Same as for 1st interval	Not permissible
B5.20	Less Than NPS 4 (DN 100) Nozzle-to-Safe End Butt Welds	IWB-2500-8	Surface	IWB-3514	All welds	Same as for 1st interval	See [Note (1)]
B5.30	Nozzle-to-Safe End Socket Welds	IWB-2500-8	Surface	IWB-3514	All welds	Same as for 1st interval	See [Note (1)]
	Pressurizer						
B5.40	NPS 4 (DN 100) or Larger Nozzle-to-Safe End Butt Welds	IWB-2500-8	Volumetric and surface	IWB-3514	All welds	Same as for 1st interval	Not permissible
B5.50	Less Than NPS 4 (DN 100) Nozzle-to-Safe End Butt Welds	IWB-2500-8	Surface	IWB-3514	All welds	Same as for 1st interval	Not permissible
B5.60	Nozzle-to-Safe End Socket Welds	IWB-2500-8	Surface	IWB-3514	All welds	Same as for 1st interval	Not permissible
	Steam Generator						
B5.70	NPS 4 (DN 100) or Larger Nozzle-to-Safe End Butt Welds	IWB-2500-8	Volumetric and surface	IWB-3514	All welds	Same as for 1st interval	Not permissible
B5.71	NPS 4 (DN 100) or Larger Nozzle-to-Component Butt Welds	IWB-2500-8	Volumetric and surface	IWB-3514	All welds	Same as for 1st interval	Not permissible
B5.80	Less Than NPS 4 (DN 100) Nozzle-to-Safe End Butt Welds	IWB-2500-8	Surface	IWB-3514	All welds	Same as for 1st interval	Not permissible
B5.90	Nozzle-to-Safe End Socket Welds	IWB-2500-8	Surface	IWB-3514	All welds	Same as for 1st interval	Not permissible
	Heat Exchangers						
B5.100	NPS 4 (DN 100) or Larger Nozzle-to-Safe End Butt Welds	IWB-2500-8	Volumetric and surface	IWB-3514	All welds	Same as for 1st interval	Not permissible
B5.110	Less Than NPS 4 (DN 100) Nozzle-to-Safe End Butt Welds	IWB-2500-8	Surface	IWB-3514	All welds	Same as for 1st interval	Not permissible
B5.120	Nozzle-to-Safe End Socket Welds	IWB-2500-8	Surface	IWB-3514	All welds	Same as for 1st interval	Not permissible
	Core Makeup Tanks						
B5.130	NPS 4 (DN 100) or Larger Nozzle-to-Safe End Butt Welds	IWB-2500-8	Volumetric and surface	IWB-3514	All welds	Same as for 1st interval	Not permissible
B5.140	Less Than NPS 4 (DN 100) Nozzle-to-Safe End Butt Welds	IWB-2500-8	Surface	IWB-3514	All welds	Same as for 1st interval	Not permissible
B5.150	Nozzle-to-Safe End Socket Welds	IWB-2500-8	Surface	IWB-3514	All welds	Same as for 1st interval	Not permissible
	Weld Overlayed Butt Welds						
B5.160	Overlayed Butt Welds (e.g., Full Structural Weld Overlay, Mitigative Weld Overlay, Repair Weld Overlay, or Optimized Weld Overlay)	See [Note (3)]	Volumetric	See [Note (3)]	See [Note (3)]	See [Note (3)]	Not permissible

Table IWB-2500-1 (B-F)
Examination Category B-F, Pressure-Retaining Dissimilar Metal Welds in Vessel Nozzles (Cont'd)

NOTES:
(1) Deferral is not permissible during the first interval. However, during successive intervals, the examinations may be performed coincident with the vessel nozzle examinations required by Examination Category B-D.
(2) For PWRs in the second and successive inspection intervals, these examinations may be deferred to the end of the interval, provided no repair/replacement activities have been performed on the examination item, and no flaws or relevant conditions requiring successive inspections in accordance with IWB-2420(b) are contained in the examination item.
(3) Examination volume, schedule (including additional examinations), and acceptance standards shall be acceptable to the regulatory authority having jurisdiction at the plant site [e.g., PWSCC or BWR IGSCC Program, Nonmandatory Appendix Q (2004 Edition with 2005 Addenda or later), Case N-504-4, Case N-740-2, or Case N-754-1]. Weld overlay examinations shall include all welds and materials in which the overlay was installed as pressure-retaining material.

