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PART 3

REPAIRS AND ALTERATIONS

THE NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS

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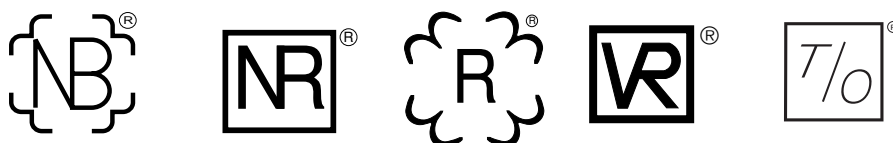
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INTRODUCTION

It is the purpose of the *National Board Inspection Code* (NBIC) to maintain the integrity of pressure-retaining items by providing rules for post-construction activities including installation, and by providing rules for post-installation activities including inspections, repairs, and alterations, thereby ensuring the safety of the pressure-retaining items' continued use.

The NBIC is intended to provide rules, information, and guidance to manufacturers, jurisdictions, Inspectors, owner-users, installers, contractors, and other individuals and organizations performing or involved in post-construction activities, thereby encouraging the uniform administration of rules pertaining to pressure retaining items.

SCOPE

The NBIC recognizes four important areas of post-construction activities where information, understanding, and following specific requirements will promote public and personal safety. These areas include:

- Installation
- Inspection
- Repairs and Alterations
- Testing of Pressure Relief Devices

The NBIC provides rules, information, and guidance for post-construction activities, but does not provide details for all conditions involving pressure-retaining items. Where complete details are not provided in this Code, the Code user is advised to seek guidance from the applicable jurisdiction or other technical sources.

The words “shall,” “should,” and “may” are used throughout the NBIC and have the following intent:

- Shall – action that is mandatory.
- Should – indicates a preferred but not mandatory means to accomplish the requirement unless specified by other sources, such as the Jurisdiction.
- May – permissive, not required or a means to accomplish the specified task.

ORGANIZATION

The NBIC is organized into four parts to coincide with specific post-construction activities involving pressure-retaining items. Each part provides general and specific rules, information, and guidance within each applicable post-construction activity. Individual NBIC parts or other published standards may contain additional information or requirements needed to meet the rules of the NBIC. Each part provides specific references to direct the user where to find this additional information. NBIC parts are identified as:

- Part 1, Installation – This part provides requirements and guidance to ensure the proper installation and functioning of all types of pressure-retaining items. Installation includes meeting specific safety criteria for construction, materials, design, supports, safety devices, operation, testing, and maintenance.
- Part 2, Inspection – This part provides information and guidance needed to perform and document inspections for all types of pressure-retaining items. This part includes information on personnel safety, non-destructive examination, tests, failure mechanisms, types of pressure equipment, fitness for service, risk-based assessments, and performance-based standards.
- Part 3, Repairs and Alterations – This part provides requirements and guidance to perform, verify, and document acceptable repairs or alterations to pressure-retaining items regardless of code of construction. Alternative methods for examination, testing, heat treatment, etc., are provided when the original code of construction requirements cannot be met. Specific acceptable and proven repair methods are also provided.
- Part 4, Pressure Relief Devices – This part provides information and guidance to ensure pressure relief devices are installed properly, that inspections of pressure relief devices are performed and documented properly, and that repairs to pressure relief devices are performed, verified, and documented properly.

Each part of the NBIC is divided into major sections as outlined in the Table of Contents.

TEXT IDENTIFICATION AND NUMBERING

Each page in the text displays the publication name and publication year in the header; the footer of each page displays the designated section and page number. The numbering sequence for each section begins with the section number followed by a period to further designate major sections (e.g., 1.1, 1.2, 1.3). Major sections are further subdivided using periods to designate subsections within that major section (e.g., 1.1.1, 1.2.1, 1.3.1). Subsections can be further divided as necessary. Paragraphs under sections or subsections shall be designated with a small letter followed by a parenthesis (e.g., a), b), c)) and are further subdivided using a number followed by a parenthesis (e.g., 1), 2), 3)).

Subdivisions of paragraphs beyond this point will be designated using a hierarchical sequence of letters and numbers, each of which is followed by a period.

Example: 2.1 Major Section
 2.1.1 Section
 2.1.2 Section
 2.1.2. Subsection
 a) paragraph
 b) paragraph
 1) subparagraph
 2) subparagraph
 a. subdivisions
 1. subdivisions
 2. subdivisions
 b. subdivisions
 1. subdivisions
 2. subdivisions

Each part of the NBIC typically contains tables, charts, and figures within or after each major section. Tables, charts, and figures provide relevant illustrations or supporting information for text passages and are designated with numbers corresponding to the paragraph they illustrate or support within each section or subsection. Multiple tables, charts, or figures referenced by the same paragraph are marked with additional letters sequentially arranged to reflect the order of reference.

SUPPLEMENTS

Supplements are contained in each part of the NBIC to provide requirements and guidance pertaining only to a specific type of pressure-retaining item (e.g., locomotive boilers, historical boilers, graphite pressure vessels) or to a specific subject (e.g., report forms, alternative repair methods, etc.). Supplements follow the same numbering system used for the main text but are preceded by the letter “S”. Each page of the supplement is tabbed to identify the supplement number.

EDITIONS

Editions of the NBIC are published every two years. Editions are permissive on the date issued; however, they become mandatory six months after the date of issue. Substantive revisions and/or additions that have been incorporated into the NBIC since the last edition are noted with the two-digit publication year, enclosed in parentheses, in the margin next to the section, subsection, or paragraph containing the revision(s) and/or addition(s).

CODE STAMPING

ASME Code “stamping” referenced throughout the NBIC includes the ASME Boiler and Pressure Vessel Code Symbol Stamps used for conformity assessment prior to the 2010 edition/2011 addenda and the equivalent ASME Certification Mark required to meet the later editions of the ASME Boiler and Pressure Vessel Code sections. When other construction codes or standards are utilized for repairs or alterations, stamping shall mean the identification symbol stamp required by that code or standard.

INTERPRETATIONS, CODE ADDITIONS, AND CODE REVISIONS

The NBIC Committee meets regularly to consider requests for interpretations, revisions, and additions for this Code. Interpretations are provided for each part and are specific to the Code edition and addenda referenced in the interpretation; interpretations may be used with subsequent editions of the NBIC provided the requirements have not changed. Interpretations provide clarification of existing rules in the NBIC, but are not part of the NBIC. Code revisions and additions are intended to accommodate technological developments, address administrative requirements, or clarify Code intent.

Interested parties may submit requests for Code interpretations, revisions, and additions through the National Board Business Center by following these steps:

1. Navigate to <https://buscenter.nationalboard.org> in your web browser;
2. Sign in to the Business Center (this may require creating an account);
3. Navigate to the NBIC tab and select “Request”;
4. Click “Make a Request”;
5. Select your request type; and
6. Fill out all fields in the request form and click the “Submit Request” button.

National Board staff will review all new requests before submitting them to the NBIC Committee for consideration at the next scheduled NBIC meeting.

PRESENTATION REQUESTS

From time to time someone requests to give a presentation to specific NBIC committees (e.g., subgroups, subcommittees, NBIC Main Committee). Requests to give a presentation to any committee must be submitted in writing to the NBIC Committee Secretary at least one month prior to the scheduled NBIC meetings. The written request must specify the subject and committee(s) to which you are requesting to provide the presentation. All requests shall contain a copy of the presentation in a format that is acceptable to the NBIC Secretary, such as Microsoft PowerPoint. Requests should be emailed to the NBIC Secretary at NBICSecretary@nbbi.org.

Commercial promotion is not permitted.

All requests for presentations are subject to the approval of The National Board and the Chair(s) of the specific committee(s).

JURISDICTIONAL PRECEDENCE

The NBIC references the requirements of the “Jurisdiction.” Where any provision herein presents a direct or implied conflict with any jurisdictional regulation, the jurisdictional regulation shall govern. Where the requirements of the jurisdiction do not meet the minimum requirements of the NBIC Part 3, the National Board “R” or “NR” Symbol stamp shall not be applied, and the applicable “R” reports shall not be signed by the “R” or “NR” Certificate Holder or the Inspector.

UNITS OF MEASUREMENT

Both U.S. customary units and metric units are used in the NBIC. The value stated in U.S. customary units or metric units are to be regarded separately as the standard. Within the text, the metric units are noted in parentheses. In NBIC Part 2, Supplement 6 and NBIC Part 3, Supplement 6, regarding DOT Transport Tanks, the U.S. customary unit is noted in parentheses following each metric unit reference.

U.S. customary units or metric units may be used with this edition of the NBIC, but one system of units shall be used consistently throughout a repair or alteration of a pressure-retaining item. It is the responsibility of National Board-accredited repair organizations to ensure the appropriate units are used consistently

throughout all phases of work. This includes materials, design, procedures, testing, documentation, and stamping. The NBIC policy for metrication is outlined in Section 7 of each part of the NBIC.

ACCREDITATION PROGRAMS

The National Board administers four specific accreditation programs as shown below:

“R” Repairs and alterations to pressure-retaining items (NB-415)

“VR” Repairs to pressure relief valves (NB-514)

“NR” Repair and replacement activities for nuclear items (NB-417)

“T/O” Testing of pressure relief valves (NB-528)

The administrative requirements for these accreditation programs can be viewed on the National Board’s website at www.nbbi.org.

The National Board also administers four specific accreditation/acceptance programs for inspection agencies as shown below:

New Construction

National Board Acceptance of Authorized Inspection Agencies (AIA) Accredited by the American Society of Mechanical Engineers (ASME; NB-360)

Inservice

Accreditation of Authorized Inspection Agencies (AIA) Performing Inservice Inspection Activities (NB-369)

Owner-User

Accreditation of Owner-User Inspection Organizations (OUIO; NB-371)

Owners or users may be accredited for both a repair and inspection program provided the requirements for each accreditation program are met.

Federal Government

Accreditation of Federal Inspection Agencies (FIA; NB-390)

These programs can be viewed on the National Board’s website at www.nbbi.org. For questions or further information regarding these programs, contact the National Board by phone at (614) 888-8320 or by fax at (614) 847-1828.

CERTIFICATES OF AUTHORIZATION FOR ACCREDITATION PROGRAMS

Any organization seeking accreditation for a National Board program(s) shall apply to the National Board to obtain a *Certificate of Authorization* for the requested scope of activities. A confidential review shall be conducted to evaluate the organization’s Quality System and its implementation of the same. Upon completion of the evaluation, a recommendation regarding the applicable *Certificate of Authorization* will be sent to the National Board.

Certificate of Authorization scope, issuance, and revisions for National Board accreditation programs are specified in the applicable National Board procedures. When the Quality System requirements of the applicable accreditation program have been met, a *Certificate of Authorization* and National Board Symbol stamp, if applicable, will be issued.

FOREWORD

The National Board of Boiler and Pressure Vessel Inspectors is an organization comprised of Chief Inspectors for the states, cities, and territories of the United States and provinces and territories of Canada. It is organized for the purpose of promoting greater safety to life and property by securing concerted action and maintaining uniformity in post-construction activities of pressure-retaining items, thereby ensuring acceptance and interchangeability among Jurisdictional authorities responsible for the administration and enforcement of various codes and standards.

In keeping with the principles of promoting safety and maintaining uniformity, the National Board originally published the NBIC in 1946, establishing rules for inspection and repairs to boilers and pressure vessels. The *National Board Inspection Code* (NBIC) Committee is charged with the responsibility for maintaining and revising the NBIC. In the interest of public safety, the NBIC Committee decided, in 1995, to revise the scope of the NBIC to include rules for installation, inspection, and repair or alteration to boilers, pressure vessels, piping, and nonmetallic materials.

In 2007, the NBIC was restructured into three parts specifically identifying important post-construction activities involving safety of pressure-retaining items. This restructuring provides for future expansion, transparency, uniformity, and ultimately improving public safety.

In 2017, the NBIC was once again restructured into 4 parts, adding a new Part 4, Pressure Relief Devices. This purpose of this restructuring was to provide one distinct integrated part for pressure relief devices compiled from all PRD information referenced in Part 1, Installation; Part 2, Inspection; and Part 3, Repairs and Alterations.

The NBIC Committee's function is to establish rules of safety governing post-construction activities for the installation, inspection, and repair and alteration of pressure-retaining items, and to interpret these rules when questions arise regarding their intent. In formulating the rules, the NBIC Committee considers the needs and concerns of individuals and organizations involved in the safety of pressure-retaining items. The objective of the rules is to afford reasonably certain protection of life and property, so as to give a reasonably long, safe period of usefulness. Advancements in design and material and the evidence of experience are recognized.

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

The NBIC Committee meets regularly to consider revisions of existing rules, formulation of new rules, and respond to requests for interpretations. Requests for interpretation must be addressed to the NBIC Secretary in writing and must give full particulars in order to receive Committee consideration and a written reply. Proposed revisions to the code resulting from inquiries will be presented to the NBIC Committee for appropriate action.

Proposed revisions to the code approved by the NBIC Committee are submitted to the American National Standards Institute and published on the National Board web-site to invite comments from all interested persons. After the allotted time for public review and final approval, the new edition is published. The Foreword, Introduction, Personnel and Index Sections of the NBIC are provided for guidance and informational purposes only and shall not be considered a part of the Code. These sections are not approved by the NBIC Committee or submitted to the American National Standards Institute.

Organizations or users of pressure-retaining items are cautioned against making use of revisions that are less restrictive than former requirements without having assurance that they have been accepted by the Jurisdiction where the pressure-retaining item is installed.

The general philosophy underlying the NBIC is to parallel those provisions of the original code of construction, as they can be applied to post-construction activities. The NBIC does not contain rules to cover all details of post-construction activities. Where complete details are not given, it is intended that individuals or organizations, subject to the acceptance of the Inspector and Jurisdiction when applicable, provide details

for post-construction activities that will be as safe as otherwise provided by the rules in the original code of construction.

Activities not conforming to the rules of the original code of construction or the NBIC must receive specific approval from the Jurisdiction, who may establish requirements for design, construction, inspection, testing, and documentation.

There are instances where the NBIC serves to warn against pitfalls; but the code is not a handbook, and cannot substitute for education, experience, and sound engineering judgment. It is intended that this edition of the NBIC not be retroactive. Unless the Jurisdiction imposes the use of an earlier edition, the latest effective edition is the governing document.

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PART 3, SECTION 1

REPAIRS AND ALTERATIONS — GENERAL AND ADMINISTRATIVE REQUIREMENTS

1.1 SCOPE

- a) This part provides requirements and guidelines that apply when performing repairs and alterations to pressure-retaining items.
- b) The National Board administers four specific accreditation programs:
 - 1) “R” — Repairs and Alterations to Pressure-Retaining Items
 - 2) “NR” — Repair and Replacement Activities for Nuclear Items
 - 3) “VR” — Repairs to Pressure Relief Valves
 - 4) “T/O” — Test Only of Pressure Relief Valves
- c) This part describes some of the administrative requirements for the accreditation of repair organizations. Additional administrative requirements can be found in:
 - 1) NB-415, *Accreditation of “R” Repair Organizations*
 - 2) NB-417, *Accreditation of “NR” Repair Organizations*
 - 3) NB-514, *Accreditation of “VR” Repair Organizations*
 - 4) NB-528, *Accreditation of “T/O” Test Only Organizations*
- d) Requirements for repairs to pressure relief valves can be found in NBIC Part 4.

(23) 1.2 CONSTRUCTION STANDARDS FOR PRESSURE-RETAINING ITEMS

- a) Repairs and alterations shall conform to the edition and addenda of the original code of construction, standard, or specification used during the initial fabrication of the pressure-retaining item, or to a later edition and addenda most applicable to the work planned. ASME Code Cases that are active may be used for repairs and alterations of pressure retaining items with acceptance of the Inspector, and when required, the Jurisdiction. Use of an active ASME Code Case shall be noted on the appropriate Form R Report.
- b) If the original code of construction, standard, or specification is unknown, or if the original code of construction, standard, or specification is not possible or practicable, it is permissible to use other codes, standards, or specifications most applicable to the work planned, including the ASME Code or ASME RTP-1, provided the “R” or “NR” Certificate Holder has the concurrence of the Inspector and the Jurisdiction where the pressure-retaining item is installed.
- c) For historical boilers, ASME, Section I provides rules for design and features of construction.
- d) Piping systems are designed for a variety of service conditions such as steam, water, oil, gas, or air. Design requirements for repairs and alterations are to meet the original code of construction or the code most appropriate for the repair or alteration. These systems shall be designed for the most severe conditions of pressure, temperature, loadings, and expected transients considered for normal operation. All pipe materials, fittings, and valves shall be rated for the maximum service conditions for normal operation. Design corrosion of piping systems should also be considered when determining types of materials and thicknesses.

- e) For Transport Tanks, the Competent Authority, i.e. the U.S. Department of Transportation (DOT), shall be consulted for any requirements which it has established since they take precedence for repairs.
 - 1) Transport tanks manufactured prior to the adoption of ASME Section XII by the Competent Authority (DOT) were constructed in accordance with ASME Section VIII, Division 1. Certain transport tanks manufactured to this code were required to be stamped in accordance with Section VIII, Division 1, if the design pressure of the transport tank was 241 kPa (35 psi) (depending on material being transported) and greater. If the design pressure was less than 241 kPa (35 psi) (depending on material being transported), the transport tank was manufactured in accordance with Section VIII, Division 1, but not required by the Competent Authority (DOT) to be stamped.
 - 2) ASME stamped transport tanks are subject to the requirements of NBIC Part 3, for continued in-service repairs, alterations, or modifications, unless exempted by the Competent Authority (DOT).

1.3 INSPECTOR

(23)

- a) Inspection and certification shall be made by an Inspector holding a valid National Board commission with the "R" endorsement issued by the National Board and employed by an Authorized Inspection Agency in accordance with NB-263, *Rules for Commissioned Inspectors* (RCI-1) (see NBIC Part 3, Section 9, Glossary of Terms for definition of Authorized Inspection Agency).
- b) An Inspector employed by an Owner-User Inspection Organization or a Federal Inspection Agency may authorize and accept work only on pressure-retaining items owned or used by the respective organization. Each accredited Owner-User Inspection Organization's quality program shall have specific approval of the Jurisdiction as required.

1.3.1 AUTHORIZATION

- a) The Inspector's authorization to perform a repair or alteration shall be obtained by the repair organization prior to initiation of a repair or alteration to a pressure-retaining item. The Inspector shall determine that the repair or alteration methods are acceptable.
- b) Subject to acceptance of the Jurisdiction, the Inspector may give approval for routine repairs prior to the start of work, provided the Inspector ensures that the "R" Certificate Holder has adequately addressed routine repairs in the quality program.

1.3.2 INSPECTIONS AND CERTIFICATIONS

(23)

- a) Inspections and NBIC Form R Report certifications shall be performed by the same Inspector who authorized the repair or alteration activity. Where this is not possible or practicable, another Inspector may perform these duties; however, in all cases, duties associated within the same scope of work shall be performed by Inspectors employed by the same Authorized Inspection Agency.
- b) Before signing the appropriate NBIC Form R Report, the Inspector shall verify all applicable Inspector duties have been performed as required in NB-263, RCI-1.

1.4 ACCREDITATION

- a) Organizations performing repairs or alterations to pressure-retaining items shall be accredited as described in this section, as appropriate for the scope of work to be performed.
- b) Organizations performing repairs outside the scope of the NBIC may be accredited and shall meet any additional requirements of the Jurisdiction where the work is performed.

1.4.1 ACCREDITATION PROCESS

- a) The National Board administers accreditation programs for authorization of organizations performing repairs and alterations to pressure-retaining items in accordance with NB-415, *Accreditation of "R" Repair Organizations*.
- b) Any organization may apply to the National Board to obtain a *Certificate of Authorization* for the requested scope of activities. A review shall be conducted to evaluate the organization's quality system. The individual assigned to conduct the evaluation shall meet the qualification requirements prescribed by the National Board. Upon completion of the evaluation, any deficiencies within the organization's quality system will be documented and a recommendation will be made to the National Board regarding issuance of a *Certificate of Authorization*.
- c) As part of the accreditation process, an applicant's quality system is subject to a review. National Board procedures provide for the confidential review resulting in recommendations to issue or not issue a *Certificate of Authorization*.
- d) The accreditation programs provide requirements for organizations performing repairs and alterations to pressure-retaining items.
- e) The organization may perform repairs or alterations in its plants, shops, or in the field, provided such operations are described in the organization's Quality System.
- f) The Jurisdiction, as defined in Part 3, Section 9, may audit the Quality System and activities of an organization upon a valid request from an owner, user, inspection agency, or the National Board.
- g) The NBIC Committee may at any time change the rules for the issuance of Certificates of Authorization and use of the "R" Symbol Stamp. These rules shall become binding on all certificate holders.

1.4.2 NATIONAL BOARD "R" SYMBOL STAMP

- a) The "R" Symbol Stamp is furnished on loan by the National Board for a nominal fee.
- b) Provisions may be made for the issuance of the "R" Symbol Stamp for use at various field locations.
- c) Additional requirements shall be met in accordance with NB-415, *Accreditation of "R" Repair Organizations*.

(23) 1.5 QUALITY SYSTEM

A holder of a National Board *Certificate of Authorization* shall have and maintain a written Quality System. The Quality System shall identify the processes necessary to satisfactorily meet the requirements of the NBIC and shall be available for review. The Quality System may be in the form of a manual and may consist of several documents depending on the projected scope of work. The Quality System shall be treated confidentially by the National Board.

(23) 1.5.1 OUTLINE OF REQUIREMENTS FOR A QUALITY SYSTEM FOR QUALIFICATION FOR THE NATIONAL BOARD "R" CERTIFICATE OF AUTHORIZATION

The following is a guide for identifying features which should be covered in the written Quality System as outlined in this section and shall be documented relative to the scope of work performed within the Certificate Holder's Quality System. The intent, capability and applicability for each required feature shall be stated. Work may be subcontracted provided the necessary controls are clearly defined for maintaining full responsibility for code compliance by the National Board Certificate Holder certifying the work.

a) Title Page

The title page shall contain the Certificate Holder's legal name, physical address, and scope of work.

The scope of work shall clearly indicate the type of repairs and/or alterations the Certificate Holder is capable of and intends to carry out. The scope of work indicated shall include the following, as applicable.