Table IWB-2500-1 (B-G-1)
Examination Category B-G-1, Pressure-Retaining Bolting, Greater Than 2 in. (50 mm) in Diameter

Item No.	Parts Examined	Examination Requirements/ Figure No.	Examination Method	Acceptance Standard	Extent and Frequency of Examination		Deferral of Examination to End of Interval
					First Inspection Interval	Successive Inspection Intervals	
	Reactor Vessel						
B6.10	Closure Head Nuts	Surfaces	Visual, VT-1	IWB-3517	Closure head nuts	Same as for 1st interval [Note (8)]	Permissible
B6.20	Closure Studs	IWB-2500-12(a), IWB-2500-12(b), or IWB-2500-12(c)	Volumetric [Note (7)]	IWB-3515	Closure studs [Note (1)]		
B6.40	Threads in Flange	IWB-2500-12(a), IWB-2500-12(b), or IWB-2500-12(c)	Volumetric	IWB-3515	Threads in flange		
B6.50	Closure Washers, Bushings	Surfaces	Visual, VT-1	IWB-3517	Closure washer and bushings [Note (2)]		
	Pressurizer						
B6.60	Bolts and Studs	IWB-2500-12(a), IWB-2500-12(b), or IWB-2500-12(c)	Volumetric [Note (7)]	IWB-3515	Bolts and studs [Note (1)]	Same as for 1st interval	Permissible
B6.70	Flange Surface, [Note (6)] when connection disassembled	Surfaces	Visual, VT-1	IWB-3517	Flange surface		
B6.80	Nuts, Bushings, and Washers	Surfaces	Visual, VT-1	IWB-3517	Nuts, bushings, and washers [Note (2)]		
	Steam Generators						
B6.90	Bolts and Studs	IWB-2500-12(a), IWB-2500-12(b), or IWB-2500-12(c)	Volumetric [Note (7)]	IWB-3515	Bolts and studs [Note (1)]	Same as for 1st interval	Permissible
B6.100	Flange Surface, [Note (6)] when connection disassembled	Surfaces	Visual, VT-1	IWB-3517	Flange surface		
B6.110	Nuts, Bushings, and Washers	Surfaces	Visual, VT-1	IWB-3517	Nuts, bushings, and washers [Note (2)]		
	Heat Exchangers						

Table IWB-2500-1 (B-G-1)
Examination Category B-G-1, Pressure-Retaining Bolting, Greater Than 2 in. (50 mm) in Diameter (Cont'd)

Item No.	Parts Examined	Examination Requirements/ Figure No.	Examination Method	Acceptance Standard	Extent and Frequency of Examination		Deferral of Examination to End of Interval
					First Inspection Interval	Successive Inspection Intervals	
B6.120	Bolts and Studs	IWB-2500-12(a), IWB-2500-12(b), or IWB-2500-12(c)	Volumetric [Note (7)]	IWB-3515	Bolts and studs [Note (1)], [Note (3)]	Same as for 1st interval	Permissible
B6.130	Flange Surface, [Note (6)] when connection disassembled	Surfaces	Visual, VT-1	IWB-3517	Flange surface [Note (4)]		
B6.140	Nuts, Bushings, and Washers	Surfaces	Visual, VT-1	IWB-3517	Nuts, bushings, and washers [Note (2)], [Note (4)]		
	Piping					Same as for 1st interval	Permissible
B6.150	Bolts and Studs	IWB-2500-12(a), IWB-2500-12(b), or IWB-2500-12(c)	Volumetric [Note (7)]	IWB-3515	Bolts and studs [Note (1)], [Note (5)]		
B6.160	Flange Surface, [Note (6)] when connection disassembled	Surfaces	Visual, VT-1	IWB-3517	Flange surface [Note (5)]		
B6.170	Nuts, Bushings, and Washers	Surfaces	Visual, VT-1	IWB-3517	Nuts, bushings, and washers [Note (2)], [Note (5)]		
	Pumps					Same as for 1st interval	Permissible
B6.180	Bolts and Studs	IWB-2500-12(a), IWB-2500-12(b), or IWB-2500-12(c)	Volumetric [Note (7)]	IWB-3515	Bolts and studs [Note (1)], [Note (3)]		
B6.190	Flange Surface, [Note (6)] when connection disassembled	Surfaces	Visual, VT-1	IWB-3517	Flange surface [Note (4)]		
B6.200	Nuts, Bushings, and Washers	Surfaces	Visual, VT-1	IWB-3517	Nuts, bushings, and washers [Note (2)], [Note (4)]		