- 1) Repairs Only at either Shop or Field or Both
- 2) Alterations Only at either Shop or Field or Both
- 3) Repairs and Alterations at either Shop or Field or Both
- 4) Metallic Repairs
- 5) Non-Metallic Repairs
- 6) Design Only

b) Contents Page

The Quality System shall contain a page listing the contents of the manual by section, number (if applicable), revision level, and date of each section, as required for manual control.

c) Statement of Authority and Responsibility

A dated *Statement of Authority and Responsibility* shall clearly identify that the Quality System has the full support of management and endorsed by signature of a senior management official. The *Statement* shall also include:

- 1) A statement that all repairs or alterations carried out by the Certificate Holder shall meet the requirements of the NBIC and the Jurisdiction, as applicable;
- 2) The title of individual who has the authority and responsibility charged with the development and implementation of the Quality System and the freedom to identify quality problems, and to initiate, recommend and provide solutions and where required, stop or prohibit work from continuing; and
- 3) A statement that conflicts or disagrees with in the implementation of the Quality System shall be brought to the attention of the Certificate Holder's senior management official for a resolution that will not conflict with code, jurisdiction/regulatory authority, or Quality System requirements.

d) Quality System Control

The Quality System shall define how revisions of individual sections, exhibits or documents will be identified, and how distribution and retrieval will be achieved to ensure only the latest accepted revisions are available for use. In addition, the following shall be documented:

- 1) The title of the individual responsible for the preparation and approval of the Quality System including review of code editions, standards, and jurisdictional requirements.
- 2) Acceptance from the Authorized Inspection Agency prior to issuance and implementation of the Quality System.

e) Certification

When electronic certification of documents is used, the Quality System shall include provisions describing the controls and safeguards that are employed to ensure the integrity of the certification.

f) Organization

The Quality System shall include an organizational chart which reflects actual levels of authority and lines of communication associated with functional job titles identified. In addition, roles and responsibilities associated with functional job titles identified within the Quality System, that can affect the quality of the repair or alteration, shall be clearly defined and documented.

g) Drawings, Design, and Specifications

The Quality System shall contain controls to ensure that all applicable design information, drawings, calculations, specifications, and instructions are prepared or obtained, controlled, and interpreted in accordance with the scope of work and the original code of construction, including:

- 1) Initiation of unique identifying numbers.
- 2) Description of the scope of work.
- 3) Performance and approval of design including title of approver.
- 4) Drawings and other pertinent information (i.e., Code Edition, pressure, temperature, minimum design metal temperature, nondestructive examination (NDE), heat treatment, weld details, etc.).
- 5) Review of design calculations, drawings, material specifications and process control sheets with Inspector to obtain acceptance.
- 6) Revision and distribution control of design documents.

h) Repair and Alteration Methods

The Quality System shall describe the methods for performing and documenting repairs and alterations in sufficient detail to permit the Inspector to determine at what stages specific inspections are to be performed. The method of repair or alteration must have prior acceptance of the Inspector, and when required, the jurisdiction.

i) Materials

The Quality System shall describe the method used to ensure that only acceptable materials (including welding material) are used for repairs and alterations. The Quality System shall include a description of how existing material is identified and new material is ordered, verified, and identified. The Quality System shall identify the title of the individual(s) responsible for each function and a brief description of how the function is to be performed.

j) Welding

The Quality System shall identify the title(s) of the individual(s) responsible for the welding procedure specification (WPS), its qualification, and the qualification of welders and welding operators. Only qualified WPS's and welders or welding operators shall be used in the repair or alteration of pressure-retaining items. Continuity for welders and welding operators will be maintained as required by the NBIC. The Quality System shall also describe controls for ensuring that the required WPS or Standard Welding Procedure Specification (SWPS) is available to the welder or welding operator prior to welding and establish the basis for welder to weld traceability.

NOTE: For qualification of welders and welding procedures to the 2019 ASME Code or later, the Quality System shall identify the title and qualifications of personnel performing supervisory activities as defined in ASME Section IX as applicable.

k) Nondestructive Examination (NDE)

The title(s) of the individual(s) responsible to determine the type and extent of NDE required for the repair and/or alteration shall be identified. The Quality System shall identify the title(s) of the

individual(s) responsible for the review and acceptance of subcontracted NDE procedures and personnel. When NDE is performed in-house, the title(s) of the individual(s) responsible for the written practice and the standard used for the basis of training, qualification, and records shall be documented.

l) Heat treatment

The Quality System shall identify the title(s) of the individual(s) responsible to ensure that a proper heat treatment has been applied to the repair and/or alteration. The Quality System shall identify the title(s) of the individual(s) responsible for the review and acceptance of subcontracted heat treatment procedures and personnel. The use of alternative welding methods per NBIC, Part 3, shall be described in the Quality System.

m) Examinations and Tests

The Quality System shall describe the process used to ensure that all required examinations and tests have been successfully performed and accepted by the Inspector.

n) Calibration

The Quality System shall describe a system for the calibration of examination, measuring, and test equipment used in the performance of repairs and alterations. At a minimum, it shall include:

- 1) Examination, measuring, and test equipment, subject to calibration, shall have a unique identification number and a calibration date as well as a specified next calibration due date;
- 2) The methodology of how the various equipment will be calibrated; and
- 3) The title of the person(s) responsible for the calibration system.

o) Authorization and Acceptance of Repair and/or Alteration

The Quality System shall specifically state that before the work is started, authorization of the repair/alteration plan and acceptance of the method(s) used shall be obtained from the Inspector.

p) Inspections and Document Review

The Quality System shall make provisions for the Inspector to have access to the physical work and all documents as necessary to ensure compliance with the NBIC. A copy of the current Quality System shall be available to the Inspector.

q) Control of the "R" Symbol Stamp

The Quality System shall provide adequate control of the "R" Symbol Stamp. In addition, the Quality System shall make provisions for Inspector acceptance for the application of the "R" Symbol Stamp to the pressure retaining item or nameplate.

The accepted abbreviation of the "R" Certificate Holder's name shall be included in the manual.

r) Report of Repair or Alteration Form

The Quality System shall indicate the title of the individuals responsible for preparing, certifying, and presenting the NBIC Report Forms to the Inspector. The Inspector shall confirm NBIC compliance by certifying and dating the applicable NBIC Form "R" Report upon completion of the work. The distribution of the NBIC Form "R" Report shall be described in the Quality System.

s) Exhibits

Forms referenced in the Quality System shall be included and may be a part of the referencing document or included as an exhibit or appendix. For clarity, the forms may be completed and identified as examples. Different forms may be utilized without the need for acceptance by the Inspector as long as they contain the same information as the exhibited forms.

t) Nonconformances

A system shall be established to identify and control a product or service which does not conform to the applicable rules of the NBIC, code of construction, jurisdictional requirements, or the Quality System to prevent their use. The title(s) of the individual(s) who has responsibility and authority for the disposition and resolution of a nonconformance shall be defined including provisions for Inspector involvement. Handling of programmatic concerns which do not affect product or service may be addressed in the Quality System.

u) Records Retention

A system for maintaining and retrieving records supporting or substantiating the Quality System within the scope of the "R" *Certificate of Authorization*.

- 1) Records may represent any information used to provide documented evidence of the quality of items and quality control activities of the work completed to a pressure-retaining item (PRI), and documented on a Form "R" report as applicable.
- 2) Records may include, but are not limited to those depicting or calculating an acceptable design, material compliance or certifications, NDE-reports, PWHT-charts, a WPS used, a welder, bonder, or cementing technician's process continuity records, drawings, sketches, photographs, etc.
- 3) The record retention schedule described in the Quality System shall follow the instructions identified in NBIC Part 3, Table 1.5.1.

TABLE 1.5.1

Form “R” Reports, Records, or Documents	Instructions	Minimum Retention Period
a) Form “R” Reports and supporting records and documentation	The organization performing repairs and alterations shall retain a copy of the completed “R” Form report on file, and all records substantiating the summary of work described in NBIC Part 3, Table S9.2 and S9.3 of Supplement 9, Item 19, for a minimum of 5 years. When the method of repair described in NBIC Part 3, 3.3.4.8 is used, the record retention period shall be described in b).	5 years
b) Form “R” Report with REPORT OF FITNESS FOR SERVICE ASSESSMENT FORM (NB-403) attached.	When the method of repair described in NBIC Part 3, 3.3.4.8 is used, the record retention period shall be for the duration described on the FITNESS FOR SERVICE ASSESSMENT (FFSA) Form required by the repair method and as described in NBIC Part 2, 4.4. Notes: 1. The “R” Certificate Holder should be aware that when used, some of the referenced codes and standards identified in NBIC Part 2, 1.3 describe requirements for permanent record retention throughout the service life of each equipment item. 2. When the “R” Certificate Holder is not the owner or user of the equipment, the record retention period is limited to the FFSA-results described on line 8 of the Report of Fitness for Service Assessment Form (NB-403).	5 years or as described on line 8 as reported on Form NB-403; whichever period is longer.
c) Continuity records for a welder, welding operator, bonder, or cementing technician.	Minimally, continuity records for a welder, bonder, or cementing technician within the Certificate Holder’s quality system shall be described and established at the time of the applicant’s initial certificate review and demonstrated at each triennial review required thereafter.	As applicable to the scope of work identified on the <i>Certificate of Authorization</i> , the continuity records are subject to review during each National Board triennial certificate review. Continuity records shall be maintained for a minimum of 5 years.

Form “R” Reports, Records, or Documents	Instructions	Minimum Retention Period
d) Administrative record review of the “R” Certificate Holder’s administrative processes.	Records supporting completed administrative reviews or audits of procedures or processes required by the “R” Certificate Holder’s Quality System Manual, or in combination with the applicable part of the NBIC Part 3, Supplement 6 as it applies to the identified scope listed on the “R” <i>Certificate of Authorization</i> .	Subject to review during the triennial evaluation of the certificate holder’s Quality System.

1.6 “NR” PROGRAM REQUIREMENTS

1.6.1 SCOPE

- a) This section provides requirements that must be met for an organization to obtain a National Board *Certificate of Authorization* to use the “NR” Symbol Stamp for repair/replacement activities to nuclear items constructed in accordance with the requirements of the ASME Code or other internationally recognized codes or standards for construction or inservice inspection of nuclear facilities.
- b) For administrative requirements to obtain or renew a National Board “NR” *Certificate of Authorization* and the “NR” Symbol Stamp, refer to National Board Procedure NB-417, *Accreditation of “NR” Repair Organizations*.

(23) 1.6.2 GENERAL

- a) An organization applying for an “NR” *Certificate of Authorization* shall have a written Quality Assurance Program (QAP) that details the specific requirements to be met based on the intended category of activities selected by that organization as described below and shown in Table 1.6.2. Controls used, including electronic capabilities, in the Quality Assurance Program shall be documented in a Quality Assurance Manual (QAM). Controls required to be included within the QAM shall include who, what, when, where, why and how with an understanding that the how can be a reference to an implementation procedure or instruction. Quality activities to be described in the Quality Assurance Program are identified in Section 1.6.5 of this part. Applicants shall address all requirements in their Quality Assurance Program based on the category of activity and scope of work to be performed (organization’s capabilities) to which certification is requested.

1) Category 1

Any ASME Section III Code certified item or system requiring repair/replacement activities irrespective of physical location and installation status prior to fuel loading.

2) Category 2

After fuel loading, any item or system under the scope of ASME Section XI Division I requiring repair/replacement activities irrespective of physical location. Based on regulatory or jurisdictional acceptance, Category 2 may be used prior to fuel loading.

3) Category 3

Items other than those covered by Category 1 or Category 2, requiring repair/replacement activities irrespective of physical location, installation status and fuel loading.

- b) Repair organizations performing repairs of pressure relief devices in nuclear service shall meet the additional requirements of NBIC Part 4, Section 4 and NBIC Part 4, Supplement 6.

TABLE 1.6.2**“NR” QUALITY ASSURANCE PROGRAM (QAP) REQUIREMENTS**

Category of Activity	Owner	Organizations other than Owner
Category 1	10 CFR Part 50 Appendix B ^{1,2} and ASME Section III NCA-4000 & NQA-1 Part 1	10 CFR Part 50 Appendix B ^{1,2} and ASME Section III NCA-4000 & NQA-1 Part 1
Category 2	10 CFR Part 50, Appendix B ^{1,2} or NQA-1 ³ , Part 1 and ASME Section XI Division I, IWA-4142	10 CFR Part 50, Appendix B ^{1,2} supplemented as needed with Owner’s QA program; or ASME NQA-1 ³ , Part 1; or ASME Section III, NCA-4000
Category 3	ASME NQA-1 ³ , Part 1, or Specify the Standard to which certification is desired	ASME NQA-1 ³ , Part 1, or Specify the Standard to which certification is desired
Note 1: Code of Federal Regulations (CFR) – rules and regulations published by the executive departments and agencies of the federal government of the United States.		
Note 2: 10 CFR 50 Appendix B – Title 10 of the Code of Federal Regulations Part 50 Appendix B describes the quality assurance criteria for nuclear plants and fuel reprocessing plants.		
Note 3: The Edition (and Addenda, as applicable) of NQA-1 to be utilized shall be the latest endorsed by the Regulatory Authority, or as specified in the Owner’s QA Program description reviewed and approved by the Regulatory Authority.		

1.6.2.1 DEFINITIONS

(23)

The NBIC terms and definitions shall be supplemented, as applicable, by the terms and definitions of ASME Section III, Section XI Division I, NQA-1, or other standards specified by the Regulatory Authority.

The following terms are as defined in the NBIC Glossary of Terms Section 9:

- a) Authorized Inspection Agency
- b) Authorized Nuclear Inspection Agency
- c) Jurisdiction
- d) “NR” Certificate Holder

TABLE 1.6.2.1
ACRONYMS

ASME	American Society of Mechanical Engineers
Applicant	An Organization applying for “NR” <i>Certificate of Authorization</i> (new or renewal)
CFR	Code of Federal Regulations
Code	ASME Code of Construction, Section III, Division I, (NCA, NB, NC, ND, NE, NF, NG, and NH) or ASME Section XI Division I Rules for Inservice Inspection of Nuclear Power Plant Components as applicable.
Jurisdiction	Enforcement Authority
NB	National Board of Boiler and Pressure Vessel Inspectors
NBIC	National Board Inspection Code
NB-263, RCI-1	Rules for Commissioned Inspectors
NCA	ASME Section III, Subsection NCA, General Requirements for Division 1 and Division 2
NQA-1*	ASME Quality Assurance Requirements for Nuclear Facility Applications
NR	Nuclear Repair
“NR” CH	“NR” Certificate Holder
QA	Quality Assurance
QAI-1	ASME Qualifications for Authorized Inspection
QAM	Quality Assurance Manual
QAP	Quality Assurance Program
QC	Quality Control
WA	ASME Section III, Division 3, Subsection WA, General Requirements

Note:

* Edition(s) endorsed by the Regulatory Authority

1.6.3 PREREQUISITES FOR ISSUING A NATIONAL BOARD “NR” CERTIFICATE OF AUTHORIZATION

Before an organization can obtain a National Board “NR” *Certificate of Authorization*, the organization shall:

- Have and maintain an inspection agreement with an Authorized Nuclear Inspection Agency accepted in accordance with NB-360, *National Board Acceptance of Authorized Inspection Agencies (AIA) Accredited by the American Society of Mechanical Engineers (ASME)*, with accreditation to perform repair and alteration acceptance inspections.
- Have a written Quality Assurance Program which includes the quality assurance manual and any supporting procedures, instructions and specifications required to comply with this section. The Quality Assurance Program shall address all controls for the intended category and scope of activities requested.
- Have a current edition of the NBIC.

- d) Have available ASME Section XI Division I, the code of construction and referenced code sections and standards appropriate for the scope of work to be performed. ASME Section XI Division I and codes of construction (Editions/Addenda) shall meet the requirements of the Regulatory Authority and the owner.

1.6.4 OBTAINING OR RENEWING A NATIONAL BOARD “NR” CERTIFICATE OF AUTHORIZATION

- a) Before an “NR” *Certificate of Authorization* will be issued or renewed, the applicant must have the Quality Assurance Program and the implementation of the program reviewed and found acceptable by representatives of the National Board, the Jurisdiction, and the Authorized Nuclear Inspection Agency. The Jurisdiction will be the National Board Member Jurisdiction in which the applicant is located or the location where the Quality Assurance Program is demonstrated/implemented. At the request of the Jurisdiction, or where there is no National Board Member Jurisdiction, the National Board representative shall act on behalf of the Jurisdiction. The implementation of the Quality Assurance Program shall be satisfactorily demonstrated by the organization. Demonstration of implementation shall meet the most stringent (classification) code requirements for the scope and category of work to be specified on the *Certificate of Authorization* or as requested by the applicant.
- b) If the applicant is an ASME “N” type *Certificate of Authorization* holder, has satisfactorily demonstrated within the last twelve (12) months the implementation of their Quality Assurance Program and can provide documentation that the organization is capable of implementing its Quality Assurance Program as being in compliance with this section, a further hardware verification implementation may not be necessary.
- c) The Regulatory Authority or Jurisdiction, upon request to the National Board, may attend the survey process for an “NR” *Certificate of Authorization* to be issued or renewed.
- d) The “NR” *Certificate of Authorization* holder shall be subject to an audit annually by the Authorized Nuclear Inspection Agency to ensure compliance with the Quality Assurance Program.

1.6.5 QUALITY ASSURANCE PROGRAM

- a) An applicant or a holder of a National Board “NR” *Certificate of Authorization* (“NR” Certificate Holder) shall have and maintain a written Quality Assurance Program. The Quality Assurance Program shall satisfactorily meet the requirements of this section, and Jurisdictional and Regulatory requirements as applicable. The Quality Assurance Program may be brief or voluminous, depending on the circumstances. It shall be treated confidentially by the National Board and available for review by the Survey Team.
- b) Each applicant or “NR” Certificate Holder is responsible for establishing and executing a Quality Assurance Program. The applicant or “NR” Certificate Holder may subcontract activities needed to implement the Quality Assurance Program, as limited by ASME Section III and XI Division I, but responsibility for adherence to the Quality Assurance Program remains with the Applicant or “NR” Certificate Holder.
- c) These rules set forth the requirements for planning, managing, and implementing the organization’s Quality Assurance Program to control and ensure quality is performed and maintained during repair/replacement activities of components, items, parts, and systems for nuclear facilities. These rules are to be the basis for evaluating such programs prior to the issuance or renewal of the National Board “NR” *Certificate of Authorization*. Rules identified in subsections 1.6.6, 1.6.7 and 1.6.8 of this section detail the Quality Assurance Program requirements for each category of activity. These rules are established to meet and follow the requirements specified in NBIC Part 3, Table 1.6.2 of this section.

1.6.6 QUALITY ASSURANCE PROGRAM REQUIREMENTS FOR CATEGORY 1 ACTIVITIES

1.6.6.1 SCOPE

Owners or organizations other than owners shall have a written Quality Assurance Program meeting the criteria specified in NBIC Part 3, Table 1.6.2 for Category 1 activities. The following quality elements shall be specified and described within the QAM.

(23) 1.6.6.2 QUALITY PROGRAM ELEMENTS

a) Organization

The provisions identified in ASME NQA-1, Part 1, Requirement 1, shall apply in its entirety. The authority and responsibility for individuals involved in activities affecting quality shall be clearly established and documented throughout the Quality Assurance Program and identified on a functional organizational chart contained within the QA Manual.

b) Statement of Policy and Authority shall:

- 1) identify the titles of individuals who have the authority and responsibility charged with ensuring the quality program is implemented as described;
- 2) confirm their freedom in the organization to identify quality problems and to initiate, recommend and provide solutions;
- 3) include a statement that if there is a disagreement in the implementation of the quality assurance program, the matter is to be referred for resolution to a higher authority and shall be resolved in a manner that will not conflict with code, jurisdiction/regulatory authority or quality program requirements;
- 4) include a statement of the full support of management; and
- 5) be dated and signed by a senior management official within the organization.

c) Quality Assurance Program (QAP)

The provisions identified in ASME NQA-1, Part 1, Requirement 2, shall apply, except paragraph 301. Additionally, the following criteria shall be used when developing and maintaining the QAP.

- 1) The Quality Assurance Program as used in this section shall include a written Quality Assurance Manual, with supporting procedures and instructions used to meet all the requirements of this Section.
- 2) Qualification of non-destructive examination personnel shall be as required by the code of construction or as specified in the owner's Quality Assurance Program.
- 3) The "NR" Certificate Holder shall be responsible for advising the Authorized Nuclear Inspection Agency of proposed changes to the Quality Assurance Manual to obtain acceptance of the Authorized Nuclear Inspector Supervisor before putting such changes into effect. The "NR" Certificate Holder shall make a current controlled copy of the Quality Assurance Manual available to the Authorized Nuclear Inspector and Authorized Nuclear Inspector Supervisor. The Certificate Holder shall be responsible for notifying the Authorized Nuclear Inspector of QAM changes, including evidence of acceptance by the Authorized Nuclear Inspector Supervisor.
- 4) The Quality Assurance Manual need not be in the same format or sequential arrangement as the requirements in these rules as long as all applicable requirements have been covered.

- 5) The “NR” Certificate Holder shall implement and maintain a program for qualification, indoctrination, training and maintaining proficiency of personnel involved with quality functions, including personnel of subcontracted services.
- 6) The “NR” Certificate Holder shall address in their QAM the requirements for interfacing with the owner specified in NBIC Part 3, 1.6.9.
- 7) Specified controls including responsibilities for personnel shall be described in the quality assurance program.

d) Design Control

The provisions identified in ASME NQA-1, Part 1, Requirement 3, shall apply except Paragraph 601. The following additional requirements shall be considered when applicable:

- 1) The “NR” Certificate Holder shall establish measures to ensure applicable requirements of the owner’s design specifications, owner’s requirements, and code of construction requirements are correctly translated into drawings, specifications, procedures and instructions.
- 2) All design documents, including revisions, shall be verified by the “NR” Certificate Holder to be correct and adequate in accordance with the owners requirements.
- 3) Repair/replacement plans shall be completed prior to performing any work, inspections, examinations or testing; however repair/replacement plans are not required for the design phase of a repair/replacement activity including activities that require design only (except rerating).
- 4) The repair/replacement plan (see NBIC Part 3, Table 1.6.9) shall identify any applicable Code Edition/Addenda and Code Cases, owner’s requirements and the Construction Code Edition/Addenda utilized to perform the work.
- 5) The repair/replacement plan shall identify expected life of the item when less than the intended life as specified in the owner’s design specification.
- 6) The “NR” Certificate Holder shall ensure that specifications, drawings, procedures and instructions do not conflict with the owner’s design specifications. A system must be described in the Quality Assurance Manual to resolve or eliminate such conflicts. Resolution shall consider the Design Specification Requirements, as well as, the owner requirements, Jurisdictional and Regulatory Authority Requirements as applicable.
- 7) Computer programs used for design analysis shall meet the requirements of NQA-1, Part II, Subpart 2.7 unless independently verified with the design analysis for each application.

e) Procurement Document Control

The provisions identified in ASME NQA-1, Part 1, Requirement 4, shall apply. Procurement documents shall require suppliers to provide a Quality Assurance Program consistent with the applicable requirements of ASME Section III and this section.

f) Instructions, Procedures, and Drawings

The provisions identified in ASME NQA-1, Part 1, Requirement 5, shall apply. All activities affecting quality shall be prescribed by documented instructions, procedures or drawings appropriate for the scope of work to be performed. Instructions, procedures or drawings shall describe acceptance criteria to ensure quality activities are accomplished.

g) Document Control

The provisions identified in ASME NQA-1, Part 1, Requirement 6, shall apply. The Quality Assurance Program shall detail measures to control the preparation, review, issuance, use, approval and

distribution of all documents related to quality as identified in the applicants Quality Assurance Program. Revisions shall meet the same requirements as the originals unless the applicant specifies other measures within their program. Measures shall ensure the latest approved documents represent the repair/replacement activities performed.

h) Control of Purchased Material, Items, and Services

The provisions identified in ASME NQA-1, Part 1, Requirement 7 shall apply, except:

- 1) Procurement of Authorized Inspection Agency services is not applicable as specified in paragraph 507.
- 2) The decision to perform bid evaluation as described in paragraph 300 is the responsibility of the "NR" Certificate Holder.
- 3) For Certificates of Conformance specified in paragraph 503 changes, waivers, or deviations including resolution of non-conformances must meet the requirements of ASME Section III and this Section.
- 4) The provisions identified in ASME NQA-1, Part 1, Requirement 7, paragraph 700 are not applicable to this section.
- 5) Documentary evidence for items shall conform to the requirements of ASME Section III, NCA and this Section. Materials shall meet the material certification requirements as specified in ASME Section III, NCA-3800 or NCA-4470 as applicable. Documented evidence for ASME stamped items is satisfied by a Manufacturer's Data Report. Utilization of unqualified source material shall meet the requirements of ASME Section III, NCA-4255.5.
- 6) The "NR" Certificate Holder may obtain items from an owner, provided the owner provides the required documentation and items are identified to meet Code and the Certificate Holders Quality Assurance Program. The "NR" Certificate Holder shall not be required to audit the owner as an approved supplier, provided the items used are exclusively for the owner and the owner procured and controlled the items under the owner's Quality Assurance Program.
- 7) The Quality Assurance Program shall establish controls to ensure all purchased materials, items, and services conform to the requirements of the owner's design specifications and the code of construction Edition/Addenda used to perform the work. Materials shall meet the requirements specified in ASME Section III, NCA-3800 or NCA-4470 as applicable.

i) Identification and Control of Items

The provisions identified in ASME NQA-1, Part 1, Requirement 8, shall apply and include the following additional requirements:

- 1) Controls shall assure only correct and acceptable items, parts and components are used or installed when performing repair/replacement activities.
- 2) Welding, brazing and fusing materials shall be identified and controlled.
- 3) Required Certified Material Test Reports and Certificates of Conformance shall be received, traceable to the items, reviewed to comply with the material specification and found acceptable.
- 4) The "NR" Certificate Holder shall utilize checklists to identify required characteristics using accepted procedures, compliance with records received, results of examinations and tests performed, range of values when required, and spaces for inclusion of document numbers and revision levels, signatures initials / stamps and dates of examinations or tests performed, verified, and/or witnessed by the "NR" Certificate Holder's qualified Representative and Authorized Nuclear Inspector.

j) Control of Processes

The provisions identified in ASME NQA-1, Part 1, Requirement 9, shall apply. Documents used to control processes shall include spaces for signatures, initials, stamps and dates that activities were performed by the Certificate Holder's representative and the Authorized Nuclear Inspector when the processes conforms to the specified acceptance criteria as listed on drawings, procedures, instructions, specifications or other appropriate documents including revisions.

k) Examinations, Tests, and Inspections

The provisions identified in ASME NQA-1, Part 1, Requirement 10, shall apply, except paragraph 700 for inspections during operations is not required.

- 1) A repair/replacement plan shall be described in the Quality Assurance Manual that addresses required information to perform the work needed for repair/replacement activities. Spaces shall be included for mandatory hold points where witnessing is required by the "NR" Certificate Holder's Qualified Representative, the Authorized Nuclear Inspector or the owner's representative, if required. Work shall not proceed beyond designated mandatory hold points without documented consent as appropriate.
- 2) The following guidance is provided for information to be included within the repair/replacement plan:
 - a. A detailed description of repair/replacement activities to be performed;
 - b. Describe any defects and examination methods used to detect the defects;
 - c. Defect removal method and requirements for identifying reference points;
 - d. Any procedures including revisions utilized; (e.g. welding, brazing, heat treat, examination, testing) and material requirements;
 - e. Required documentation and stamping;
 - f. Acceptance criteria used to verify acceptability; and
 - g. Applicable Code editions/addenda and code cases.
- 3) Repair/Replacement plans and evaluations shall be subject to review by the Jurisdictional and Regulatory Authority when required.

l) Test Control

The provisions identified in ASME NQA-1, Part 1, Requirement 11 shall apply. Testing shall be performed in accordance with written test procedures with acceptance criteria clearly defined. Pre-requisites for performing each test to include calibration, equipment, trained personnel, environmental conditions and provisions for data acquisition shall be described. Test results shall be documented and evaluated by qualified personnel.

m) Control of Measuring and Test Equipment

The "NR" Certificate Holder may utilize calibration and test activities performed by subcontractors when surveys and audits are performed. As an alternative to performing a survey and audit for procuring Laboratory Calibration and Test Services, the "NR" Certificate Holder as documented in their Quality Program may accept accreditation of an International Calibration and Test Laboratory Services by the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA) provided this alternative method is described in the "NR" Certificate Holder's Quality Program and the following requirements are met:

- 1) The “NR” Certificate Holder shall review and document verification that the supplier of calibration or test services was accredited by an accredited body recognized by the ILAC MRA encompassing ISO/IEC-17025:2005 or 2017, “General Requirements for the Competence of Testing and Calibration Laboratories”.
 - 2) For procurement of calibration services, the published scope of accreditation for the calibration laboratory covers the needed measurement parameters, ranges and uncertainties.
 - 3) For procurement of testing services, the published scope of accreditation for the test laboratory covers the needed testing services including test methodology and tolerances/uncertainty.
 - 4) The “NR” Certificate Holder’s purchase documents shall include:
 - a. Service provided shall be in accordance with their accredited ISO/IEC-17025:2005 or 2017 program and scope of accreditation;
 - b. As-found calibration data shall be reported in the certificate of calibration when items are found to be out-of-calibration;
 - c. Standards used to perform calibration shall be identified in the certificate of calibration;
 - d. Notification of any condition that adversely impacts the laboratories ability to maintain the scope of accreditation;
 - e. Any additional technical and/or quality requirements, as necessary, which may include tolerances, accuracies, ranges, and standards; and
 - f. Service suppliers shall not subcontract services to any other supplier.
 - 5) The “NR” Certificate Holder shall upon receipt inspection, validate that the laboratory documentation certifies that:
 - a. Services provided by the laboratory has been performed in accordance with their ISO/IEC-17025:2005 or 2017 program and performed within their scope; and
 - b. Purchase order requirements have been met.
- n) Handling, Storage, and Shipping
- The provisions of ASME NQA-1, Part 1, and Requirement 13 shall apply.
- o) Quality Assurance Records
- The provisions identified in ASME NQA-1, Part 1, Requirement 17, shall apply, except Paragraphs 400, 500, and 600 are not applicable. The following requirements shall be followed:
- 1) Records shall be identifiable and retrievable;
 - 2) Records shall be retained consistent with the owners requirements for duration, location and assigned responsibility;
 - 3) Forms NR-1 and NVR-1 as applicable shall be completed by the “NR” Certificate Holder upon completion of all repair/replacement activities. Completion of forms, registrations and stamping of the “NR” symbol stamp shall meet the requirements of NBIC Part 3, Section 5. A log shall be maintained in accordance with NBIC Part 3, 5.6;
 - 4) Lifetime and non-permanent records shall be as specified in ASME Section III, NCA-4134, Tables NCA-4134.17-1, and 4134.17-2;

- 5) Radiographs (digital images or film) may be reproduced provided that:
 - a. The process shall be subject to owner's approval;
 - b. The "NR" Certificate Holder is responsible for the process used and shall include a system for controlling and monitoring the accuracy so that the image will provide the same information as the original; and
 - c. Procedures shall contain requirements for exposure scanning, focusing, contrast, resolution and distinguishing film artifacts as applicable for reproduced images.
- 6) Records shall be classified, maintained and indexed and shall be accessible to the owner, owner's designee, and the Authorized Nuclear Inspector; and
- 7) When the "NR" Certificate Holder is the owner, designated records and reports received by the owner, shall be filed and maintained in a manner to allow access by the Authorized Nuclear Inspector. Suitable protection from deterioration and damage shall be provided by the owner. All records and reports shall be retained as specified in the owners QAP for the lifetime of the component or system.

p) Corrective Action

The provisions identified in ASME NQA-1, Part 1, Requirement 16 shall apply.

- 1) Measures shall be established to ensure that conditions adverse to quality such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and other non-conformances are promptly identified and corrected.
- 2) In the case of significant conditions adverse to quality, the measures shall also ensure that the cause of these conditions be determined and corrected to preclude repetition. The identification of significant conditions adverse to quality, the cause, condition, and the corrective action taken shall be documented and reported to the appropriate levels of management.
- 3) These requirements shall also extend to the performance of subcontractors' corrective action measures.

q) Inspection or Test Status (not to include operating status)

The provisions identified in ASME NQA-1, Part 1, Requirement 14 shall apply. Measures shall be established to indicate inspection and test status of parts, items, or components during the repair/replacement activity. The system used shall provide positive identification of the part, item, or component by means of stamps, labels, routing cards, or other acceptable methods. The system shall include any procedures or instructions necessary to achieve compliance. Procedures shall be provided for the identification of acceptable and unacceptable items and for the control of status indicators. The authority for application and removal of status indicators shall also be specified.

r) Nonconforming Materials or Items

The provisions identified in ASME NQA-1, Part 1, Requirement 15 shall apply. Measures shall be established to control materials or items that do not conform to requirements to prevent their inadvertent use, including measures to identify and control the proper installation of items and to preclude nonconformance with the requirements of these rules. These measures shall include procedures for identification, documentation, segregation when practical, and disposition. Nonconforming items shall be reviewed for acceptance, rejection, or repair in accordance with documented procedures. The responsibility and authority for the disposition of nonconforming items shall be defined. Repaired or replaced items shall be re-examined in accordance with the applicable procedures. Measures that control further processing of a nonconforming or defective item, pending a decision on its disposition, shall be established and maintained. Ultimate disposition of nonconforming items shall be documented.

s) Audits

The provisions identified in ASME NQA-1, Part 1, Requirement 18 shall apply and shall include the following:

A comprehensive system of planned and periodic audits of the “NR” Certificate Holder’s Quality Assurance Program shall be performed. Internal and Supplier Audit frequencies shall be specified in the organization’s Quality Assurance Manual. Internal Audits shall be conducted at least annually (within 12 months) for any ongoing code activity to verify compliance with Quality Assurance Program requirements and/or performance criteria, and to determine the effectiveness of the Quality Assurance Program. When no code work has been performed, the internal audit need only include those areas of responsibility required to be continually maintained, such as training, audits, organizational structure, and Quality Assurance Program revisions, etc. External audits (e.g., Supplier audits) of organizations with certification/accreditation permitted by ASME may not be required if acceptable to the Regulatory Authority. The Quality Assurance Manual shall as a minimum describe the following:

- 1) Audits shall be performed in accordance with written procedures or checklists by qualified audit personnel not having direct responsibility in areas being audited;
- 2) Audit personnel shall be qualified in accordance with the current requirements of ASME NQA-1;
- 3) Audit results shall be documented and reviewed by responsible management for adequacy and effectiveness of the quality assurance program;
- 4) Requirements for follow-up actions shall be specified for any deficiencies noted during the audit;
- 5) Audit records and applicable documentation shall be made available to the Authorized Nuclear Inspection Agency for review; and
- 6) Audit records shall include as a minimum;
 - a. Written procedures;
 - b. Checklists;
 - c. Reports;
 - d. Written replies; and
 - e. Completion of corrective actions.

Performance of Authorized Inspection Agency audits required by ASME QAI-1 and NB-263, RCI-1 shall be addressed in the Quality Assurance Manual.

t) Authorized Nuclear Inspector

Measures shall be taken to reference the commissioned rules for the National Board Authorized Nuclear Inspector, in accordance with NB-263, RCI-1 *Rules for Commissioned Inspectors*. The Authorized Nuclear Inspector shall hold the “N”, “I”, and “R” endorsements on his/her Commission. The “NR” Certificate Holder shall ensure that the latest documents, including the Quality Assurance Manual, procedures, and instructions, are made available to the Authorized Nuclear Inspector. The Authorized Nuclear Inspector shall be consulted prior to the issuance of a repair/replacement plan by the “NR” Certificate Holder in order that the Authorized Nuclear Inspector may select any in-process inspection or hold points when performing repair/replacement activities. The “NR” Certificate Holder shall keep the Authorized Nuclear Inspector informed of progress of the repair/replacement activity so that inspections may be performed. The Authorized Nuclear Inspector shall not sign Form NR-1 or Form NVR-1, as applicable, unless satisfied that all work carried out is in accordance with this section. The Authorized Nuclear Inspector and Authorized Nuclear Inspector Supervisor shall have access to areas where work is being performed, including subcontractors facilities, in order to perform their required duties. The ANI

shall be involved in dispositions and verification for non-conformances and corrective actions involving quality or code requirements. Additional requirements regarding Owner Interface are specified in 1.6.9.

u) Exhibits

Forms and exhibits referenced in the Quality Assurance Manual shall be explained in the text and included as part of the referencing document or as an appendix to the Quality Assurance Manual. Forms shall be controlled and identified to show the latest approved revision, name, and other corresponding references as stated in the Quality Assurance Manual.

1.6.7 QUALITY ASSURANCE PROGRAM REQUIREMENTS FOR CATEGORY 2 ACTIVITIES

1.6.7.1 SCOPE

Owners or organizations other than owners shall have a written Quality Assurance Program meeting one of the criteria specified in Table 1.6.2 of this section. Organizations applying for a Category 2 “NR” *Certificate of Authorization* shall specify in their written Quality Assurance Program which program criteria their Quality Assurance Program follows. Owners shall have a Quality Assurance Program meeting the requirements of either 10 CFR 50, Appendix B or NQA-1 Part 1 and shall include the additional requirements specified in ASME Section XI Division I, IWA-4142 when applicable. Organizations other than the owner shall comply with requirements specified in either 10 CFR 50, Appendix B supplemented as needed with the owner’s QAP; NQA-1 Part 1; or NCA-4000. Organizations may elect to choose to follow all the rules specified in one of the allowed QAP criteria specified in Table 1.6.2 or they may elect to combine or supplement requirements from other specified QAP’s. When organizations elect to combine QAP requirements, it shall be clearly specified and understood in the QAM which QAP requirement is being followed for each activity specified in their QAM. The following quality elements shall be specified and described within the QAM.

1.6.7.2 QUALITY PROGRAM ELEMENTS

(23)

a) Organization

The authority and responsibility for individuals involved in activities affecting quality shall be clearly established and documented throughout the Quality Assurance Program and identified on a functional organizational chart contained within the QA Manual.

b) Statement of Policy and Authority shall:

- 1) identify the titles of individuals who have the authority and responsibility charged with ensuring the quality program is implemented as described;
- 2) confirm their freedom in the organization to identify quality problems and to initiate, recommend and provide solutions;
- 3) include a statement that if there is a disagreement in the implementation of the quality assurance program, the matter is to be referred for resolution to a higher authority and shall be resolved in a manner that will not conflict with code, jurisdiction/regulatory authority or quality program requirements;
- 4) include a statement of the full support of management; and
- 5) be dated and signed by a senior management official within the organization.

c) Quality Assurance Program (QAP)

- 1) Qualification of non-destructive examination personnel shall be as required by the code or as specified in the owner’s Quality Assurance Program.

- 2) Prior to returning an item to service, the owner shall evaluate the suitability of the item subjected to the repair/replacement activity. Corrective actions shall be taken when an item is determined to be deficient or does not satisfy the requirements of this section.
 - 3) The "NR" Certificate Holder shall provide a copy of the Quality Assurance Manual to the owner for review and acceptance. The "NR" Certificate Holder shall make a current controlled copy of the Quality Assurance Manual available to the Authorized Nuclear Inspector and Authorized Nuclear Inspector Supervisor. When a repair/replacement activity is split between the owner and an "NR" Certificate Holder, each Quality Assurance Program shall comply with this section for their respective activities. The owner shall establish interfaces for assuring this section is met for the two Quality Assurance Programs.
 - 4) The "NR" Certificate Holder shall be responsible for advising the Authorized Nuclear Inspection Agency of proposed changes to the Quality Assurance Manual to obtain acceptance of the Authorized Nuclear Inspector Supervisor before putting such changes into effect. The Certificate Holder shall be responsible for notifying the Authorized Nuclear Inspector of QAM changes, including evidence of acceptance by the Authorized Nuclear Inspector Supervisor.
 - 5) The Quality Assurance Manual need not be in the same format or sequential arrangement as the requirements in these rules as long as all applicable requirements have been covered.
 - 6) The "NR" Certificate Holder shall implement and maintain a program for qualification, indoctrination, training and maintaining proficiency of personnel involved with quality functions, including personnel of subcontracted services.
 - 7) The "NR" Certificate Holder shall address in their QAM the requirements for interfacing with the owner specified in 1.6.9 of this section.
 - 8) Specified controls including responsibilities for personnel shall be described in the quality assurance program.
- d) Design Control
- 1) Repair/replacement activities, code edition and addenda used shall correspond with the owner's Inservice Inspection Program unless later code editions and addenda have been accepted by the owner, the Enforcement and/or the Regulatory authority having jurisdiction at the plant site.
 - 2) The repair/replacement plan (see NBIC Part 3, 1.6.7.2 j)) shall identify expected life of the item when less than the intended life as specified in the owner's requirements and the owner shall be advised of the condition.
 - 3) The "NR" Certificate Holder shall assure that specifications, drawings, procedures and instructions do not conflict with the owner's requirements. A system must be described in the Quality Assurance Manual to resolve or eliminate such conflicts. Resolution shall consider the design specification requirements, as well as, the owner Requirements, Jurisdictional and Regulatory requirements as applicable.
 - 4) ASME Section XI Division I establishes that the owner is responsible for design in connection with repair/replacement activities. The "NR" Certificate Holder must ensure that the design specification, drawings, or other specifications or instructions furnished by the owner satisfy the code edition and addenda of the owner's requirements. To satisfy this requirement, the "NR" Certificate Holder shall establish requirements that correctly incorporate the owner's requirements into their specifications, drawings, procedures, and instructions, which may be necessary to carry out the work. The "NR" Certificate Holder's system shall include provisions to ensure that the appropriate quality standards are specified and included in all quality records. These records shall be reviewed for compliance with the owner's requirements and the requirements of ASME Section XI Division I.

e) Procurement Document Control

Procurement documents shall require suppliers to provide a Quality Assurance Program consistent with the applicable requirements of ASME Section III, NCA and this section. Documents for procurement of materials, items, and subcontracted services shall include requirements to the extent necessary to ensure compliance with the owner's requirements and IWA-4000 of ASME Section XI Division I. To the extent necessary, procurement documents shall require suppliers to maintain a Quality Assurance Program consistent with the applicable requirements of the edition and addenda of the code of construction to which the items are constructed. Measures shall be established to ensure that all purchased material, items, and services conform to these requirements.

f) Instructions, Procedures, and Drawings

Repair/replacement plans and any verification of acceptability (evaluations) shall be subject to review by Jurisdiction and Regulatory Authorities having jurisdiction at the plant site. Activities affecting quality shall be prescribed by documented instructions, procedures or drawings of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings. Instructions, procedures, or drawings shall include appropriate quantitative and qualitative criteria for determining that activities affecting quality have been satisfactorily accomplished. The "NR" Certificate Holder shall maintain a written description of procedures, instructions, or drawings used by the organization for control of quality and examination requirements detailing the implementation of the Quality Assurance Program requirements. Copies of these procedures shall be readily available to the Authorized Nuclear Inspector and Authorized Nuclear Inservice Inspector, as applicable.

g) Document Control

The program shall include measures to control the issuance, use, and disposition of documents, such as specifications, instructions, procedures, and drawings, including changes thereto. These measures shall ensure that the latest applicable documents, including changes, are reviewed for adequacy and approved for release by authorized personnel and distributed for use at the location where the prescribed activity is performed.

h) Control of Purchased Material, Items, and Services

Purchase of materials and small products shall meet the requirements specified in ASME Section XI Division I, IWA 4142. Measures shall be established to ensure that purchased material, items, and services conform to the owner's requirements and applicable edition and addenda of the code of construction and ASME Section XI Division I. These measures shall include identification for material traceability. Provisions shall be identified for source evaluation and objective evidence shall be provided evidencing quality standards for material examination upon receipt.

i) Identification and Control of Items

- 1) Measures shall be established for identification and control of material and items, including partially fabricated assemblies. These measures shall ensure that identification is maintained and traceable, either on the material or component, or on records throughout the repair/replacement activity. These measures shall be designed to prevent the use of incorrect or defective items and those which have not received the required examinations, tests, or inspections.
- 2) Identification for traceability shall be applied using methods and materials that are legible and not detrimental to the component or system involved. Such identification shall be located in areas that will not interfere with the function or quality aspects of the item.
- 3) Certified Material Test Reports shall be identified as required by the applicable material specification in ASME Section II and shall satisfy any additional requirements specified in the original code of construction. The Certified Material Test Report or Certificate of Compliance need not be duplicated for submission with compliance documents when a record of compliance and satisfactory reviews

of the Certified Material Test Report and Certificate of Compliance is provided. Quality documents shall provide a record that the Certified Material Test Report and Certificate of Compliance have been received, reviewed, and found acceptable. When the "NR" Certificate Holder authorizes a subcontracted organization to perform examinations and tests in accordance with the original code of construction, the "NR" Certificate Holder shall certify compliance either on a Certified Material Test Report or Certificate of Compliance that the material satisfies the original code of construction requirements.

j) Control of Processes

- 1) The "NR" Certificate Holder shall operate under a controlled system such as process sheets, checklists, travelers, plans or equivalent procedures. Measures shall be established to ensure that processes such as welding, nondestructive examination, and heat treating are controlled in accordance with the rules of the applicable section of the ASME Code and are accomplished by qualified personnel using qualified procedures.
- 2) Process sheets, checklists, travelers, or equivalent documentation shall be prepared, including the document numbers and revisions to which the process conforms with space provided for reporting results of completion of specific operations at checkpoints of repair/replacement activities.

k) Examinations, Tests, and Inspections

- 1) A repair/replacement plan shall be prepared in accordance with the Quality Assurance Program whenever repair/replacement activities are performed. As a minimum, the repair/replacement plan shall include the requirements specified in ASME Section XI Division I, IWA-4150.
- 2) In-process and final examinations and tests shall be established to ensure conformance with specifications, drawings, instructions, and procedures which incorporate or reference the requirements and acceptance criteria contained in applicable design documents. Inspection, test and examination activities to verify the quality of work shall be performed by persons other than those who performed the activity being examined. Such persons shall not report directly to the immediate supervisors responsible for the work being examined.
- 3) Process sheets, travelers, or checklists shall be prepared, including the document numbers and revision to which the examination or test is to be performed, with space provided for recording results.
- 4) Mandatory hold/inspection points at which witnessing is required by the "NR" Certificate Holder's representative or the Authorized Nuclear Inspector/Authorized Nuclear Inservice Inspector shall be indicated in the controlling documents. Work shall not proceed beyond mandatory hold/inspection points without the consent of the "NR" Certificate Holder's representative or the Authorized Nuclear Inspector/Authorized Nuclear Inservice Inspector, as applicable.

l) Test Control

- 1) Testing shall be performed in accordance with the owner's written test procedures or procedures acceptable to the owner, that incorporate or reference the requirements and acceptance criteria contained in applicable design documents.
- 2) Test procedures shall include provisions for ensuring that prerequisites for the given test have been met, that adequate instrumentation is available and used, and that necessary monitoring is performed. Prerequisites may include calibrated instrumentation, appropriate equipment, trained personnel, condition of test equipment, the item to be tested, suitable environmental conditions, and provisions for data acquisition.
- 3) Test results shall be documented and evaluated to ensure that test requirements have been satisfied.

m) Control of Measuring and Test Equipment

The “NR” Certificate Holder may utilize calibration and test activities performed by subcontractors when surveys and audits are performed. As an alternative to performing a survey and audit for procuring Laboratory Calibration and Test Services, the “NR” Certificate Holder as documented in their Quality Program may accept accreditation of an International Calibration and Test Laboratory Services by the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA) provided this alternative method is described in the “NR” Certificate Holder’s Quality Program and the following requirements are met:

- 1) The “NR” Certificate Holder shall review and document verification that the supplier of calibration or test services was accredited by an accredited body recognized by the ILAC MRA encompassing ISO/IEC-17025:2005 or 2017, “General Requirements for the Competence of Testing and Calibration Laboratories”;
- 2) For procurement of calibration services, the published scope of accreditation for the calibration laboratory covers the needed measurement parameters, ranges and uncertainties;
- 3) For procurement of testing services, the published scope of accreditation for the test laboratory covers the needed testing services including test methodology and tolerances/uncertainty;
- 4) The “NR” Certificate Holder’s purchase documents shall include:
 - a. Service provided shall be in accordance with their accredited ISO/IEC-17025:2005 or 2017 program and scope of accreditation;
 - b. As-found calibration data shall be reported in the certificate of calibration when items are found to be out-of-calibration;
 - c. Standards used to perform calibration shall be identified in the certificate of calibration;
 - d. Notification of any condition that adversely impacts the laboratories ability to maintain the scope of accreditation;
 - e. Any additional technical and/or quality requirements, as necessary, which may include tolerances, accuracies, ranges, and standards; and
 - f. Service suppliers shall not subcontract services to any other supplier.
- 5) The “NR” Certificate Holder shall upon receipt inspection, validate that the laboratory documentation certifies that:
 - a. Services provided by the laboratory has been performed in accordance with their ISO/IEC-17025:2005 or 2017 program and performed within their scope; and
 - b. Purchase order requirements have been met.

n) Handling, Storage, and Shipping

Measures and controls shall be established to maintain quality requirements for handling, storage, and shipping of parts, materials, items, and components.

o) Quality Assurance Records

Documentation, reports and records shall be in accordance with ASME Section XI Division I, IWA-6000.