Table IWB-2500-1 (B-G-1)
Examination Category B-G-1, Pressure-Retaining Bolting, Greater Than 2 in. (50 mm) in Diameter (Cont'd)

Item No.	Parts Examined	Examination Requirements/ Figure No.	Examination Method	Acceptance Standard	Extent and Frequency of Examination		Deferral of Examination to End of Interval
					First Inspection Interval	Successive Inspection Intervals	
	Valves					Same as for 1st interval	Permissible
B6.210	Bolts and Studs	IWB-2500-12(a), IWB-2500-12(b), or IWB-2500-12(c)	Volumetric [Note (7)]	IWB-3515	Bolts and studs [Note (1)], [Note (3)]		
B6.220	Flange Surface, [Note (6)] when connection disassembled	Surfaces	Visual, VT-1	IWB-3517	Flange surface [Note (4)]		
B6.230	Nuts, Bushings, and Washers	Surfaces	Visual, VT-1	IWB-3517	Nuts, bushings, and washers [Note (2)], [Note (4)]		
	Core Makeup Tanks					Same as for 1st interval	Permissible
B6.240	Bolts and Studs	IWB-2500-12(a), IWB-2500-12(b), or IWB-2500-12(c)	Volumetric [Note (7)]	IWB-3515	Bolts and studs [Note (1)]		
B6.250	Flange Surface, [Note (6)] when connection disassembled	Surfaces	Visual, VT-1	IWB-3517	Flange surface		
B6.260	Nuts, Bushings, and Washers	Surfaces	Visual, VT-1	IWB-3517	Nuts, bushings, and washers [Note (2)]		

GENERAL NOTE: Bolting diameter is defined as the smaller of the minor thread diameter of the portion of the bolting that is under tension or the bolting shank diameter.

NOTES:

(1) Bolting may be examined:
- *(a)* in place under tension;
- *(b)* when the connection is disassembled;
- *(c)* when the bolting is removed.

(2) Bushings are required to be examined only when the bolting is removed. Bushings may be examined in place.

(3) Volumetric examination of bolts and studs for heat exchangers, pumps, or valves may be conducted on one heat exchanger, one pump, or one valve among a group of heat exchangers, pumps, or valves that are similar in design, type, and function. In addition, when the component to be examined contains a group of bolted connections of similar design and size, such as flanged connections, the examination may be conducted on one bolted connection among the group.

(4) Visual examination of nuts, bushings, washers, and flange surfaces for heat exchangers, pumps, or valves may be conducted on one heat exchanger, one pump, or one valve among a group of heat exchangers, pumps, or valves that are similar in design, type, and function. In addition, when the component to be examined contains a group of bolted connections of similar design and size, such as flanged connections, the examination may be conducted on one bolted connection among the group. Visual examination is required only once during the interval, when the connection is disassembled, and only if the component is examined in accordance with Examination Category B-B, B-L-2, or B-M-2.

(5) The examination of flange bolting in piping systems may be limited to one bolted connection among a group of bolted connections that are similar in design, size, function, and service.

(6) Examination includes 1 in. (25 mm) annular surface of flange surrounding each stud.

(7) When bolts or studs are removed for examination, surface examination meeting the acceptance standards of IWB-3515 may be substituted for volumetric examination.

(8) For Item Number B6.40, examinations are not required after a second or subsequent inspection interval, provided no defects have been previously detected.