- 1) The owner is responsible for designating records to be maintained. Measures shall be established for the “NR” Certificate Holder to maintain these records [see NBIC Part 3, 1.6.7.2.o) 2)] required for Quality Assurance of repair/replacement activities. These shall include documents such as records

of materials, manufacturing, examination, and test data taken before and during repair/replacement activity. Procedures, specifications, and drawings used shall be fully identified by pertinent material or item identification numbers, revision numbers, and issue dates. The records shall also include related data such as personnel qualification, procedures, equipment, and related repairs. The "NR" Certificate Holder shall take such steps as may be required to provide suitable protection from deterioration and damage for records while in his care. Also, it is required that the "NR" Certificate Holder have a system for correction or amending records that satisfies the owner's requirements. These records may be either the original or a reproduced, legible copy and shall be transferred to the owner upon request.

- 2) Records to be maintained as required in NBIC Part 3, 1.6.7.2 o) 1) above shall include the following, as applicable:
 - a. An index that details the location and individual responsible for maintaining the records;
 - b. Manufacturer's Data Reports, properly executed, for each replacement component, part, appurtenance, piping system, and piping assembly, when required by the design specification or the owner;
 - c. The required as-constructed drawings certified as to correctness;
 - d. Copies of applicable Certified Material Test Reports and Certificates of Compliance;
 - e. As-built sketch(es) including tabulations of materials repair/replacement procedures, and instructions to achieve compliance with ASME Section XI Division I;
 - f. Nondestructive examination reports, including results of examinations, shall identify the name and certification level of personnel interpreting the examination results. Final radiographs shall be included where radiography has been performed. Radiographs may be microfilmed or digitally reproduced in accordance with the requirements listed in ASME Section V, Article 2, Mandatory Appendix VI. The accuracy of the reproduction process shall be verified and monitored for legibility, storage, retrievability and reproduction quality;
 - g. Records of heat treatments may be either the heat treatment charts or a summary description of heat treatment time and temperature data certified by the "NR" Certificate Holder. Heat treatments performed by the material manufacturer to satisfy requirements of the material specifications may be reported on the Certified Material Test Report; and
 - h. Nonconformance reports shall satisfy IWA-4000 of ASME Section XI Division I and shall be reconciled by the owner prior to certification of the Form NR-1 or NVR-1, as applicable.
- 3) After a repair/replacement activity, all records including audit reports required to verify compliance with the applicable engineering documents and the "NR" Certificate Holder's Quality Assurance Program, shall be maintained at a place mutually agreed upon by the owner and the "NR" Certificate Holder. The "NR" Certificate Holder shall maintain records and reports for a period of five years after completion of the repair/replacement activity.
- 4) When the "NR" Certificate Holder is the owner, designated records and reports received by the owner, shall be filed and maintained in a manner to allow access by the Authorized Nuclear Insertion Inspector. Suitable protection from deterioration and damage shall be provided by the owner. These records and reports shall be retained as specified in the owners QAP for the lifetime of the component or system.
- 5) The original of the completed Form NR-1 or Form NVR-1, as applicable, shall be registered with the National Board and, if required, a copy forwarded to the Jurisdiction where the nuclear power plant is located. A log shall be maintained in accordance with NBIC Part 3, 5.6.

p) Corrective Action

- 1) Measures shall be established to ensure that conditions adverse to quality such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and other nonconformances are promptly identified, controlled and corrected.
- 2) In the case of significant conditions adverse to quality, the measures shall also ensure that the cause of these conditions be determined and corrected to preclude repetition. The identification of significant conditions adverse to quality, the cause, condition, and the corrective action taken shall be documented and reported to the appropriate levels of management.
- 3) Corrective action requirements shall also extend to the performance of subcontractors' activities.

q) Inspection or Test Status (not to include operating status)

Measures shall be established to indicate examination and test status of parts, items, or components during the repair/replacement activity. The system used shall provide positive identification of the part, item, or component by means of stamps, labels, routing cards, or other acceptable methods. The system shall include any procedures or instructions necessary to achieve compliance. Also, measures shall be provided for the identification of acceptable and unacceptable items. They shall also include procedures for control of status indicators, including the authority for application and removal of status indicators.

r) Nonconforming Materials or Items

- 1) Measures shall be established to control materials or items that do not conform to specified requirements to prevent their inadvertent use, including measures to identify and control the proper installation of items and to preclude nonconformance with the requirements of these rules. These measures shall include procedures for identification, documentation, segregation, and disposition. Nonconforming items shall be reviewed for acceptance, rejection, or repair in accordance with documented procedures. The responsibility and authority for the disposition of nonconforming items shall be defined. Repaired/replaced or altered items shall be re-examined in accordance with the applicable procedures.
- 2) Measures that control further processing of a nonconforming or defective item, pending a decision on its disposition, shall be established and maintained. Ultimate disposition of nonconforming items shall be documented.

s) Audits

A comprehensive system of planned and periodic audits of the "NR" Certificate Holder's Quality Assurance Program shall be performed. Internal and External Audit frequencies shall be specified in the organization's Quality Assurance Manual. Internal Audits shall be conducted at least annually (within 12 months) to verify compliance with Quality Assurance Program requirements and/or performance criteria, and to determine the effectiveness of the Quality Assurance Program. When no code work has been performed, the internal audit need only include those areas of responsibility required to be continually maintained, such as training, audits, organizational structure, Quality Assurance Program revisions, etc. External audits (e.g., Supplier audits) shall be performed on a triennial basis and supplemented by annual evaluations of the Supplier's performance to determine if the regular schedule audit frequency shall be maintained or decreased or if other corrective action is required. A continuous or ongoing evaluation of the Supplier's performance may be conducted in lieu of the annual evaluations, provided that the results are reviewed in order to determine if corrective action is required. A grace period of 90 days may be applied to scheduled audits and annual evaluations of supplier performance. When the grace period is used, the next scheduled date for the activity shall be based on the activity schedule date and not on the date the activity was actually performed. If the activity is performed early, the next schedule date shall be based on the date the activity was actually performed.

The Quality Assurance Manual shall as a minimum describe the following:

- 1) Audits shall be performed in accordance with written procedures or checklists by qualified audit personnel not having direct responsibility in areas being audited;
- 2) Audit personnel shall be qualified in accordance with the current requirements of NQA-1;
- 3) Audit results shall be documented and reviewed by responsible management for adequacy and effectiveness of the quality assurance program;
- 4) Requirements for follow-up actions for any deficiencies noted during the audit;
- 5) Audit records and applicable documentation shall be made available to the Authorized Nuclear Inspection Agency for review; and
- 6) Audit records shall include as a minimum:
 - a. written procedures;
 - b. checklists;
 - c. reports;
 - d. written replies; and
 - e. completion of corrective actions.

Performance of Authorized Inspection Agency audits required by ASME QAI-1 and NB-263, RCI-1 shall be addressed in the Quality Assurance Manual.

t) Authorized Nuclear Inspector

Measures shall be taken to reference the commissioned rules for the National Board Authorized Nuclear Inspector, in accordance with NB-263, RCI-1 *Rules for Commissioned Inspectors*. The Authorized Nuclear Inspector shall hold the “N”, “I”, and “R” endorsements on his/her Commission. The “NR” Certificate Holder shall ensure that the latest documents including the Quality Assurance Manual, procedures, and instructions, are made available to the Authorized Nuclear Inspector. The Authorized Nuclear Inspector shall be consulted prior to the issuance of a repair/replacement plan by the “NR” Certificate Holder in order that the Authorized Nuclear Inspector may select any in process inspection or hold points when performing repair/replacement activities. The “NR” Certificate Holder shall keep the Authorized Nuclear Inspector informed of progress of the repair/replacement activity so that inspections may be performed. The Authorized Nuclear Inspector shall not sign Form NR-1 or Form NVR-1, as applicable, unless satisfied that all work carried out is in accordance with this section. The Authorized Nuclear Inspector and Authorized Nuclear Inspector Supervisor shall have access to areas where work is being performed, including subcontractors facilities, in order to perform their required duties. The ANI shall be involved in dispositions and verification for nonconformances and corrective actions involving quality or code requirements. Additional requirements regarding Owner Interface are specified in 1.6.9.

u) Exhibits

Forms and exhibits referenced in the Quality Assurance Manual shall be explained in the text and included as part of the referencing document or as an appendix to the Quality Assurance Manual. Forms shall be controlled and identified to show the latest approved revision, name, and other corresponding references as stated in the Quality Assurance Manual.

1.6.8 QUALITY ASSURANCE PROGRAM REQUIREMENTS FOR CATEGORY 3 ACTIVITIES

1.6.8.1 SCOPE

Organizations requesting a Category 3 “NR” *Certificate of Authorization* may elect to follow the requirements specified in ASME NQA-1 Part 1 or follow specific Quality Assurance Program requirements outlined in other specified standards as required by the owner, Regulatory Authority or Jurisdiction. Organizations shall specify in the QAM what QAP requirements are followed. When standards other than ASME NQA-1 are followed, the organization shall have available a copy of that standard for review by the NB Survey Team and the ANIA, as applicable. Each organization shall, as a minimum, include in their written QAM the specified elements listed in Category 1 and/or 2 (1.6.6, 1.6.7) QAP requirements. Additional requirements, as specified within NBIC Part 3, 1.6.8 and 1.6.9 shall be included within the QAP. Also, limitations or additions to ASME NQA-1, as specified for Category 1 or 2 may be incorporated and referenced within the QAM.

1.6.8.2 QUALITY PROGRAM ELEMENTS

(23)

a) Organization

The authority and responsibility for individuals involved in activities affecting quality shall be clearly established and documented throughout the Quality Assurance Program and identified on a functional organizational chart contained within the QA Manual.

b) Statement of Policy and Authority shall:

- 1) identify the titles of individuals who have the authority and responsibility charged with ensuring the quality program is implemented as described;
- 2) confirm their freedom in the organization to identify quality problems and to initiate, recommend and provide solutions;
- 3) include a statement that if there is a disagreement in the implementation of the quality assurance program, the matter is to be referred for resolution to a higher authority and shall be resolved in a manner that will not conflict with code, jurisdiction/regulatory authority or quality program requirements;
- 4) include a statement of the full support of management; and
- 5) be dated and signed by a senior management official within the organization.

c) QAP

The quality assurance program shall be documented by written policies, procedures and instructions. It shall account for special controls, processes, test equipment, tools and skills to obtain quality and for verification of quality by inspections and tests. Indoctrination, training and maintaining proficiency of personnel effecting quality shall be described. The status, adequacy and effectiveness of the QAP shall be regularly reviewed by management. The scope shall be included within the written QAM. The “NR” Certificate Holder shall make a current controlled copy of the Quality Assurance Manual available to the Authorized Nuclear Inspector and Authorized Nuclear Inspector Supervisor. The “NR” Certificate Holder shall address in their QAM the requirements for interfacing with the owner specified in 1.6.9 of this section. Specified controls including responsibilities for personnel shall be described in the quality assurance program.

d) Design Control

Established measures to assure applicable quality standards and regulatory requirements are accurately specified and translated into design documents. Any deviations shall be identified and controlled. Control measures (such as review, approval, release, distribution and revisions) for suitability of materials, parts, equipment, procedures, instructions and processes, shall be performed to ensure adherence to specified design basis requirements. Qualifications, responsibilities and certifications of design personnel shall be clearly defined within the quality assurance program.

e) Procurement Document Control

Documents for procurement of material, equipment and services shall ensure regulatory requirements, design bases and other quality requirements are included or referenced. Procurement documents shall require contractors or subcontractors provide a Quality Assurance Program consistent with the provisions specified herein. Controls necessary to ensure materials, equipment, and services meet specified design criteria shall be clearly described within the quality assurance program.

f) Instructions, Procedures, and Drawings

Activities affecting quality shall be accomplished in accordance with prescribed instructions, procedures or drawings and shall include appropriate quantitative or qualitative acceptance criteria to determine activities are satisfactorily accomplished.

g) Document Control

Shall define measures to control the preparation, issuance, use, review approval, revisions and distribution of all documents, including procedures, instructions and drawings related to quality. Responsibilities shall be described within the quality program.

h) Control of Purchased, Materials, Items and Services

Purchased material, items and services shall conform to the procurement documents. Measures shall be established for source evaluation and selection, objective evidence of quality, inspections at the source and examination of products upon delivery. Effectiveness of quality of suppliers shall be assessed by the applicant or designee at specified intervals. Documented evidence shall be performed and made available to assure materials and services conform to procurement documents, quality procedures and instructions.

i) Identification and Control of Items

Specified controls shall ensure only correct and acceptable items, parts and components are used and installed and traceable to required documents such as certified material test reports, certificates of conformance, or data reports. These controls shall include traceability on the items or on records traceable to the items during fabrication and final acceptance and test.

j) Control of Processes

Documents used to control processes shall be prepared, including the document numbers and revision to which the process conforms and shall include space for providing reporting of results of specific operations at checkpoints of repair/replacement activity, and provide spaces for signatures, initials, stamps and dates for activities performed by the Certificate Holders' representative and the Authorized Nuclear Inspector. Special processes including welding, nondestructive examinations, heat treating, and bending are performed using qualified and approved procedures and qualified personnel in accordance with applicable codes, standards and other specified criteria.

k) Examinations, Tests, and Inspections

A repair / replacement plan, developed in accordance with Table 1.6.9, shall address all required information for performing examinations, tests and inspections including but not limited to:

- 1) Establishing hold points;
- 2) Identifying procedures, methods, acceptance criteria;
- 3) Defects identified, removal methods, welding, brazing, fusing, and material requirements, reference points used for identification; and
- 4) Evaluations of results

Examinations, tests and inspections shall be performed using trained and qualified personnel. Personnel records for qualification and training shall be available for review.

l) Test Control

Tests shall be performed using written procedures identifying prerequisites, acceptance limits, calibration, equipment, personnel qualifications, environmental conditions, and required documentation. Personnel responsibilities shall be described for performance, acceptance/inspection and documenting results.

m) Control of Measuring and Test Equipment

The "NR" Certificate Holder may utilize calibration and test activities performed by subcontractors when surveys and audits are performed. As an alternative to performing a survey and audit for procuring Laboratory Calibration and Test Services, the "NR" Certificate Holder as documented in their Quality Program may accept accreditation of an International Calibration and Test Laboratory Services by the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA) provided this alternative method is described in the "NR" Certificate Holder's Quality Program and the following requirements are met:

- 1) The "NR" Certificate Holder shall review and document verification that the supplier of calibration or test services was accredited by an accredited body recognized by the ILAC MRA encompassing ISO/IEC-17025:2005 or 2017, "General Requirements for the Competence of Testing and Calibration Laboratories";
- 2) For procurement of calibration services, the published scope of accreditation for the calibration laboratory covers the needed measurement parameters, ranges and uncertainties;
- 3) For procurement of testing services, the published scope of accreditation for the test laboratory covers the needed testing services including test methodology and tolerances/uncertainty;
- 4) The "NR" Certificate Holder's purchase documents shall include:
 - a. Service provided shall be in accordance with their accredited ISO/IEC-17025:2005 or 2017 program and scope of accreditation;
 - b. As-found calibration data shall be reported in the certificate of calibration when items are found to be out-of-calibration;
 - c. Standards used to perform calibration shall be identified in the certificate of calibration;
 - d. Notification of any condition that adversely impacts the laboratories ability to maintain the scope of accreditation;
 - e. Any additional technical and/or quality requirements, as necessary, which may include tolerances, accuracies, ranges, and standards; and

f. Service suppliers shall not subcontract services to any other supplier.

5) The "NR" Certificate Holder shall upon receipt inspection, validate that the laboratory documentation certifies that:

a. Services provided by the laboratory has been performed in accordance with their ISO/IEC-17025:2005 or 2017 program and performed within their scope; and

b. Purchase order requirements have been met.

n) Handling, Storage, and Shipping

Processes or procedures shall be established to prevent damage, deterioration or misuse of material, items or components used and stored. Controls for handling, shipping, storage, cleanliness and preservation shall be specified in the quality program.

o) Records

1) All quality related records shall be classified, identified, verified, maintained, distributed retrievable, and accessible. When the "NR" Certificate Holder is the owner, designated records and reports received by the owner, shall be filed and maintained in a manner to allow access by the Authorized Nuclear Inservice Inspector (ANII). Suitable protection from deterioration and damage shall be provided by the owner. These records and reports shall be retained as specified in the owner's QAP for the lifetime of the component or system. Records to support evidence of activities affecting quality shall include as applicable:

a. Inspections and acceptance criteria/results;

b. Tests performed and supporting reports;

c. Procedures/instructions;

d. Qualification of personnel, procedures, and equipment;

e. Types of observations and results;

f. Audits;

g. Nonconformances; and

h. Corrective actions.

2) The original of the completed Form NR-1 or Form NVR-1, as applicable, shall be registered with the National Board and, if required, a copy forwarded to the Jurisdiction where the nuclear power plant is located. A log shall be maintained in accordance with NBIC Part 3, 5.6.

p) Corrective Action

1) Measures shall be established to ensure that conditions adverse to quality such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and other nonconformances are promptly identified and corrected.

2) In the case of significant conditions adverse to quality, the measures shall also ensure that the cause of these conditions be determined and corrected to preclude repetition. The identification of significant conditions adverse to quality, the cause, condition, and the corrective action taken shall be documented and reported to the appropriate levels of management.

3) Corrective action requirements shall also extend to the performance of subcontractors' activities.

q) Inspection or Test Status

Measures shall be established to indicate inspection and test status of parts, items or components during repair/replacement activity. Measures shall include identification, procedures, control indicators (acceptable, unacceptable) and responsibility of personnel.

r) Nonconforming Material or Items

Measures to control material or items, nonconforming to specified criteria shall be established. Measures shall include identifying, controlling, documenting, reviewing, verifying, dispositioning and segregation when practical.

s) Audits

A comprehensive system of planned and periodic audits of the “NR” Certificate Holder’s Quality Assurance Program shall be performed. Audit frequency shall be specified in the organization’s Quality Assurance Manual. Audits shall be conducted at least annually (within 12 months) to verify compliance with Quality Assurance Program requirements, performance criteria and to determine the effectiveness of the Quality Assurance Program. When no code work has been performed, the required annual audit need only include those areas of responsibility required to be continually maintained such as training, audits, organizational structure, Quality Assurance Program revisions, etc. The Quality Assurance Manual shall as a minimum describe the following:

- 1) Audits shall be performed in accordance with written procedures or checklists by qualified audit personnel not having direct responsibility in areas being audited;
- 2) Audit personnel shall be qualified in accordance with recognized standards, such as NQA-1;
- 3) Audit results shall be documented and reviewed by responsible management for adequacy and effectiveness of the quality assurance program;
- 4) Requirements for follow-up actions for any deficiencies noted during the audit;
- 5) Audit records and applicable documentation shall be made available to the Authorized Nuclear Inspection Agency for review;
- 6) Audit records shall include as a minimum:
 - a. written procedures;
 - b. checklists;
 - c. reports;
 - d. written replies; and
 - e. completion of corrective actions.

Performance of Authorized Inspection Agency audits required by ASME QAI-1 and NB-263, RCI-1 shall be addressed in the Quality Assurance Manual.

t) Authorized Nuclear Inspector

Measures shall be taken to reference the commissioned rules for the National Board Authorized Nuclear Inspector, in accordance with NB-263, RCI-1 *Rules for Commissioned Inspectors*. The Authorized Nuclear Inspector shall hold the “N”, “I”, and “R” endorsements on his/her Commission. The “NR” Certificate Holder shall ensure that the latest documents, including the Quality Assurance Manual, procedures, and instructions, are made available to the Authorized Nuclear Inspector. The Authorized Nuclear Inspector shall be consulted prior to the issuance of a repair/replacement plan by the “NR”

Certificate Holder in order that the Authorized Nuclear Inspector may select any in process inspection or hold points when performing repair/replacement activities. The “NR” Certificate Holder shall keep the Authorized Nuclear Inspector informed of progress of the repair/replacement activity so that inspections may be performed.

The Authorized Nuclear Inspector shall not sign Form NR-1 or Form NVR-1, as applicable, unless satisfied that all work carried out is in accordance with this section. The Authorized Nuclear Inspector and Authorized Nuclear Inspector Supervisor shall have access to areas where work is being performed, including subcontractors, facilities, in order to perform their required duties. The ANI shall be involved in dispositions and verification for non-conformances and corrective actions involving quality or code requirements. Additional requirements regarding Owner Interface are specified in 1.6.9.

u) Exhibits

Quality related forms and exhibits described in the Quality Assurance Program shall be identified, controlled and where applicable included as a reference document within the QAM or referenced procedures.

1.6.9 INTERFACE WITH THE OWNER’S REPAIR/REPLACEMENT PROGRAM (FOR CATEGORIES 1, 2, AND 3 AS APPLICABLE)

Interface with the owner’s repair/replacement program shall meet the following:

- a) The “NR” Certificate Holder’s repair/replacement plan (see Table 1.6.9) shall be subject to the acceptance of the owner and the owner’s Authorized Nuclear Inservice Inspector (ANII) and shall be subject to review by the Jurisdiction and Regulatory Authorities having jurisdiction at the plant site.
- b) Repair/Replacement activities of nuclear components shall meet the requirements of ASME Section III, ASME Section XI Division I, and/or other applicable standard, and the owner’s requirements, and shall be subject to verification by the Jurisdiction and Regulatory Authorities having jurisdiction at the plant site.
- c) Documentation of the repair/replacement activities of nuclear components shall be recorded on the Report of Repair/Replacement Activities of Nuclear Components and Systems for Nuclear Facilities, Form NR-1, or Report of Repair/Replacement Activities for Nuclear Pressure Relief Devices, Form NVR-1, in accordance with the NBIC Part 3, Section 5. The completed forms shall be signed by a representative of the “NR” Certificate Holder and the Authorized Nuclear Inspector when the repair/replacement activity meets the requirements of this section. For repair/replacement activities that involve design changes, Form NR-1, or Form NVR-1, as applicable, shall indicate the organization responsible for the design or design reconciliation in accordance with the owner’s requirements.
- d) The “NR” Certificate Holder shall provide a copy of the signed Form NR-1 or Form NVR-1, as applicable, to the owner, the Enforcement, and the Regulatory Authority if required, and the Authorized Nuclear Inspection Agency. The original Form NR-1 or Form NVR-1, as applicable, shall be registered with the National Board by the “NR” Certificate Holder. A NB registration log shall be maintained by the “NR” Certificate Holder. See NBIC Part 3, Section 5.5 and 5.6.
- e) The “NR” Certificate Holder shall provide a nameplate/stamping for repair/replacement activities for each nuclear component unless otherwise specified by the owner’s Quality Assurance Program. The required information and format shall be as shown in NBIC Part 3, Section 5.

TABLE 1.6.9
REPAIR/REPLACEMENT PLAN CRITERIA

	Essential Requirements	Instruction
A	Edition and/or addenda of codes	Including codes of construction, code cases, or standards used for the work performed, the NBIC Code edition, and the owner's requirements.
B	Identification of items	Description of items affected by the repair/replacement activity, including serial numbers, vendor identification, and code classes if applicable. Location of installation if applicable.
C	Performance of the Repair/Replacement activity	Description of any defects, and nondestructive examination methods used to detect the defects Defect removal method, measurement, and area identification/reference points. Applicable welding/brazing procedures, heat treatment, nondestructive examination, and tests. Final examination criteria to verify acceptability. Preservice examination criteria if applicable.
D	Materials	Original specifications, new material specifications, including heat numbers, code edition/class and reconciliation requirements if applicable.
E	Description of Repair/Replacement activity	Include expected life of the item after completion if different from the original intended life as specified by the design specification. Application of the "NR" code symbol stamp if required.
F	Documentation	Generated as required by the quality assurance program and/or the owner's requirements. Retention and submittal in accordance with the quality assurance program and/or the owner's requirements.
G	Evaluations/Acceptance	Evaluations/acceptance by the jurisdictional/regulatory authority as applicable.
H	Testing	Post repair/replacement testing criteria. Test acceptance criteria to verify acceptability. Types (pneumatic, hydrostatic, system leakage, or other).
I	Design	When applicable, design documents shall be certified by qualified/certified engineer.
J	Authorized Inspection Agency	Authorized Nuclear Inspector review/acceptance. Authorized Nuclear Inservice Inspector review/acceptance.
K	Responsibilities for review, verification, and acceptance	Design, quality, work performed, examination/test, and records. Owner acceptance of the repair/replacement plan.