Table IWB-2500-1 (B-G-2)
Examination Category B-G-2, Pressure-Retaining Bolting, 2 in. (50 mm) and Less in Diameter

Item No.	Parts Examined [Note (1)]	Examination Requirements/ Figure No.	Examination Method	Acceptance Standard	Extent and Frequency of Examination		Deferral of Examination to End of Interval
					First Inspection Interval	Successive Inspection Intervals	
	Reactor Vessel				All bolts, studs, and nuts [Note (2)]	Same as for 1st interval	Not permissible
B7.10	Bolts, Studs, and Nuts	Surface	Visual, VT-1	IWB-3517			
	Pressurizer				All bolts, studs, and nuts [Note (2)]	Same as for 1st interval	Not permissible
B7.20	Bolts, Studs, and Nuts	Surface	Visual, VT-1	IWB-3517			
	Steam Generators				All bolts, studs, and nuts [Note (2)]	Same as for 1st interval	Not permissible
B7.30	Bolts, Studs, and Nuts	Surface	Visual, VT-1	IWB-3517			
	Heat Exchangers				All bolts, studs, and nuts [Note (2)]	Same as for 1st interval	Not permissible
B7.40	Bolts, Studs, and Nuts	Surface	Visual, VT-1	IWB-3517			
	Piping				All bolts, studs, and nuts [Note (3)]	Same as for 1st interval	Not permissible
B7.50	Bolts, Studs, and Nuts	Surface	Visual, VT-1	IWB-3517			
	Pumps				All bolts, studs, and nuts [Note (2)]	Same as for 1st interval	Not permissible
B7.60	Bolts, Studs, and Nuts	Surface	Visual, VT-1	IWB-3517			
	Valves				All bolts, studs, and nuts [Note (2)]	Same as for 1st interval	Not permissible
B7.70	Bolts, Studs, and Nuts	Surface	Visual, VT-1	IWB-3517			
	Core Makeup Tanks				All bolts, studs, and nuts [Note (2)]	Same as for 1st interval	Not permissible
B7.80	Bolts, Studs, and Nuts	Surface	Visual, VT-1	IWB-3517			

GENERAL NOTE: Bolting diameter is defined as the smaller of the minor thread diameter of the portion of the bolting that is under tension or the bolting shank diameter.

NOTES:
(1) Bolting is required to be examined only when a connection is disassembled or bolting is removed.
(2) For components other than piping, examination of bolting is required only when the component is examined under Examination Category B-A, B-B, B-L-2, or B-M-2. Examination of bolted connection is required only once during the interval.
(3) The examination of flange bolting in piping systems may be limited to one bolted connection among a group of bolted connections that are similar in design, size, function, and service. Examination is required only when a flange is disassembled. Examination of a bolted connection is required only once during the interval.

Table IWB-2500-1 (B-J)
Examination Category B-J, Pressure-Retaining Welds in Piping

Item No.	Parts Examined	Examination Requirements/ Figure No.	Examination Method	Acceptance Standard	Extent and Frequency of Examination		Deferral of Examination to End of Interval
					First Inspection Interval	Successive Inspection Intervals [Note (1)]	
B9.10	NPS 4 or larger (DN 100)	IWB-2500-8	Surface and volumetric	IWB-3514	Welds [Note (2)], [Note (3)], [Note (4)], [Note (5)], [Note (6)]	Same as for first interval	Not permissible
B9.11	Circumferential welds						
B9.20	Less than NPS 4 (DN 100)	IWB-2500-8		IWB-3514	Welds [Note (2)], [Note (3)], [Note (4)]	Same as for first interval	Not permissible
B9.21	Circumferential welds other than PWR high pressure safety injection systems		Surface				
B9.22	Circumferential welds of PWR high pressure safety injection systems		Volumetric		Welds [Note (3)], [Note (5)], [Note (6)], [Note (7)]		
B9.30	Branch pipe connection welds	IWB-2500-9, IWB-2500-10, and IWB-2500-11		IWB-3514		Same as for first interval	Not permissible
B9.31	NPS 4 or larger (DN 100)		Surface and volumetric		Welds [Note (2)], [Note (3)], [Note (4)], [Note (5)], [Note (6)]		
B9.32	Less than NPS 4 (DN 100)		Surface		Welds [Note (2)], [Note (3)], [Note (4)]		
B9.40	Socket welds	IWB-2500-8	Surface	IWB-3514	Welds [Note (2)], [Note (3)]	Same as for first interval	Not permissible
B9.50	Overlayed Butt Welds (e.g., Full Structural Weld Overlay, Mitigative Weld Overlay, Repair Weld Overlay, or Optimized Weld Overlay)	See [Note (8)]	Volumetric	See [Note (8)]	Weld [Note (8)]	See [Note (8)]	Not permissible

NOTES:

(1) To the extent practicable, the initially selected welds are to be examined in the same sequence during successive inspection intervals.