PART 3, SECTION 2

REPAIRS AND ALTERATIONS — WELDING, BRAZING, FUSING AND HEAT TREATMENT

2.1 SCOPE

- a) This section provides requirements and guidelines for welding, brazing, fusing and heat treating when performing welded repairs and alterations to pressure-retaining items.
- b) Careful consideration shall be given to pressure-retaining items that have been fabricated of either creep strength enhanced ferritic steel materials or ferritic steel materials enhanced by heat treatment. The tensile and creep strength properties of these materials can be degraded by not following specific welding procedure specification and heat treatment requirements. The user is cautioned to seek technical guidance for welding and heat treating requirements for these materials in accordance with the original code of construction.
- c) Careful consideration shall be given to pressure-retaining items that have been previously brazed to preclude the possibility of degrading the prior work.

2.2 WELDING, BRAZING, AND FUSING

Welding, brazing and fusing shall be performed in accordance with the requirements of the original code of construction used for the pressure-retaining item whenever possible.

2.2.1 PROCEDURE SPECIFICATIONS

A procedure specification is a written document providing direction to the person applying the material joining process. Welding, brazing and fusing shall be performed in accordance with procedure specifications for welding (WPS), brazing (BPS), and fusing (FPS) qualified in accordance with the original code of construction or the construction standard or code selected. When this is not possible or practicable, the procedure specification may be qualified in accordance with ASME Section IX.

Welding procedures may be simultaneously qualified by more than one organization under the rules of ASME Section IX QG-106.4. The "R" Certificate Holder's written quality control program shall include requirements for addressing the rules of Section IX QG-106.4.

(23) 2.2.1.1 PROCEDURE SPECIFICATIONS WITH IMPACT TESTING

Welding procedures shall be qualified with impact testing when required by the original code of construction. The requirements for impact testing shall be in accordance with the rules of the original code of construction except that vessel (production) impact testing is not required.

The test coupon material does not need to be in the same heat-treated condition as the existing material.

2.2.2 STANDARD WELDING PROCEDURE SPECIFICATIONS

An "R" Certificate Holder may use one or more applicable Standard Welding Procedure Specifications (SWPS) shown in NBIC Part 3, Table 2.3 without supporting Procedure Qualification Records (PQRs) since SWPS are pre-qualified.

2.2.3 PERFORMANCE QUALIFICATION

The “R” Certificate Holder shall qualify the performance of personnel for each process they will use for repairs and alterations of pressure retaining items. Such qualification shall be in accordance with the requirements of the original code of construction, the construction standard, code selected or ASME Section IX. Use of a Standard Welding Procedure Specification shown in NBIC Part 3, 2.3 is permitted for performance qualification testing.

2.2.4 QUALIFICATION RECORDS

The “R” Certificate Holder shall maintain a record of the results obtained in procedure specification qualification (except for those qualifications for which the provisions of NBIC Part 3, 2.2.2 are used) and of the results obtained in performance qualifications. These records shall be certified by the “R” Certificate Holder and shall be available to the Inspector.

2.2.5 QUALIFIED PERSONNEL IDENTIFICATION

The “R” Certificate Holder shall establish a system for the assignment of a unique identification mark to each person qualified in accordance with the requirements of the NBIC. The “R” Certificate Holder shall also establish a written procedure whereby production joints are identified and traceable to the person who made them. This procedure shall use one or more of the following methods and be acceptable to the Inspector.

- a) The person’s identification mark may be stamped (low stress stamp, if used) adjacent to production joints made by the individual; or
- b) the “R” Certificate Holder may keep a documented record of production joints and the persons used in making the joints.

2.2.6 CONTINUITY OF QUALIFIED PERSONNEL

The performance qualification of a qualified person shall be affected when one of the following conditions occur:

- a) When the person has not used a specific process during a period of six months or more, their qualifications for that process shall expire; or
- b) When there is specific reason to question the person’s ability to make joints that meet the specification, the qualification which supports the process that is being performed shall be revoked. All other qualifications not questioned remain in effect.

2.2.6.1 PROCESS CONTINUITY RECORDS

- a) The “R” Certificate Holder shall maintain process continuity records and shall make the records available to the Inspector.
- b) The method of recording process continuity and the record retention period shall be described in the “R” Certificate Holder’s Quality System Manual.
- c) When there is specific reason to question a person’s ability to make joints that meet the specification, the qualification which supports the process that is being performed shall be revoked. All other qualifications not questioned remain in effect.

(23) 2.3 STANDARD WELDING PROCEDURE SPECIFICATIONS (SWPS)

- a) One or more SWPSs from NBIC Part 3, Table 2.3 may be used as an alternative to one or more WPS documents qualified by the organization making the repair or alteration, provided the organization accepts by certification (contained therein) full responsibility for the application of the SWPS in conformance with the application as stated in the SWPS. When using SWPSs, all variables listed on the Standard Welding Procedure are considered essential, and therefore, the repair organization cannot deviate, modify, amend, or revise any SWPS. US Customary Units or metric units may be used for all SWPSs in NBIC Part 3, Table 2.3, but one system shall be used for application of the entire SWPS in accordance with the metric conversions contained in the SWPS. The user may issue supplementary instructions as allowed by the SWPS. Standard Welding Procedures Specifications shall not be used in the same product joint together with the other Standard Welding Procedure Specifications or other welding procedure specifications qualified by the organization. SWPSs may be purchase at the AWS Bookstore at <https://pubs.aws.org>.
- b) The AWS reaffirms, amends or revises SWPSs in accordance with ANSI procedures.
- c) The use of previous versions of the listed SWPSs is permitted. Previous versions include Reaffirmed, Amended, or Revised SWPSs regardless of the publication date.

(23) TABLE 2.3
SWPS DESIGNATION: YEAR

B2.1-1-001: 2020	B2.1-1-201: 2019	B2.1-8-215: 2012	B2.1-1/8-229: 2013
B2.1-1-002: 2020	B2.1-1-202: 2019	B2.1-8-216: 2012	B2.1-1/8-230: 2013
B2.1-1-016: 2018	B2.1-1-203: 2019	B2.1-4-217: 2021	B2.1-1/8-231: 2015
B2.1-1-017: 2018	B2.1-1-204: 2019	B2.1-4-218: 2021	B2.1-1-232: 2020
B2.1-1-018: 2021	B2.1-1-205: 2019	B2.1-4-219: 2021	B2.1-1-233: 2020
B2.1-1-019: 2018	B2.1-1-206: 2019	B2.1-4-220: 2021	B2.1-1-234: 2020
B2.1-1-020: 2018	B2.1-1-207: 2019	B2.1-4-221: 2021	B2.1-1-235: 2020
B2.1-1-021: 2018	B2.1-1-208: 2019	B2.1-5A-222: 2022	
B2.1-1-022: 2018	B2.1-1-209: 2019	B2.1-5A-223: 2022	
B2.1-8-023: 2018	B2.1-1-210: 2012	B2.1-5A-224: 2022	
B2.1-8-024: 2012	B2.1-1-211: 2012	B2.1-5A-225: 2022	
B2.1-8-025: 2012	B2.1-8-212: 2012	B2.1-5A-226: 2022	
B2.1-1-026: 2018	B2.1-8-213: 2012	B2.1-1/8-227: 2013	
B2.1-1-027: 2018	B2.1-8-214: 2012	B2.1-1/8-228: 2013	

2.4 AWS REFERENCE STANDARDS

The following AWS Standards have been adopted by the NBIC for use as referenced below:

- a) AWS B2.1 - Specification for Welding Procedure and Performance Qualification
- b) AWS B2.1 BMG - Base Metal Grouping for Welding Procedure and Performance Qualification

2.5 HEAT TREATMENT

2.5.1 PREHEATING

- a) Preheating may be employed during use of a process to assist in completion of the joint. The need for and the temperature of preheat are dependent on a number of factors such as chemical analysis, degree of restraint of the items being joined, material thickness, and mechanical properties. The procedure specification for the material being joined shall specify the preheat temperature requirements.
- b) See minimum temperatures for preheating given in NBIC Part 3, Table 2.5.1 as a general guide. It is cautioned that the preheating temperatures listed may not be the same as those of the original code of construction and do not necessarily ensure satisfactory completion of the joint. Requirements for individual materials within the P-Number listing may have preheating requirements more or less restrictive than this general guide. When reference is made in this section to materials by the ASME designation, P-Number and Group Number, the suggestions of this section apply to the applicable materials of the original code of construction, either ASME or other, which conform by chemical composition and mechanical properties to ASME materials having the ASME P-Number and Group Number designations.

TABLE 2.5.1
MINIMUM TEMPERATURES FOR PREHEATING

Thicknesses referenced are nominal at the weld for the parts to be joined.	
a) P-No. 1 Group Nos. 1, 2, and 3	1) 175°F (79°C) for material that has both a specified maximum carbon content in excess of 0.30% and a thickness at the joint in excess of 1 in. (25 mm). 2) 50°F (10°C) for all other materials in this P-Number.
b) P-No. 3 Group Nos. 1, 2, and 3	1) 175°F (79°C) for material that has either a specified minimum tensile strength in excess of 70,000 psi (480 MPa) or a thickness at the joint in excess of 5/8 in. (16 mm). 2) 50°F (10°C) for all other materials in this P-Number.
c) P-No. 4 Group Nos. 1 and 2	1) 250°F (120°C) for material that has either a specified minimum tensile strength in excess of 60,000 psi (410 MPa) or a thickness at the joint in excess of 1/2 in. (13 mm). 2) 50°F (10°C) for all other materials in this P-Number.
d) P-No. 5A Group 1 and 5B, Group 1 and P-No. 15E Group 1	1) 400°F (205°C) for material that has either a specified minimum tensile strength in excess of 60,000 psi (410 MPa) or has both a specified minimum chromium content above 6.0% and thickness at the joint in excess of 1/2 in. (13 mm). 2) 300°F (150°C) for all other materials in this P-Number.
e) P-No. 6 Group Nos. 1, 2, and 3	400°F (205°C)
f) P-No. 7 Group Nos. 1 and 2	None
g) P-No. 8 Group Nos. 1 and 2	None
h) P-No. 9 Group	1) 250°F (120°C) for P-9A Gr. 1 materials 2) 300°F (150°C) for P-9B Gr. 1 materials

i) P-No. 10 Group	1) 175°F (79°C) for P-10A Gr. 1 materials 2) 250°F (120°C) for P-10B Gr. 2 materials 3) 175°F (79°C) for P-10C Gr. 3 materials 4) 250°F (120°C) for P-10F Gr. 6 materials 5) For P-10C Gr. 3 materials, preheat is neither required nor prohibited, and consideration shall be given to the limitation of interpass temperature for various thicknesses to avoid detrimental effects on the mechanical properties of heat treated material. 6) For P-10D Gr. 4 and P-10E Gr. 5 materials, 300°F (150°C) with interpass temperature maintained between 350°F and 450°F (175°C and 230°C).
j) P-No. 11 Group	1) P-11A Group Group 1 - None (Note 1) Group 2 - Same as for P-No. 5 (Note 1) Group 3 - Same as for P-No. 5 (Note 1) Group 4 - 250°F (120°C) 2) P-11B Group Group 1 - Same as for P-No. 3 (Note 1) Group 2 - Same as for P-No. 3 (Note 1) Group 3 - Same as for P-No. 3 (Note 1) Group 4 - Same as for P-No. 3 (Note 1) Group 5 - Same as for P-No. 3 (Note 1) Group 6 - Same as for P-No. 5 (Note 1) Group 7 - Same as for P-No. 5 (Note 1)

Note 1:

Consideration shall be given to the limitation of interpass temperature for various thicknesses to avoid detrimental effects on the mechanical properties of heat treated materials.

2.5.2 POSTWELD HEAT TREATMENT (PWHT)

- a) Postweld heat treatment shall be performed as required by the original code of construction, the construction standard or code selected in accordance with a written procedure. The procedure shall contain the parameters for postweld heat treatment.
- b) Postweld heat treatment shall be performed by heating either the entire item or a circumferential band around the item. When heating a circumferential band, the heat treatment procedure shall specify the soak band (SB) width, the heated band (HB) width, the gradient control band (GCB) width, the location of thermocouples and method of attachment of thermocouples in addition to the heating rate, holding time, temperature and cooling rate. Figures 2.5.2-a and 2.5.2-b show these bands. AWS D10.10, Recommended Practices for Local Heating of Welds in Piping and Tubing may be referred to for further information.
- c) When it is impractical or detrimental to Postweld Heat Treat (PWHT) the entire item or band around the item, the following local PWHT method may be performed on spherical or cylindrical pressure-retaining items using the time and temperature parameters in the original code of construction and in accordance with a written procedure acceptable to the Inspector and, when required, by the Jurisdiction:
 - 1) Heat a local area around the nozzle, welded attachment, or repair area such that the area is brought up uniformly to the required PWHT temperature. The application of local PWHT should be

performed with controlled heating methods, such as induction or electric resistance heaters, and employing thermocouples to monitor PWHT temperature. The Soak Band (SB) shall extend tangentially and radially from the edge of the nozzle wall, or attachment weld or repair area equally by a minimum distance as defined by the thickness of the shell, t or 2 in. (50 mm), whichever is less. See Figure 2.5.2-b.

Soak Band (SB) — this is the region on the spherical or cylindrical shell that will be heated uniformly to the required PWHT temperature. This band encompasses a circular region in the tangential and radial directions starting from the edge of a welded nozzle, or repair area or welded attachment that will be subjected to PWHT.

- 2) The length of the Heating Band (HB) shall consist of the SB distance plus $4\sqrt{R * t}$. In no case shall the distance of the HB that extends beyond the edge of the nozzle weld, attachment weld or repair area be less than $2.5\sqrt{R * t}$.

Heating Band (HB) — this is the region that encompasses the application of heat for PWHT and is defined in length by the equation, $SB + 4\sqrt{R * t}$ where R is the outer radius of the spherical or cylindrical shell in inches (mm), and t is equal to the nominal thickness of the spherical or cylindrical shell in inches (mm).

- 3) The Gradient Control Band (GCB) shall be kept as low as possible in all directions to avoid harmful temperature gradients adjacent to nozzles or geometric discontinuities.

Gradient Control Band — this is the region that encompasses the SB, HB and extends beyond the edge of the HB.

- 4) For PWHT of nozzle welds, repair welds, and external attachment welds on smooth spherical shells, heads, and cylindrical shells, the temperature differential within the GCB measured at the outside edge of the SB and the temperature measured at the outside edge of the HB shall not exceed one-half (1/2) of the peak soak PWHT temperature.
- 5) The term t , as used above to determine SB, HB and GCB shall be the nominal thickness of either a full penetration weld, or the groove weld depth of a partial penetration repair weld. If a fillet weld is used in combination with a groove weld, the nominal thickness for PWHT shall be the depth of the groove weld.

FIGURE 2.5.2-a
LOCAL POSTWELD HEAT TREATMENT TEMPERATURE CONTROL BANDS BUTT WELD IN CYLINDER

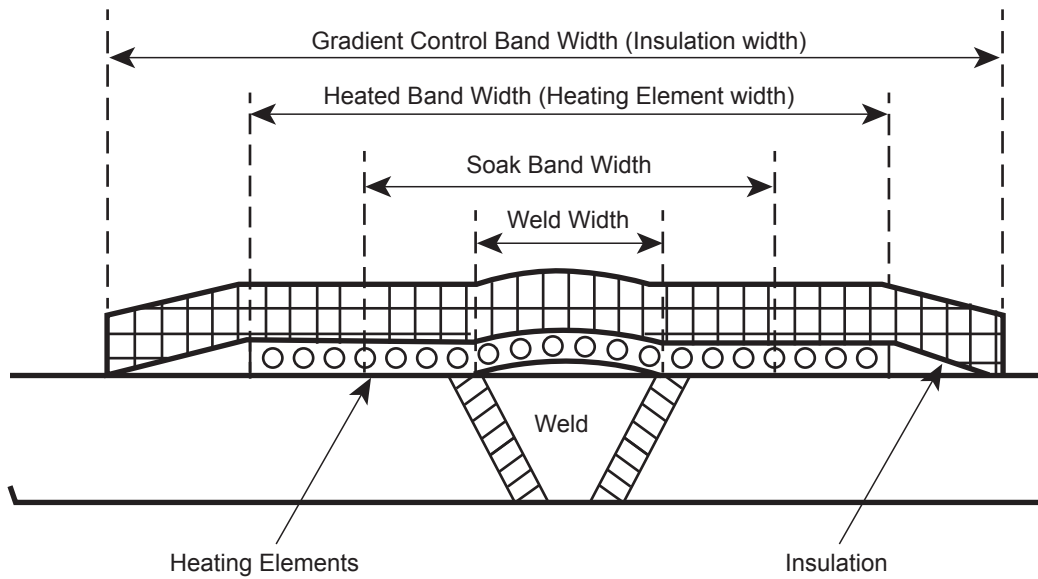
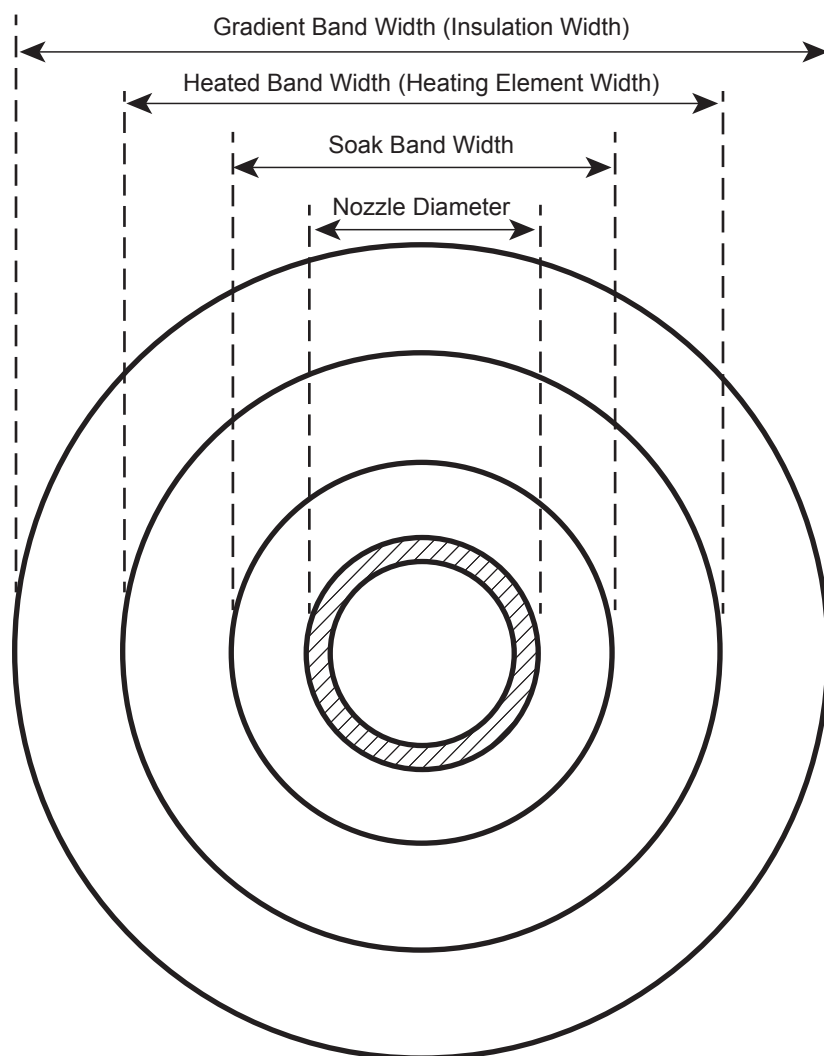


FIGURE 2.5.2-b

LOCAL POSTWELD HEAT TREATMENT TEMPERATURE CONTROL BANDS NOZZLE WELD OR ATTACHMENT TANGENTIAL DIRECTION HEATING BANDS



2.5.3 ALTERNATIVE WELDING METHODS WITHOUT POSTWELD HEAT TREATMENT

- a) Under certain conditions, postweld heat treatment, in accordance with the original code of construction, may be inadvisable or impractical. In such instances, the following alternative methods may be used.
- b) Competent technical advice shall be obtained from the manufacturer of the pressure-retaining item or from another qualified source, such advice being especially necessary if the alternative is to be used in highly stressed areas, if service conditions are conducive to stress corrosion cracking, if materials are subject to hydrogen embrittlement, or are operating at temperatures in the creep range, or if the alternative is being considered for “on-stream” repairs or “hot tapping” on piping systems. Selection of the welding method used shall be based on the rules of the original code of construction together with the above mentioned advice concerning the adequacy of the weld in the as-welded condition at operating and pressure test conditions.

- c) When reference is made in this section to materials by the ASME designation, P-Number and Group Number, the requirements of this section apply to the applicable materials of the original code of construction, either ASME or other, which conform by chemical composition and mechanical properties to the ASME P-Number and Group Number designations.
- d) The detailed welding methods listed in the following subsections may be used as an alternative to post-weld heat treatment (PWHT). NBIC Part 3, 2.5.3.1 is a method in which the welding procedure requires an elevation of the preheat temperature. In contrast, NBIC Part 3, 2.5.3.2 through 2.5.3.5, are methods in which the welding procedure requires the use of a temper-bead welding technique. Welding Method 6 as described in 2.5.3.6 requires use of a controlled fill technique. In 2.5.3.5 is a method in which the welding procedure used for joining dissimilar materials requires either an elevation of the preheat temperature or a temper-bead welding technique, depending on the chemical composition of the base metal that is joined to an austenitic steel. Temper-bead welding procedure nomenclature is defined in Section IX of the *ASME Boiler and Pressure Vessel Code*. Typically, this technique minimizes heat input of the initial beads, thus limiting heat beyond the weld heat-affected zone (HAZ) of the base metal. Heat input shall be increased for successive beads in accordance with the rules of QW-290 for temper bead welding in ASME Section IX. The Welding Procedure and Welder Performance Qualifications shall, in all cases, be in accordance with the requirements of the latest Edition of Section IX of the *ASME Boiler and Pressure Vessel Code*.

e) Nondestructive Examination of Welds

Prior to welding, the area prepared for welding shall be examined using either the Magnetic Particle (MT) or the Liquid Penetrant (PT) examination method to determine that no defects exist. After the finished weld has reached ambient temperature, and, when required by the specific welding method, the surface temper bead reinforcement layer has been removed substantially flush with the surface of the base metal, the weld shall be examined again by either of the above methods to determine that no defects exist using acceptance standards acceptable to the Inspector or original code of construction. In addition, welds greater than 3/8 in. (10 mm) deep or welds in a pressure retaining item that were originally required to be volumetrically examined by the rules of the original code of construction, shall be examined in accordance with paragraph NBIC Part 3, 4.2.

- f) Methods that may be used as alternatives to postweld heat treatment are described in the following subsections.

2.5.3.1 WELDING METHOD 1

When using this method, the following is required:

- a) This method may be used when the applicable rules of the original code of construction did not require notch toughness testing;
- b) The materials shall be limited to P-No. 1, Groups 1, 2, and 3 and to P-No. 3, Groups 1 and 2 (excluding Mn-Mo steels in Group 2), as permitted for welded construction by the applicable rules of the original code of construction;
- c) The welding shall be limited to the Shielded Metal-Arc welding (SMAW), Gas Metal-Arc Welding (GMAW), Flux Cored Arc Welding (FCAW), and Gas Tungsten-Arc Welding (GTAW) processes;
- d) The Welders and Welding Operators, Welding Procedures Specifications shall be qualified in accordance with the applicable rules of the original code of construction, except that no postweld heat treatment shall be applied to the test coupon;
- e) The weld area shall be preheated and maintained at a minimum temperature of 300°F (149°C) during welding. Alternatively, for P-No.1, Groups 1, 2 and 3 materials, the preheat may be reduced to 175°F (79°C) provided:

- 1) Provided the carbon equivalent of the base material to be welded is determined to be 0.40 or less.
- 2) The electrodes and filler metals are classified by the filler metal specification with a diffusible hydrogen designator of H4 or lower.
- 3) When shielding gas is used, it shall have a dew point that is -60°F (-50°C) or lower.
- f) The preheat temperature shall be checked to assure that 4 in. (102 mm) of the material or four times the material thickness (whichever is greater) on each side of the groove (or full thickness of joint for a groove weld) is maintained at the preheat temperature during welding. When the weld does not penetrate through the full thickness of the material, the preheat need only be maintained at a distance of 4 in. (102 mm) or four times the depth of the repair weld, whichever is greater, on each side of the joint.

2.5.3.2 WELDING METHOD 2

(23)

When using this method, the following is required:

- a) This method shall be used when the applicable rules of the original code of construction required notch toughness testing or shall be used when the applicable rules of the original code of construction did not require notch toughness testing provided the adequacy of the notch toughness of the weld, including the heat-affected zone, in the as-welded condition at operating and pressure test conditions is verified;
 - b) The materials shall be limited to carbon and low alloy steels permitted for welded construction by the applicable rules of the original code of construction, including those materials conforming to any of the following ASME P-No. designations: P-No. 1, Groups 1, 2, and 3; P-No. 3, Groups 1, 2, and 3; P-No. 4; P-No. 5A; P-No. 9A; P-No. 10A; P-No. 10B; P-No. 10C; P-No. 11A; or P-No. 11B;
 - c) The welding shall be limited to the Shielded Metal-Arc Welding (SMAW), Gas Metal-Arc Welding (GMAW), Flux Cored-Arc Welding (FCAW), and Gas Tungsten-Arc Welding (GTAW) processes;
 - d) The Welding Procedures Specifications shall be qualified in accordance with the temper bead procedure qualification requirements in QW-290 of ASME Section IX, and shall include the following additional requirements:
 - 1) For P-No. 1 Groups 1, 2, and 3 and P-No. 3 Groups 1, 2, and 3, the minimum preheat temperature shall be 350°F (177°C), and the maximum interpass shall be 450°F (232°C).
 - 2) For P-No. 9A, P-No. 10A, P-No. 10B, P-No. 10C, P-No. 11A, or P-No. 11B, the minimum preheat and interpass temperature requirements shall be in accordance with the guidelines in NBIC Part 3, 2.5.1.
 - 3) For P-No. 4 and P-No. 5A materials, the minimum preheat, interpass temperature, and technique shall be in accordance with NBIC Part 3, 2.5.3.4. The repair depth for temper bead repairs to pressure retaining items of P-No. 4 and P-No. 5A materials is limited to welds not penetrating through full thickness.
 - 4) Full thickness temper bead weld repairs are permitted to pressure retaining items of P-No 4 and P-No 5A materials under the following conditions:
 - a. ASME Section VIII, Division 2 pressure vessels, where application of PWHT on in-service vessels has been demonstrated to cause harm to vessel material.
 - b. For tube-to-header welds in steam service.
- Full thickness weld repairs above shall be completed per NBIC Part 3, 3.3.5 with the following requirements:
- a. The full thickness repair weld shall be verified as being the full penetration.

- b. Volumetric examination of the full thickness weld shall be performed.
- e) The test material for the welding procedure qualification shall be of the same material specification (including specification type, grade, class, and condition of heat treatment) as the material being repaired. In the event that the notch toughness of the material to be repaired is unknown, evidence from tests of that material or from another acceptable source (see NBIC Part 3, 2.5.3) may be used for the base metal notch toughness when qualifying the WPS as required in NBIC Part 3, 2.5.3.2 h). In the event that the original material specification is obsolete, the test material used should conform as closely as possible to the original material used for construction based on nominal composition and carbon equivalent ($IIW \text{ Formula } CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$; elements are expressed in Weight Percent Amounts), but in no case shall the material be lower in strength;
- f) The qualification thickness for the test plates and repair groove depths shall be in accordance with ASME Section IX; for pressure retaining items repaired using this temper bead method, hardness testing and carbon equivalency requirements may be waived for ASME Section IX temper bead procedure qualification provided the pressure retaining item operates in steam service above 900°F (482°C);
- g) The organization making the repair shall include, when qualifying its WPS, sufficient tests to determine that the notch toughness of the weld metal and the heat-affected zone of the base metal in the “as-welded” condition is adequate at the minimum operating and pressure test temperatures (including start-up and shutdown). If for reasons of corrosion resistance, special hardness limits are necessary, such limits shall be included when qualifying the WPS;
- h) Notch toughness shall be determined and evaluated by Charpy impact tests in accordance with the provisions of the original code of construction. Exemptions from impact testing described in the original code of construction are not applicable;
- i) For the welding process in NBIC Part 3, 2.5.3.2 c), use of austenitic or ferritic filler metals is permitted. For ferritic filler metals, use only electrodes and filler metals that are classified by the filler metal specification with a diffusible-hydrogen designator of H8 or lower for the FCAW and SMAW processes. When shielding gases are used with a process, the gas shall exhibit a dew point that is below -60°F (-50°C). Surfaces on which welding will be done shall be maintained in a dry condition during welding and be free of rust, mill scale, and hydrogen producing contaminants such as oil, grease, and other organic materials;
- j) After the weld has been deposited flush with the base metal, a surface temper reinforcing weld layer shall be applied;
- k) For welds made by SMAW and FCAW, after completion of welding and without allowing the weldment to cool below the minimum preheat temperature, the temperature of the weldment shall be raised to a temperature of 450°F (232°C) minimum for a minimum period of two hours. This hydrogen bake-out treatment may be omitted provided the electrode used is classified by the filler metal manufacturer with a diffusible-hydrogen designator of H4 (e.g., E7018-H4); and
- l) After the finished repair weld has cooled to ambient temperature, the surface temper reinforcing layer shall be removed substantially flush with the surface of the base material.

2.5.3.3 WELDING METHOD 3

When using this method, the following is required:

- a) This method may be used when the applicable rules of the original code of construction did not require notch toughness testing;
- b) The materials shall be limited to any P-No. 1 or P-No. 3 material as permitted for welded construction by the applicable rules of the original code of construction;

- c) The welding shall be limited to the SMAW, FCAW, and GTAW processes;
- d) The test material for the welding procedure qualification shall be of the same P-No. and Group No. as the base material specification of the repair. In the event that the original material specification is obsolete, the test material used should conform to the nominal composition and carbon equivalent (IIW Formula $CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$; elements are expressed in Weight Percent Amounts), as the material being repaired, but in no case shall the material be lower in strength;
- e) If for reasons of corrosion resistance, special hardness limits are necessary, such limits shall be included when qualifying the WPS. For pressure retaining items repaired using this temper bead method, hardness testing and carbon equivalency requirements may be waived for ASME Section IX temper bead procedure qualification provided the pressure retaining item operates in steam service above 900°F (482°C);
- f) The qualification thickness for the test plates and repair groove depths shall be in accordance with ASME Section IX; and
- g) The WPS shall be qualified in accordance with the temper bead procedure qualification requirements in QW-290 of ASME Section IX, and shall include the following additional requirements:
 - 1) The minimum preheat temperature for welding shall be 350°F (177°C) and the maximum interpass temperature shall be 450°F (232°C);
 - 2) For the welding processes in NBIC Part 3, 2.5.3.3 c), use of austenitic or ferritic filler metal is permitted. For ferritic filler metals, use only electrodes or filler metals that are classified by the filler metal specification with a diffusible-hydrogen designator of H8 or lower for the FCAW and SMAW processes;
 - 3) After completion of welding using SMAW and without allowing the weldment to cool below the minimum preheat temperature, the temperature of the weldment shall be raised to a temperature of 450°F (232°C) minimum for a minimum period of two hours. This hydrogen bake-out treatment may be omitted, provided the electrode used is classified by the filler metal manufacturer with a diffusible-hydrogen designator of H4 (e.g., E7018-H4); and
 - 4) After the finished repair weld has cooled to ambient temperature, the final temper bead reinforcement layer shall be removed substantially flush with the surface of the base material.

2.5.3.4 WELDING METHOD 4

When using this method, the following is required:

- a) This method is limited to repair welds in pressure retaining items for which the applicable rules of the original code of construction did not require notch toughness testing. The repair depth for temper bead repairs to pressure retaining items is limited to welds not penetrating through the full thickness.

Full thickness temper bead weld repairs are permitted under the following conditions:

- 1) ASME Section VIII, Division 2 pressure vessels, where application of PWHT on in-service vessels has been demonstrated to cause harm to vessel material.
- 2) For tube-to-header welds in steam service.

Full thickness weld repairs shall be completed per NBIC Part 3, 3.3.5 with the following requirements:

- 1) The full thickness repair shall be verified as being full penetration.
- 2) Volumetric examination of the full thickness weld shall be performed.

- b) The materials shall be limited to P-No. 4, Groups 1 and 2, and P-No. 5A steels as permitted for welded construction by the applicable rules of the original code of construction;
- c) The welding shall be limited to the SMAW, FCAW, GMAW or GTAW processes using low-hydrogen electrodes and filler metals classified by the filler metal specification with a diffusible-hydrogen designator of H8 or lower, and suitably controlled by maintenance procedures to avoid contamination by hydrogen producing sources. The surface of the metal prepared for welding shall be free of contaminants;
- d) The test material for the welding procedure qualification shall be of the same P-No. and Group No. as the base material specification of the repair. In the event that the original material specification is obsolete, the test material used should conform to the nominal composition and carbon equivalent (IIW Formula $CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$; elements are expressed in Weight Percent Amounts), as the material being repaired, but in no case shall the material be lower in strength;
- e) If for reasons of corrosion resistance, special hardness limits are necessary, such limits shall be included when qualifying the WPS;
- f) The qualification thickness for the test plates and repair groove depths shall be in accordance with ASME Section IX. For pressure-retaining items repaired using the temper bead method, hardness testing and carbon equivalency requirements may be waived for ASME Section IX temper bead procedure qualification provided the pressure-retaining item operates in steam service above 900°F (482°C);
- g) The welding procedures (WPS) shall be qualified in accordance with the temper bead procedure qualification requirements in QW-290 of ASME Section IX, and shall include the following additional requirements:
- 1) The minimum preheat temperature for welding shall be 300°F (150°C) for P-No. 4 material and 400°F (200 °C) for P-No. 5A material. The preheat temperature shall be checked to ensure that 4 in. (102 mm) of the material or four times the material thickness (whichever is greater) on each side of the groove (or full thickness of joint for a groove weld) is maintained at the minimum temperature during welding. The interpass temperature shall not exceed 800°F (430°C). When the weld does not penetrate through the full thickness of the material, the minimum preheat and maximum interpass temperature need only be maintained for 4 in. (102 mm) or four times the depth of the repair weld (whichever is greater) on each side of the joint;
 - 2) For the welding processes in NBIC Part 3, 2.5.3.4 c), use of austenitic or ferritic filler metal is permitted. For ferritic filler metals, use only electrodes or filler metals that are classified by the filler metal specification with a diffusible-hydrogen designator of H8 or lower for the FCAW and SMAW processes;
 - 3) After the weld has been deposited flush with the base metal, a surface temper reinforcing weld layer shall be applied;
 - 4) For welds made by the SMAW and FCAW processes, after completion of welding and without allowing the weldment to cool below the minimum preheat temperature, the temperature of the weldment shall be raised to 450°F (232°C) minimum for a minimum period of two hours. This hydrogen bake-out treatment may be omitted, provided the electrode used is classified by the filler metal manufacturer with a diffusible-hydrogen designator of H4 (e.g., E7018 H4); and
 - 5) After the finished repair weld has cooled to ambient temperature, the surface temper reinforcing weld layer shall be removed substantially flush with the surface of the base metal (and for a fillet weld to the required size and suitable contour of the toes).

2.5.3.5 WELDING METHOD 5

When using this method, the following is required:

- a) This welding method may be used when the applicable rules of the original code of construction or the construction standard or code selected permit joining dissimilar materials used in pressure-retaining items;
- b) The materials shall be limited to ASME P-No. 1, Groups 1, 2, and 3, P-No. 3, Groups 1, 2, and 3, P-No. 4, P-No. 5A, P-No. 9A, P-No. 10A, P-No. 10B, P-No. 10C, P-No. 11A, P-No. 11B joined to either P-No. 8, P-No. 42, P-No. 43, or P-No. 45, as permitted for welded construction by the applicable rules of the original code of construction;
- c) The welding shall be limited to the SMAW, FCAW, GMAW and machine or automatic GTAW processes. The filler metal used for joining the dissimilar materials shall be either A-No 8 or Nickel-Chrome alloy classification (F-No 43). When selecting a filler metal for dissimilar metal weld joints, determine if the weld joint will be exposed to elevated temperature service. A-No 8 filler metals exposed to service temperatures greater than 800°F (427°C) will exhibit reduced creep life along the fusion zone of the ferritic material due to carbon diffusion. Instead, a low hydrogen, Nickel-Chromium alloy classification filler metal shall be used for dissimilar weld joints exposed to service temperatures at or above 800°F (427°C);
- d) The WPS shall be qualified in accordance with the temper bead rules of QW-290 in ASME Section IX. For pressure retaining items fabricated to ASME Section I and repaired using this temper bead method, hardness testing and carbon equivalency requirements may be waived for ASME Section IX temper bead procedure qualification provided the pressure retaining item operates in steam service above 900°F (482°C);
- e) If the original code of construction did not require notch toughness testing, qualification of welding procedures (WPS) for joining ASME P-No. 1, P-No. 3 ferritic materials to either P-No. 8, P-No. 42, P-No. 43, or P-No. 45 materials shall be in accordance with requirements in either NBIC Part 3, 2.5.3.1, Welding Method 1 or in NBIC Part 3, 2.5.3.3, Welding Method 3;
- f) If the original code of construction did not require notch toughness testing, qualification of welding procedures (WPS) for joining ASME P-No. 4, P-No. 5A ferritic materials to either P-No. 8, P-No. 42, P-No. 43, P-No. 45 materials shall be in accordance with the requirements in NBIC Part 3, 2.5.3.4, Welding Method 4; and
- g) If the original code of construction required notch toughness testing, qualification of welding procedures (WPS) for joining ferritic materials to either P-No. 8, P-No. 42, P-No. 43, or P-No. 45 materials shall be in accordance with the requirements in NBIC Part 3, 2.5.3.2, Welding Method 2.

2.5.3.6 WELDING METHOD 6

(23)

This welding method provides requirements for welding only Grade 91 tube material within the steam boiler setting. When using this welding method, the following applies:

- a) This method is limited to butt welds, weld build-up repairs, or attachment weld to NPS 5 (DN 125) or less in diameter and ½ in. (13 mm) or less in wall thickness for which the applicable rules of the original code of construction did not require notch toughness testing;
- b) Application shall be limited to only boiler tube repairs at a location internal to the boiler setting;
- c) Upon the completion of weld repair, the repair area shall be kept above the dew point temperature so that condensation does not form on the repair surface before returned to service or a moisture-barrier coating shall be applied to the surface.

- 1) The material shall be limited to P-No 15E, Group 1, Grade 91, creep strength enhanced ferritic steel (CSEF).
- 2) The welding shall be limited to the SMAW and/or GTAW processes, manual or automatic, using suitably controlled maintenance procedures to avoid contamination by hydrogen producing sources. The surface of the metal shall be free of contaminants and kept dry.
- 3) The welding procedure qualification test coupon shall be P-No 15 E, Group 1, Grade 91.
- 4) Qualification thickness limits of base metal and weld deposit thickness shall be in accordance with ASME Section IX, QW-451.
- 5) The Welding Procedure Specification (WPS) shall be qualified in accordance with the requirements of ASME Section IX. No postweld heat treatment shall be applied to the test coupon. Additionally, the WPS shall include the following requirements:
 - a. The minimum preheat for the GTAW process shall be 200°F (100°C). The minimum preheat for the SMAW process shall be 300°F (150°C). The preheat temperature shall be checked to ensure the minimum preheat temperature is maintained during welding and until welding is completed. The maximum interpass temperature shall be 550°F (290°C);
 - b. When the SMAW process is specified for a fill pass layer, the electrode diameter is restricted to a maximum size of 1/8 in. (3.2 mm). When the GTAW-process is specified any limits in filler size is to be shown on the WPS;
 - c. Regardless of the welding process (SMAW or GTAW), only the use of stringer beads shall be permitted;
 - d. The filler metal shall be limited to an austenitic, nickel-base filler metal to those assigned to F-number 43 in Section IX, QW-432 and limited to the following consumables: ERNiCr-3 (e.g., Filler Metal 82), ENiCrFe-3 (e.g., INCONEL Welding Electrode 182), ENiCrFe-2 (e.g., INCO-WELD A), UNS N08087;
 - e. A martensitic, iron-base filler metal to those assigned to F-number 4 or F-number 6 in ASME Section IX, QW-432 and limited to the following consumables: E8015-B8, E8018-B8 or ER80S-B8; and
 - f. For weld build-up repairs due to wastage, the filler metal shall be limited to those assigned to F-number 43 in ASME Section IX, QW-432.

(23) 2.5.3.7 WELDING METHOD 7

When using this welding method, the following applies:

- a) This welding method may be used when the applicable rules of the original code of construction or the construction standard or code selected permit joining dissimilar materials.
- b) The materials shall be limited to ASME P-No. 15E, Group 1 joined to either P-No. 5A or P-No. 8, P-No. 42, P-No. 43 or P-No. 45, as permitted for welded construction by the applicable rules of the original code of construction.
- c) The welding shall be limited to the SMAW and/or GTAW processes, manual or automatic, using suitably controlled maintenance procedures to avoid contamination by hydrogen producing sources. The surface of the metal shall be free of contaminants and kept dry.
- d) This method is limited to butt welds in tubing NPS 5 (DN 125) or less in diameter and ½ in. (13 mm) or less in wall thickness and to non-pressure part welds for which the applicable rules of the original code of construction did not require notch toughness testing.

- e) Application shall be limited to a location internal to the boiler setting.
- f) Upon the completion of weld repair, the repair area shall be kept above the dew point temperature so that condensation does not form on the repair surface before returned to service or a moisture-barrier coating shall be applied to the surface.
- g) Qualification thickness limits of base metal and weld deposit thickness shall be in accordance with ASME Section IX, QW-451.
- h) The welding procedure qualification test coupon shall be ASME P-No. 15 E, Group 1, joined to either P-No. 5A, P-No. 8, P-No. 42, P-No. 43, or P-No. 45.
- i) The Welding Procedure Specification (WPS) shall be qualified in accordance with the requirements of ASME Section IX. No postweld heat treatment shall be applied to the test coupon. Additionally, the WPS shall include the following requirements:
 - 1) The minimum preheat for the GTAW process shall be 200°F (93°C). The minimum preheat for the SMAW process shall be 300°F (149°C). The maximum interpass temperature shall be 550°F (288°C). The preheat temperature shall be checked to ensure the minimum preheat temperature is maintained during welding and until welding is completed.
 - 2) When the SMAW process is specified for a fill pass layer, the electrode diameter is restricted to a maximum size of 1/8 in. (3.2 mm). When the GTAW-process is specified any limits in filler size is to be shown on the WPS.
 - 3) Regardless of the welding process, only the use of stringer beads shall be permitted.
 - 4) For the joining of ASME P-No. 15E, Group 1 to P-No. 5A, the filler metal shall be limited to a martensitic, iron-base filler metal to those assigned to F-No. 4 or F-No. 6 in ASME Section IX, QW-432 and limited to the following consumables: E8015-B8, E8018-B8 or ER80S-B8.
 - 5) For the joining of ASME P-No. 15E, Group 1 to P-No. 8, P-No. 42, P-No. 43 or P-No. 45, the filler metal shall be limited to an austenitic, nickel-base filler metal to those assigned to F-No. 43 in ASME Section IX, QW-432 and limited to the following consumables: ERNiCr-3, ENiCrFe-3, ENiCrFe-2, UNS N08087.

PART 3, SECTION 3

REPAIRS AND ALTERATIONS — REQUIREMENTS FOR REPAIRS AND ALTERATIONS

3.1 SCOPE

This section provides requirements and guidelines for materials, replacement parts, and methods used when performing repairs and alterations to pressure-retaining items. Specific repair or alteration methods for other types of pressure equipment are in NBIC Part 3, Section 6.

3.2 GENERAL REQUIREMENTS FOR REPAIRS AND ALTERATIONS

3.2.1 MATERIAL REQUIREMENTS FOR REPAIRS AND ALTERATIONS

- a) The materials used in making repairs or alterations shall conform insofar as possible to the original code of construction or construction standard or code selected, including the material specification requirements used for the work planned. Carbon or alloy steel having a carbon content of more than 0.35% shall not be welded unless permitted by the original code of construction. The “R” Certificate Holder is responsible for verifying identification of existing materials from original data, drawings, or pressure-retaining item records, and identification of the materials to be installed. Consideration shall be given to the condition of the existing material, especially in the weld preparation area. If the existing material cannot be verified (unknown), the “R” Certificate Holder shall perform a chemical analysis and hardness testing, as a minimum, of the unknown material to verify its weldability and strength or may elect to qualify a weld procedure. If there is a question with regard to the weldability characteristics of the material, then competent technical advice should be obtained.
- b) For corrugating rolls manufactured per the requirements of paragraph UF-7 of ASME Section VIII, Div. 1, weld overlay of the surfaces is permitted for all classes of SA-649 forging material and an exception to the 0.35% carbon limit is permitted. The requirements to qualify welding procedures and welder performance shall be in accordance with ASME Section IX for hard facing (wear resistance) and/or corrosion resistant overlays. Preheat or post weld heat treatment is neither required or prohibited.
- c) Use of replacement material or Parts that have previously been in service or considered as used material may be permitted if deemed acceptable by the “R” Certificate Holder, the Inspector, and if required, the Jurisdiction. This material shall conform insofar as possible to the original code of construction or construction standard, or code selected, and the NBIC. Consideration shall be given to the condition of replacement material that has previously been used, including its service history, prior to acceptance. Material/Parts that have been in time-dependent service shall not be permitted as replacement material/Parts without evaluation for exposure time.

3.2.2 REPLACEMENT PARTS

Replacement parts to be used in repairs or alterations shall meet the following applicable requirements:

- a) Replacement parts that will be subject to internal or external pressure that consist of new materials which should be formed to the required shape by casting, spinning, forging, die forming, and on which no fabrication welding is performed, shall be supplied as material. Such parts shall be marked with the material and part identification and the name or trademark of the parts manufacturer. In lieu of full identification marking on the material or part, the part manufacturer may use a coded marking system traceable to the original marking. Such markings shall be considered as the parts manufacturer's certification that the part complies with the original code of construction. Examples include seamless or welded tubes or pipe, forged nozzles, heads or tubesheets, or subassemblies attached together mechanically.