(2) Category B-J welds shall be selected for examination such that 25% (excluding welds exempted by IWB-1220 or welds in Item No. B9.22) of the circumferential butt welds (or branch connection or socket welds) are examined during the interval. The welds selected for examination shall be prorated to include the welds listed in (a), (b), and (c) below, up to 25% of the total population of Category B-J welds. If additional welds are required to meet the 25% criteria, they shall be selected in accordance with (d) below.

(a) terminal ends in each pipe or branch run connected to vessels.

(b) terminal ends and joints in each pipe or branch run connected to other components where the stress levels exceed either of the following limits under loads associated with specific seismic events and operational conditions:

(1) primary plus secondary stress intensity range of $2.4S_m$ for ferritic steel and austenitic steel

(2) cumulative usage factor, U, of 0.4

(c) dissimilar metal welds not covered under Category B-F.

(d) additional piping welds so that the total number of circumferential butt welds (or branch connection or socket welds) selected for examination equals 25% of the circumferential butt welds (or branch connection or socket welds). These additional welds may be located as follows:

(1) For PWR plants

Table IWB-2500-1 (B-J)
Examination Category B-J, Pressure-Retaining Welds in Piping (Cont'd)

NOTES (CONT'D):

(-a) one hot-leg and one cold-leg in one reactor coolant piping loop

(-b) one branch, representative of an essentially symmetric piping configuration among each group of branch runs that are connected to reactor coolant loops and that perform similar system functions

(-c) each piping and branch run exclusive of the categories of loop and runs that are part of system piping of (-a) and (-b) above

(2) For BWR plants

(-a) one reactor coolant recirculation loop (where a loop or run branches, only one branch)

(-b) one branch run representative of an essentially symmetric piping configuration among each group of branch runs that are connected to a loop and that perform similar system functions

(-c) one steam line run representative of an essentially symmetric piping configuration among the runs

(-d) one feedwater line run representative of an essentially symmetric piping configuration among the runs (where a loop or run branches, only one branch)

(-e) each piping and branch exclusive of the categories of loops and runs that are part of the system piping of (-a) through (-d) above

(3) Includes essentially 100% of the examination volume or area.

(4) For circumferential welds with intersecting longitudinal welds, surface examination of the longitudinal piping welds is required for those portions of the welds within the examination boundaries of intersecting Examination Categories B-F and B-J circumferential welds.

(5) For circumferential welds with intersecting longitudinal welds, volumetric examination of the longitudinal piping welds is required for those portions of the welds within the examination boundaries of intersecting Examination Categories B-F and B-J circumferential welds. The following requirements shall also be met:

(a) When longitudinal welds are specified and locations are known, examination requirements shall be met for both transverse and parallel flaws at the intersection of the welds and for that length of longitudinal weld within the circumferential weld examination volume.

(b) When longitudinal welds are specified but locations are unknown, or the existence of longitudinal welds is uncertain, the examination requirements shall be met for both transverse and parallel flaws within the entire examination volume of intersecting circumferential welds.

(6) For welds in carbon or low alloy steels, only those welds showing reportable preservice transverse indications need to be examined by the ultrasonic method for reflectors transverse to the weld length direction except that circumferential welds with intersecting longitudinal welds shall meet [Note (5)].

(7) A 10% sample of PWR high pressure safety injection system circumferential welds in piping greater than or equal to NPS 1½ (DN 40) and less than NPS 4 (DN 100) shall be selected for examination. This sample shall be selected from locations determined by the Owner as most likely to be subject to thermal fatigue. Thermal fatigue may be caused by conditions such as valve leakage or turbulence effects.

(8) Examination volume, schedule (including additional examinations), and acceptance standards shall be acceptable to the regulatory authority having jurisdiction at the plant site [e.g., PWSCC or BWR IGSCC Program, Nonmandatory Appendix Q (2004 Edition with 2005 Addenda or later), Case N-504-4, Case N-740-2, or Case N-754-1]. Weld overlay examinations shall include all welds and materials in which the overlay was installed as pressure-retaining material.