- b) Replacement parts that will be subject to internal or external pressure that are preassembled by attachment welds shall have the welding performed in accordance with the original code of construction. The supplier or manufacturer shall certify that the material and fabrication are in accordance with the original code of construction. This certification shall be supplied in the form of bills of material and drawings with statement of certification. Examples include boiler furnace wall or floor panel assemblies, prefabricated openings in boiler furnace walls, such as burner openings, air ports, inspection openings, or sootblower openings.
- c) When ASME Code is the original code of construction, replacement parts subject to internal or external pressure fabricated by welding, which require inspection by an Authorized Inspector shall be fabricated by an organization having an appropriate ASME *Certificate of Authorization*. The item shall be inspected and stamped as required by the applicable section of the ASME Code. A completed ASME *Manufacturer's Partial Data Report* shall be supplied by the manufacturer.
 - 1) ASME stamping and completion of an ASME Manufacturer's Partial Data Report is not required for parts fabricated by the "R" Certificate Holder that will be used on pressure retaining items being repaired or altered by the same "R" Certificate Holder. The controls for this activity shall be described in the quality control system.
 - 2) The "R" Certificate Holder, using replacement parts fabricated and certified to an ASME Code edition and addenda different from that used for the original construction, shall consider and seek technical advice, where appropriate, for change or conflicts in design, materials, welding, heat treatment, examinations and tests to ensure a safe repair/alteration is performed. Note that work once classified as a repair could now be considered an alteration.
- d) When the original code of construction is other than ASME Code, replacement parts subject to internal or external pressure, fabricated by welding, shall be manufactured by an organization certified as required by the original code of construction. The item shall be inspected and stamped as required by the original code of construction. Certification to the original code of construction, as required by the original code of construction or equivalent, shall be supplied with the item. When this is not possible or practicable, the organization fabricating the part shall have a National Board "R" *Certificate of Authorization*; replacement parts shall be documented on Form R-3 and the "R" Symbol Stamp applied as described in NBIC Part 3, Section 5.
- e) Replacement parts addressed by 3.2.2 c) or d) above shall receive a pressure test at the pressure determined for the completed pressure equipment (boiler, pressure vessel, etc.) in accordance with the original code of construction. If replacement parts have not been pressure tested to this pressure prior to installation they may be installed without performing the pressure test provided the owner, the Inspector and, when required, the Jurisdiction accept the use of one or a combination of the examination and test methods shown in Part 3, Section 4, paragraph 4.4.1 (for repairs) or 4.4.2 (for alterations). The R Certificate Holder responsible for completing the R Form shall note in the Remarks section of the R Form the examination(s) and test(s) performed, and the reason the replacement part was not tested at the pressure determined for the completed pressure equipment in accordance with the original code of construction.

3.2.3 DRAWINGS

As appropriate, drawings shall be prepared to describe the repair or alteration. Drawings shall include sufficient information to satisfactorily perform the repair or alteration.

3.2.4 DESIGN REQUIREMENTS FOR REPAIRS AND ALTERATIONS

- a) Many repairs may not require drawings or design calculations when the original code of construction is known and drawings and/or a Manufacturer's Data Report is available;

- b) The “R” Certificate Holder performing repairs and alterations shall establish the construction standard or code and sufficient controls to ensure that all required design information, applicable drawings, design calculations, specifications, and instructions are prepared, obtained, controlled, and interpreted to provide the basis for a repair or an alteration in accordance with the original code of construction. When a *Manufacturer’s Data Report* is required by the original construction standard, a copy of the original data report shall be obtained, where available, for use in the design of the repair or alteration. When the original *Manufacturer’s Data Report* cannot be obtained, agreements on the method of establishing design basis for the repair or alteration shall be obtained from the Inspector and the Jurisdiction, when required.

3.2.5 CALCULATIONS

For alterations, calculations shall be completed prior to the start of any physical work. All design calculations shall be completed by an organization experienced in the design portion of the standard used for construction of the item. All calculations shall be made available for review by the Inspector accepting the design.

3.2.6 REFERENCE TO OTHER CODES AND STANDARDS

Other codes, standards, and practices pertaining to the repair and alteration of pressure retaining items can provide useful guidance. Use of these codes, standards and practices is subject to review and acceptance by the Inspector, and when required, by the Jurisdiction. The user is cautioned that the referenced codes, standards and practices may address methods categorized as repairs; however, some of these methods are considered alterations by the NBIC.

In the event of a conflict with the requirements of the NBIC, the requirements of the NBIC take precedence. Some examples are as follows:

- a) National Board *BULLETIN* - National Board Classic Articles Series;
- b) ASME PCC-1, Guidelines for Pressure Boundary Bolted Flange Joint Assembly;
- c) ASME PCC-2, Repair of Pressure Equipment and Piping.

3.2.7 CHANGE OF SERVICE

- a) See NBIC Part 2, Supplement 9 for requirements and guidelines to be followed when a change of service or service type is made to a pressure retaining item.
- b) Whenever there is a change of service, the local jurisdiction where the pressure retaining item is to be operated, shall be notified for acceptance, when applicable. Any specific jurisdictional requirements shall be met.

3.3 REPAIRS TO PRESSURE-RETAINING ITEMS

3.3.1 DEFECT REPAIRS

Before a repair is made to a defect in a welded joint or base metal, care should be taken to investigate its cause and to determine its extent and likelihood of recurrence.

(23) 3.3.2 ROUTINE REPAIRS

- a) Routine repairs are repairs for which the requirements for in-process involvement by the Inspector and stamping by the “R” Certificate Holder may be waived as determined appropriate by the Jurisdiction and the Inspector. Routine repairs are not permitted for ASME Section VIII Div. 2 or Div. 3 vessels. All other

applicable requirements of this code shall be met. Prior to performing routine repairs, the “R” Certificate Holder should determine that routine repairs are acceptable to the Jurisdiction where the pressure-retaining item is installed;

- b) The Inspector, with the knowledge and understanding of jurisdictional requirements, shall be responsible for meeting jurisdictional requirements and the requirements of this code;
- c) The “R” Certificate Holder’s Quality System Program shall describe the process for identifying, controlling, and implementing routine repairs. Routine repairs shall be documented on Form R-1 with this statement in the Remarks section: “Routine Repair”;
- d) Alternative welding methods without postweld heat treatment as described in NBIC Part 3, 2.5.3 shall not be used for routine repairs.
- e) The following repairs may be considered as routine repairs and shall be limited to these categories:
 - 1) Welded repairs or replacements of valves, fittings, tubes, or pipes NPS 5 (DN 125) in diameter and smaller, or sections thereof, where neither postweld heat treatment nor NDE other than visual is required by the original code of construction. This includes their attachments such as clips, lugs, skirts, etc., but does not include nozzles to pressure-retaining items;
 - 2) The addition or repair of nonload bearing attachments to pressure-retaining items where postweld heat treatment is not required;
 - 3) Weld buildup of wasted areas in heads, shells, flanges and fittings not exceeding an area of 100 in.² (64,520 mm²) or a thickness of 25% of nominal wall thickness or 1/2 in. (13 mm), whichever is less;
 - 4) Corrosion resistance weld overlay not exceeding 100 in.² (64,520 mm²);
 - 5) Seal welding a mechanical connection for leak tightness where by-design, the pressure retaining capability is not dependent on the weld for strength and requires no postweld heat treatment; and
 - 6) Plugging of heat exchanger tubes 3/4 in. (19 mm) outside diameter and smaller when explosion welding is used as the method of plugging tubes.

3.3.3 EXAMPLES OF REPAIRS

(23)

- a) Weld repairs or replacement of pressure parts or attachments that have failed in a weld or in the base material;
- b) The addition of welded attachments to pressure parts, such as:
 - 1) Studs for insulation or refractory lining;
 - 2) Hex steel or expanded metal for refractory lining;
 - 3) Ladder clips;
 - 4) Brackets having loadings that do not affect the design of the pressure-retaining item to which they are attached; and
 - 5) Tray support rings.
- c) Corrosion resistant strip lining, or weld overlay;
- d) Weld buildup of wasted areas;
- e) Replacement of heat exchanger tubesheets in accordance with the original design;
- f) Replacement or plugging of boiler or heat exchanger tubes where welding is involved;

- SECTION 3
- g) In a boiler, a change in the arrangement of tubes in furnace walls, economizers, or super heater sections;
 - h) Replacement of pressure-retaining parts identical to those existing on the pressure-retaining item and described on the original *Manufacturer's Data Report*. For example:
 - 1) Replacement of furnace floor tubes and/or sidewall tubes in a boiler;
 - 2) Replacement of a shell or head in accordance with the original design;
 - 3) Rewelding a circumferential or longitudinal seam in a shell or head; and
 - 4) Replacement of nozzles of a size where reinforcement is not a consideration.
 - i) Installation of new nozzles or openings of such a size and connection type that reinforcement and strength calculations are not a consideration required by the original code of construction;
 - j) The addition of a nozzle where reinforcement is a consideration may be considered to be a repair, provided the nozzle is identical to one in the original design, located in a similar part of the vessel, and not closer than three times its diameter from another nozzle. The addition of such a nozzle shall be restricted by any service requirements;
 - k) The installation of a flush patch to a pressure-retaining item;
 - l) The replacement of a shell course in a cylindrical pressure vessel;
 - m) Welding of gage holes;
 - n) Welding of wasted or distorted flange faces;
 - o) Replacement of slip-on flanges with weld neck flanges or vice versa;
 - p) Seal welding of buttstraps and rivets;
 - q) Subject to the administrative procedures of the Jurisdiction and approval of the Inspector, the replacement of a riveted section or part by welding;
 - r) The repair or replacement of a pressure part with a code-accepted material that has a nominal composition and strength that is equivalent to the original material, and is suitable for the intended service;
 - s) Replacement of a pressure-retaining part with a material of different nominal composition and, equal to or greater in allowable stress from that used in the original design, provided the replacement material satisfies the material and design requirements of the original code of construction under which the pressure-retaining part was built. The minimum required thickness shall be at least equal to the thickness stated on the original *Manufacturer's Data Report*;
 - t) The replacement of a pressure relieving device (PRD) attached by welding, provided the replacement device's relieving capacity is equal to or greater than the PRD capacity required by the original code of construction; or
 - u) Repairs to plate heat exchangers (PHE) are limited to the following:
 - 1) Welding on any pressure part, i.e. not limited to a flange, nozzle, or endplate;
 - 2) In kind replacement of endplates, or welded nozzles;
 - 3) Replacement of any failed connection or frame bolting, representing the replacement parts described in Part 3, 3.2.2-a), with no change of material or grade as described on the Manufacturer's Data Report (MDR) or Original Equipment Manufacturer's (OEM) drawing;

- 4) The addition or repair of load bearing attachments (e.g., welded supports or lifting lugs) to the end-plates; and
- 5) Replacement of parts bearing certification or manufacturer's stamping with no-change in material allowed as described on the MDR or verifiable OEM drawing.

3.3.4 REPAIR METHODS

3.3.4.1 SCOPE

Except as provided in NBIC Part 3, 3.3.4.8, a repair of a defect in a welded joint or base material shall not be made until the defect has been removed. A suitable nondestructive examination (NDE) method, such as magnetic particle (MT) or liquid penetrant (PT), may be necessary to ensure complete removal of the defect. If the defect penetrates the full thickness of the material, the repair shall be made with a full penetration weld such as a double butt weld or single butt weld with or without backing. Where circumstances indicate that the defect is likely to recur, consideration should be given to removing the defective area and installing a flush patch or taking other corrective measures acceptable to the Inspector, and when required, by the Jurisdiction.

3.3.4.2 DEFECT REPAIRS

a) Cracks

Except as provided in NBIC Part 3, 3.3.4.8, a repair of a crack in a welded joint or base material shall not be made until the defect has been removed. A suitable nondestructive examination method such as MT or PT may be necessary to ensure complete removal of the defect. If the defect penetrates the full thickness of the material, the repair shall be made with a full penetration weld such as a double butt weld or single butt weld with or without backing, as allowed by the original code of construction.

b) Unstayed Boiler Furnace Cracks

Cracks at the knuckle or at the turn of the flange of the furnace opening require immediate replacement of the affected area or specific approval of repairs by the Jurisdiction (See NBIC Part 3, Figure 3.3.4.2-a).

c) Rivet or Staybolt Hole Cracks

Cracks radiating from rivet or staybolt holes may be repaired if the plate is not seriously damaged. If the plate is seriously damaged, it shall be replaced. For suggested methods of repair, see NBIC Part 3, Figure 3.3.4.2-b.

d) Minor Defects

Minor cracks, isolated pits, and small plate imperfections should be examined to determine the extent of the defect and whether repair by welding is required. Except as provided in NBIC Part 3, 3.3.4.8 prior to repair by welding, the defects shall be removed to sound metal. Liquid penetrant or magnetic particle examination may be used before or after welding.

e) Defective Bolting

Defective bolting material shall not be repaired but shall be replaced with suitable material that meets the specifications of the original code of construction.

f) Bulges

- 1) A bulge on a watertube shall be investigated to determine the cause and extent of damage to the tube prior to repair. If the bulge has resulted in metallurgical changes to the original tube material,

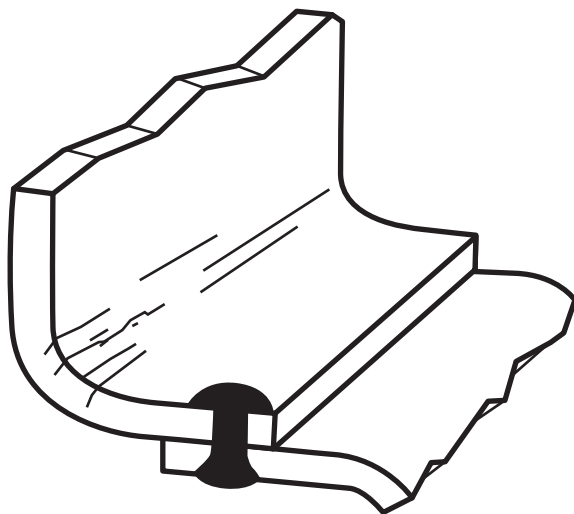
as determined by field metallography, installation of a new length of tubing or tube patch (see NBIC Part 3, 3.3.4.6 b) is required. If the bulge has cracks as determined by NDE, installation of a new length of tubing or a tube patch is required. If the bulge does not exhibit cracks and has not resulted in metallurgical changes to the original tube material, a mechanical repair may be considered subject to the concurrence of the Inspector or Jurisdiction.

- 2) A bulge on a plate shall be investigated to determine the cause and extent of damage to the plate prior to repair. If the bulge has resulted in metallurgical changes to the original plate material, as determined by field metallography, installation of a flush patch (see NBIC Part 3, 3.3.4.6 a)) is required. If the plate has cracks as determined by NDE, installation of a flush patch is required. If the bulge does not exhibit cracks and has not resulted in metallurgical changes to the original plate material, a mechanical repair may be considered, subject to the concurrence of the Inspector or Jurisdiction.

g) Blisters

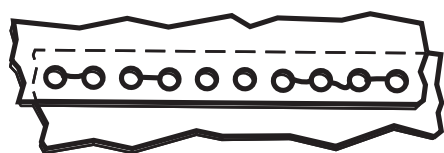
A blister may be caused by a defect in the metal such as lamination where one side exposed to the fire overheats but the other side retains its strength due to the cooling effect of the water. After the blistered material has been removed, the remaining wall thickness shall be determined by ultrasonic thickness testing. A surface examination using liquid penetrant testing or magnetic particle testing shall be made to ensure the remaining material contains no defects. If the remaining wall thickness is adequate, in the judgment of the Inspector, the area may be repaired by welding as covered in NBIC Part 3, 3.3.4.3. If the remaining wall thickness is not adequate, a plate will require a flush patch (See NBIC Part 3, 3.3.4.6 a)) and a tube will require a new length of tube or tube patch [see NBIC Part 3, 3.3.4.6 b)].

FIGURE 3.3.4.2-a
UNSTAYED BOILER FURNACES

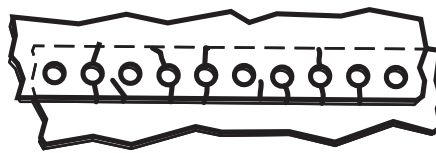


Cracks at the knuckle or at the turn of the furnace opening require immediate replacement of the affected area. If repairs are attempted, specific approval of the jurisdiction is required.

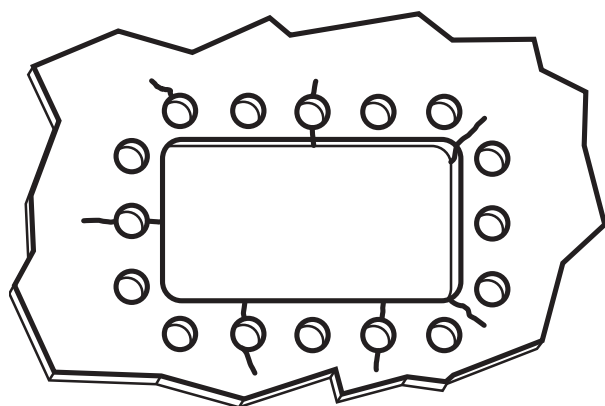
FIGURE 3.3.4.2-b
RIVET AND STAYBOLT HOLE CRACKS



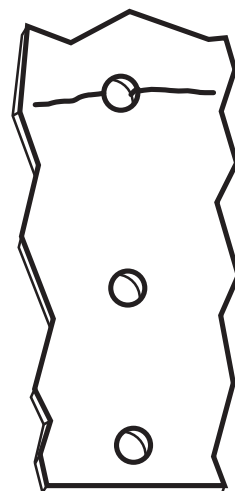
Circumferential Cracks at Girth Seams



Fire Cracks at Girth Seams



Fire Cracks at Door Openings



Cracks in Stayed Plates

Cracks radiating from rivet or staybolt holes should be repaired if the plate is not seriously damaged. If the plate is seriously damaged, it shall be replaced. A suggested repair method is described below:

- a) Prior to welding, the rivets or staybolts from which the cracks extend and the adjacent rivets (or staybolts if appropriate) should be removed;
- b) In riveted joints, tack bolts should be placed in alternate holes to hold the plate laps firmly;
- c) The cracks should then be prepared for welding by chipping, grinding, or gouging;
- d) In riveted joints, cracks which extend past the inner edge of the plate lap should be welded from both sides;
- e) Rivet holes should be reamed before new rivets are driven; and
- f) Threaded staybolt holes should be retapped and new staybolts properly driven and headed.

3.3.4.3 WASTED AREAS

- a) Shells, Drums, Headers

Wasted areas in stayed and unstayed shells, drums, and headers may be built up by welding, provided that in the judgment of the Inspector the strength of the structure has not been impaired. Where extensive weld buildup is employed, the Inspector may require an appropriate method of NDE for the completed surface of the repair. For suggested methods of building up wasted areas by welding. (See NBIC Part 3, Figure 3.3.4.3-a).

b) Access Opening

Wasted areas around access openings may be built up by welding or they may be repaired as described in NBIC Part 3, Figure 3.3.4.3-b.

c) Flanges

Wasted flange faces may be cleaned thoroughly and built up with weld metal. They should be machined in place, if possible, to a thickness not less than that of the original flange or that required by calculations in accordance with the provisions of the original code of construction. Wasted flanges may also be re-machined in place without building up with weld metal, provided the metal removed in the process does not reduce the thickness of the flange to a measurement below that calculated above. Flanges that leak because of warpage or distortion and which cannot be re-machined shall be replaced with new flanges that have at least the dimensions conforming to the original code of construction.

d) Tubes

- 1) Wasted areas on tubes may be repaired by welding, provided that, in the judgment of the Inspector the strength of the tube has not been impaired. Where deemed necessary, competent technical advice should be obtained from the manufacturer or from another qualified source. This may be necessary when considering such items as size limitations of repaired areas, minimum tube thickness to be repaired, tube environment, location of the tube in the boiler, and other similar conditions.
- 2) The WPS followed shall be qualified for weld metal buildup in accordance with ASME Section IX. When the code of construction required postweld heat treatment (PWHT) for butt welds, the WPS followed for the weld buildup, shall be qualified with PWHT.

e) External Weld Metal Buildup

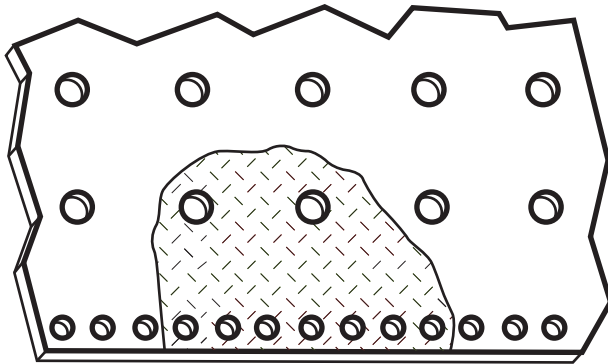
- 1) Pressure-retaining items that have localized internal thinning due to erosion and/or corrosion and where the internal surface is not readily accessible may be weld repaired by depositing weld metal on the external surface of the item as shown in NBIC Part 3, Figure 3.3.4.3-c. This method of repair is subject to approval by the Inspector and the Jurisdiction, where required.
- 2) All of the following conditions shall apply for this repair method to be permitted:
 - a. The component to be repaired shall be a ferrous material;
 - b. The maximum design temperature of the repaired component shall not exceed 650°F (340°C), and the minimum design temperature shall not be less than -20°F (-29°C);
 - c. The pressure-retaining item shall be volumetrically examined for cracks in the area to be weld repaired. If cracks are detected, this repair method shall NOT be used;
 - d. The WPS followed shall be qualified for weld metal buildup in accordance with ASME Section IX. The nominal chemical analysis of the deposited weld metal shall be equivalent to the base material that is to be repaired. In addition, the nominal tensile strength of the deposited weld metal shall be equal to or exceed the specified minimum tensile strength and shall be based on the requirements of the welding consumable. If butt welds in the component being overlaid required postweld heat treatment by the code of construction, the WPS followed for the weld buildup shall be qualified with PWHT;
 - e. The pressure-retaining item shall be taken out of service prior to performing the weld metal buildup. The owner of the pressure-retaining item shall evaluate the flammability, volatility, or potential reaction of the contents that were in the vessel to ensure safe working conditions during weld repair. When required by the results of this evaluation, the pressure-retaining item shall be drained of its contents to the extent necessary to make the repair;

- f. This method may be used more than once in the same areas to repair locally thinned areas; however, the cumulative weld buildup for all repairs shall not exceed the thickness (t) of the component at any point; and
 - g. Repairs using this method shall not cover more than 25% of the circumference of the component.
- 3) External weld buildup shall be applied in accordance with the following requirements:
- a. The area to be repaired shall be ultrasonically scanned for wall thickness, and the location and size of the thinned region shall be mapped;
 - b. The area requiring repairs and the boundaries of the weld buildup shall be marked on the external surface of the component;
 - c. The general design of the external weld buildup shall be in accordance with NBIC Part 3, Figure 3.3.4.3-c. The finished weld buildup shall be circular, oval, or rectangular in shape;
 - d. The weld buildup shall extend, at full thickness, a minimum distance B in each direction beyond the boundaries of the thinned base metal area.
 - 1. $B = 3/4 \sqrt{Rt_{nom}}$
 - 2. R = outer radius of the component, or D/2
 - 3. t_{nom} = nominal wall thickness of the component

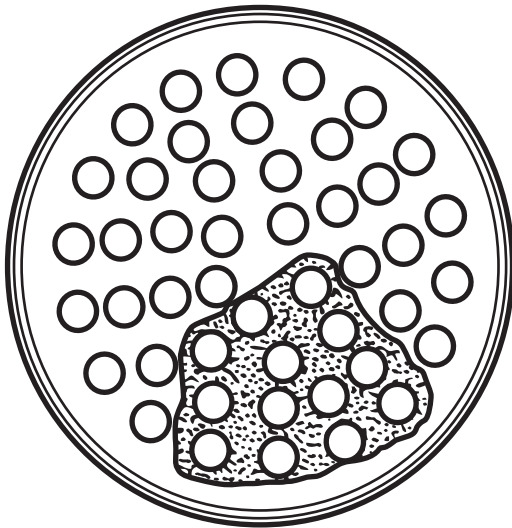
The thickness shall be sufficient to maintain the predicted life of the repair. Any corrosion allowance that is determined to be necessary shall be added to the value of B.
 - e. All edges of the weld buildup shall be tapered to the existing contour of the component, at a maximum angle (a) of 45°;
 - f. The thickness of the weld buildup shall be uniform except along tapered edges as welded surfaces are acceptable, provided they are free of coarse ridges and valleys and are suitable for any required nondestructive examinations;
 - g. All corners of the weld buildup shall have a minimum radius (r), not less than the overlay thickness;
 - h. Any corrosion allowance that is determined to be necessary shall be added to the thickness of the weld buildup;
 - i. The thickness (W) of the weld deposit plus the remaining wall thickness in the affected area (μ) of the component at its thinnest point shall not exceed the nominal wall thickness (t) of the component. This shall be verified by ultrasonic methods;
 - j. Final dimension and contour of the weld buildup may be achieved by grinding or machining. This work may be done before or after any PWHT;
 - k. The weld buildup shall be examined by liquid penetrant inspection or wet fluorescent magnetic particle inspection. If the butt welds in the component being built up were required to be volumetrically examined during the original construction, the built-up area shall be similarly volumetrically examined;
 - l. For each repair, the maximum dimension (L, length along axis) compensated by a circular or oval weld buildup shall not exceed the lesser of 1/4 the nominal outside diameter or the component or 8 in. (200 mm). The length of a rectangular patch is not limited; and
 - m. The distance between the weld toes of the multiple weld buildup regions on a component outer diameter surface area shall not be less than $3/4 \sqrt{Rt}$.

FIGURE 3.3.4.3-a**WELD BUILDUP OF WASTED AREA****Rivets and Staybolts**

- a) Prior to welding, the rivets or staybolts in the wasted area should be removed.
- b) Threaded staybolt holes should be retapped after welding.
- c) Rivet holes should be reamed after welding.
- d) Welding should not cover rivet or staybolt heads.

**Rivets and Stay Bolts****Tubesheet**

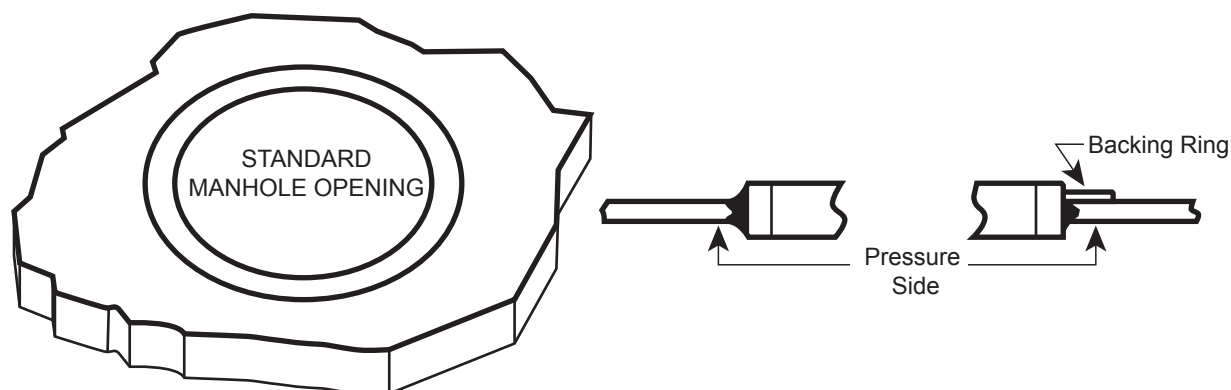
- a) Prior to welding, the tubes in the wasted area should be removed.
- b) After welding, the tube holes may be reamed before new tubes are installed.

**Tubesheet**

Wasted areas in stayed and unstayed surfaces may be repaired by weld buildup, provided that in the judgment of the inspector the strength of the structure will not be impaired. Where extensive weld buildup is employed, the inspector may require an appropriate method of NDE for the complete surface of the repair.

FIGURE 3.3.4.3-b
REPAIRS FOR ACCESS OPENINGS

A badly wasted manhole flange may be removed and replaced with a ring-type frame as shown below. The requirements for flush patches shall be met. A full penetration weld is required. May be either double groove weld or welded from one side with or without a backing ring.



A badly wasted area around a handhole opening may be repaired by adding a ring, as shown below, on the inside of the object.

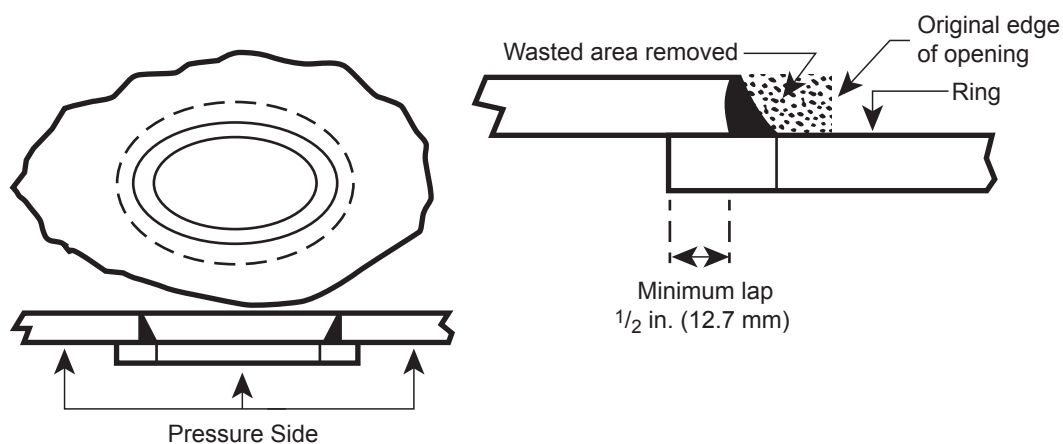
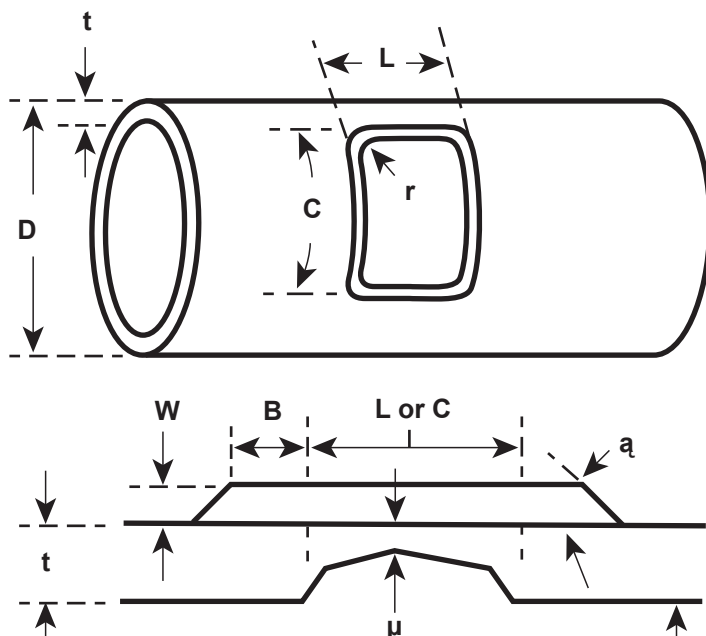


FIGURE 3.3.4.3-c
EXTERNAL OVERLAY TERMS AND DEFINITIONS



L = length of area to be repaired along the axis of the component

C = length of area to be repaired along outside circumference of the component

W = the completed thickness of the overlay

a = the angle between the component and the overlay (maximum 45°)

$B = \frac{3}{4} (Rt)^{0.5}$ minimum

R = nominal outside radius of the component

D = the nominal outside diameter of the component

t = nominal wall thickness of the component

μ = remaining wall thickness of the component shall be 1/16 in. (1.6 mm) or greater

r = minimum radius, not less than the overlay thickness

3.3.4.4 SEAL WELDING

a) Seal Welding of Tubes

Tubes may be seal welded, provided the ends of the tubes have sufficient wall thickness to prevent burn-through and the requirements of the original code of construction are satisfied as shown in NBIC Part 3, Figure 3.3.4.4-a.

b) Seal Welding of Riveted Joints

Edges of buttstraps, plate laps, and nozzles, or of connections attached by riveting, may be restored to original dimensions by welding. Seal welding of riveted joints, buttstraps, or rivets shall require the approval of the Jurisdiction. If seal welding is approved, suggested methods and precautions are shown in NBIC Part 3, Figure 3.3.4.4-b.

FIGURE 3.3.4.4-a**TYPICAL EXAMPLES OF SEAL WELDING TUBES**

Tubes may be seal welded provided the ends of the tubes have sufficient wall thickness to prevent burn-through. Seal welding shall be applied in strict accordance with the original code of construction for the requirements of the tube projection, welding, and tube expanding. Seal welding shall not be considered a strength weld.

In watertube boilers, tubes may be seal welded on the inside or outside of the tubesheet.

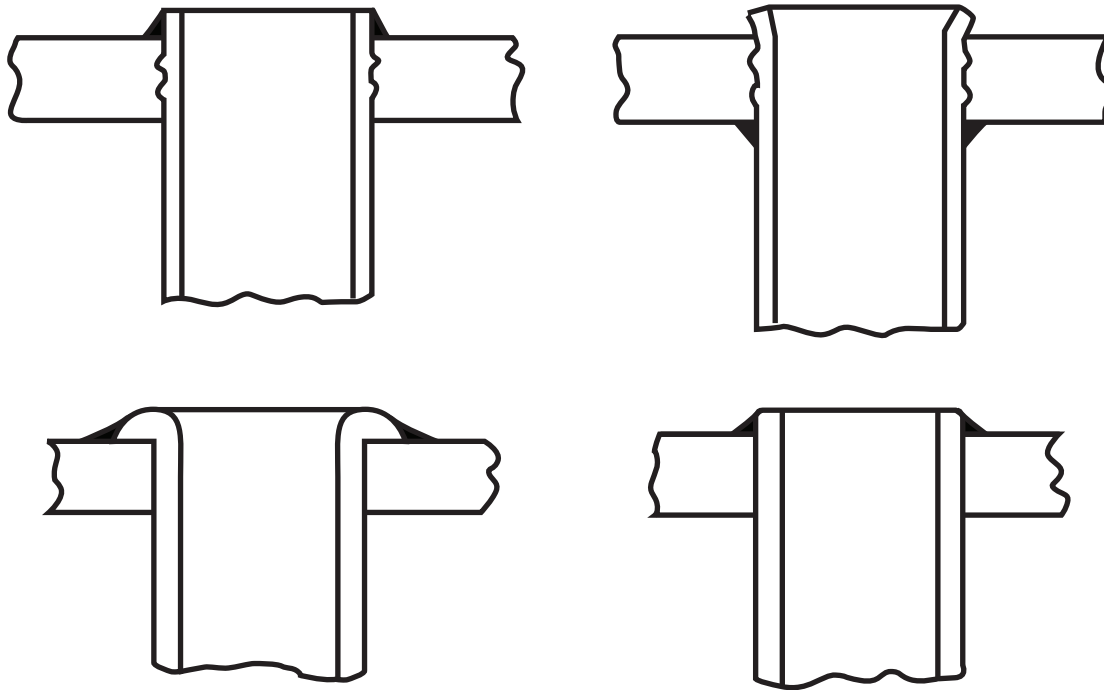
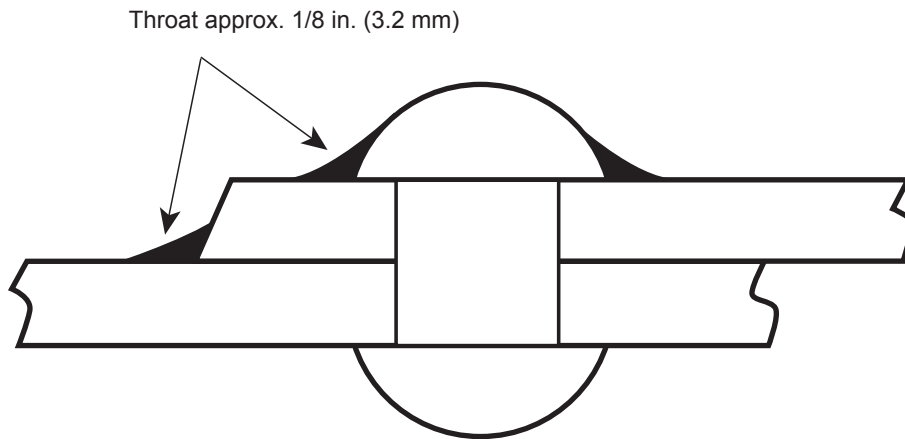


FIGURE 3.3.4.4-b**SEAL WELDING OF RIVETED JOINTS**

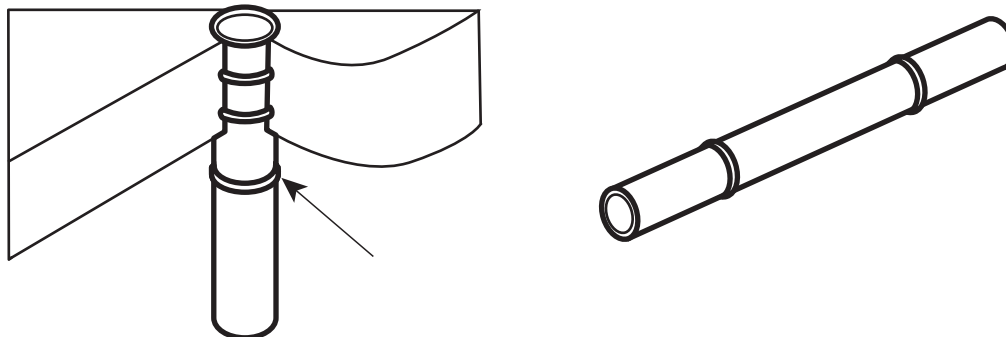
Seal welding of riveted joints requires the approval of the Jurisdiction. Seal welding shall not be considered a strength weld. Prior to welding, the area should be examined by an appropriate method of NDE to ensure that there are no cracks radiating from the rivet holes. If necessary, the rivets should be removed to ensure complete examination of the area. Seal welding should not be performed if cracks are present in riveted areas.



Typical Rivet Joint Showing Seal Weld

3.3.4.5 RE-ENDING OR PIECING PIPES OR TUBES

Re-ending or piecing pipes or tubes is permitted, provided the thickness of the remaining pipe or tube is not less than the minimum thickness required by the original code of construction. (See NBIC Part 3, Figure 3.3.4.5).

FIGURE 3.3.4.5**RE-ENDING OR PIECING OF PIPES OR TUBES**

Re-ending

Piecing

3.3.4.6 PATCHES

a) Flush Patches

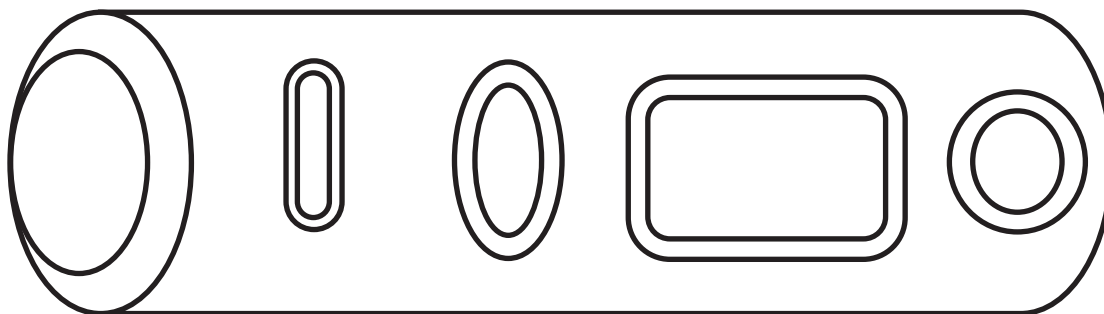
- 1) The weld around a flush patch shall be a full penetration weld and the accessible surfaces shall be ground flush where required by the applicable original code of construction. Examples of welded flush patches are shown in NBIC Part 3, Figure 3.3.4.6-a. Nondestructive examination shall be performed in accordance with the requirements from NBIC Part 3, Section 4.2.
- 2) Before installing a flush patch, defective material shall be removed until sound material is reached. The patch shall be formed to the proper shape or curvature. The edges shall align without overlap. In stayed areas, the weld seams should come between staybolt rows or riveted seams. Patches shall be made from a material whose composition and thickness meet the intended service. Patches may be any shape or size. If the patch is rectangular, a minimum radius of not less than three times the material thickness shall be provided at the corners. Square corners are not permitted. The completed welds shall meet the requirements of the original code of construction.

b) Tube Patches

In some situations it is necessary to weld a flush patch on a tube, such as when replacing tube sections and accessibility around the complete circumference of the tube is restricted, or when it is necessary to repair a small bulge. This is referred to as a window patch. Suggested methods for window patches are shown in NBIC Part 3, Figure 3.3.4.6-b.

FIGURE 3.3.4.6-a

FLUSH PATCH CONFIGURATIONS IN UNSTAYED AREAS



FLUSH PATCHES IN STAYED AREAS

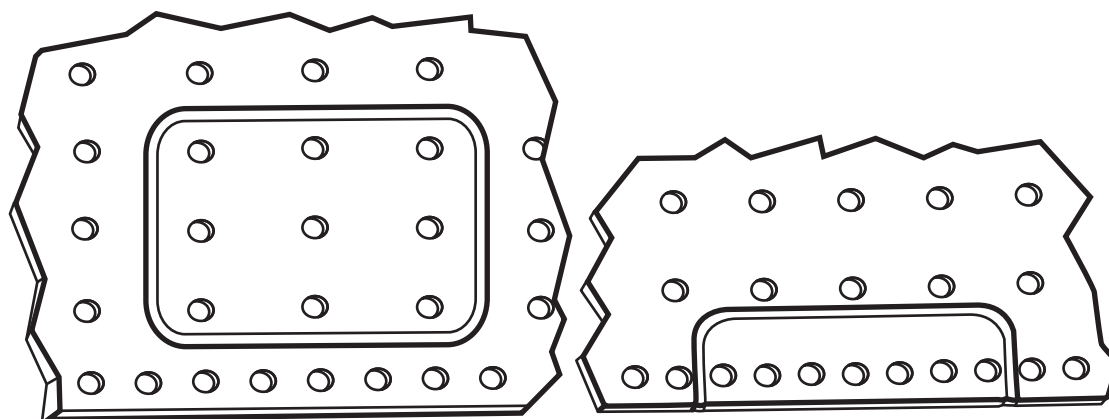
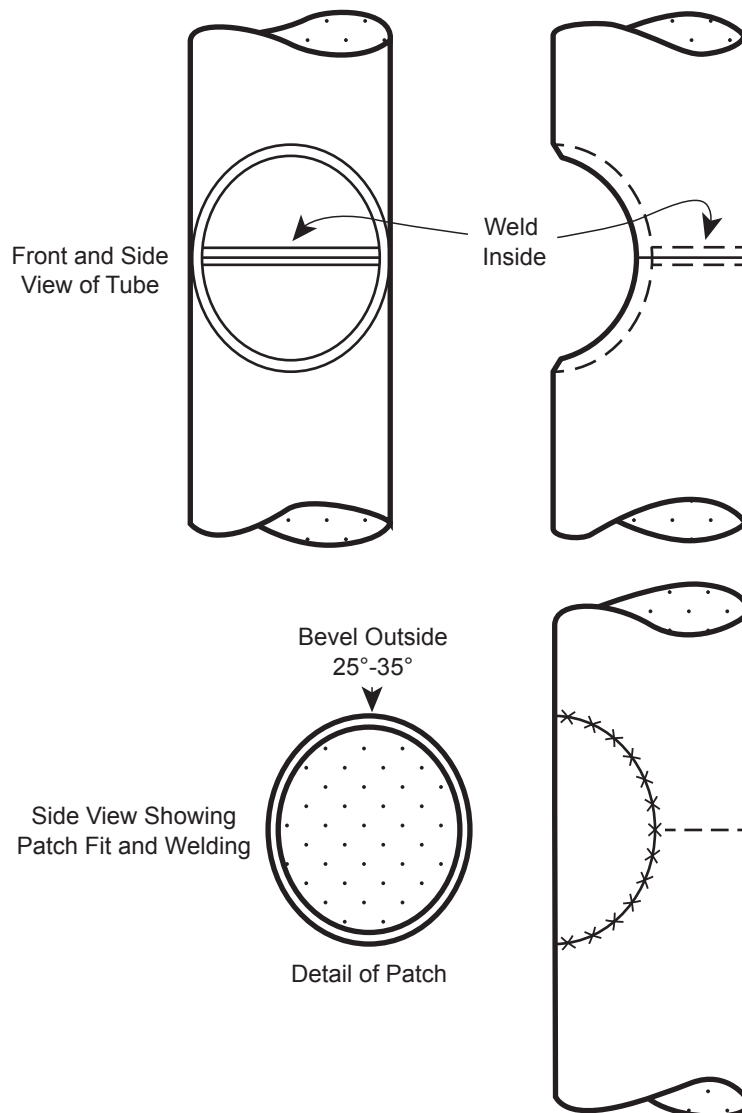


FIGURE 3.3.4.6-b**TUBE WINDOW PATCHING METHOD**

It may be necessary to weld a flush patch on a tube since, in some situations, accessibility around the complete circumference of the tube is restricted. Listed below are the suggested methods for making window patches:

- 1) The patch should be made from tube material of the same type, diameter, and thickness as the one being repaired.
- 2) Fit-up of the patch is important to weld integrity. The root opening should be uniform around the patch.
- 3) The gas tungsten-arc welding process should be used for the initial pass on the inside of the tube and for the initial pass joining the patch to the tube.
- 4) The balance of the weld may be completed by any appropriate welding process.



3.3.4.7 STAYS

Threaded stays may be replaced by welded-in stays provided that, in the judgement of the Inspector, the material adjacent to the staybolt has not been materially weakened by deterioration or wasting away. Requirements of the original code of construction governing welded-in stays shall be met.

3.3.4.8 REPAIR OF PRESSURE-RETAINING ITEMS WITHOUT COMPLETE REMOVAL OF DEFECTS

- a) There may be cases where removal of a defect in a pressure-retaining item is not practical at the time the defect is found. In such cases, with approval of the Inspector and, when required, the Jurisdiction, an engineering evaluation shall be performed to determine the scope of the repair and impact to safety prior to returning the pressure-retaining item to service for a specified period of time. The engineering evaluation shall be performed by an organization with demonstrated competency in defect (and flaw) characterization of pressure-retaining items. The method of defect evaluation and time interval for returning the pressure-retaining item back to service shall be as agreed upon by the Inspector, and when required, the Jurisdiction. The specified period of time the defect can remain in service after weld repair shall be based on no measureable defect growth during subsequent inspections, or a period of time as specified by the Jurisdiction, if applicable. This repair method is not permitted for vessels used in lethal service, vessels designed for high-cycle operation or fatigue service, compressed air storage, and in cases where high stress concentration cannot be reduced by weld repair. This repair method is not permitted for DOT vessels.
- b) One or more fitness-for-service engineering evaluation methods as described in NBIC Part 2, 4.4 shall be used to determine whether the defect may remain, either in part or in whole, in the pressure-retaining item. If it is determined that the defect can remain in the item, a risk-based inspection program shall be developed as described in NBIC Part 2, 4.5 to assure inspection of the defect and monitoring of defect growth over time. This program shall be a controlled and documented inspection program that specifies inspection intervals as agreed upon with the Inspector and, when required, the Jurisdiction, and shall be maintained until the defect can be completely removed and the item repaired.
- c) The following requirements shall apply to the weld repair of pressure-retaining items without complete removal of defects:
 - 1) Engineering evaluation of the defect in the pressure-retaining item shall be conducted using one or more fitness-for-service condition assessment method(s) as described in NBIC Part 2, 4.4. Engineering evaluation of the condition assessment results shall be performed by an organization that has demonstrated industry experience in evaluating pressure-retaining items, if the fitness-for-service engineering evaluation requires finite element analysis (FEA), the requirements in NBIC Part 2, 4.6 and NBIC Part 2, Supplement 11 shall be met.
 - 2) If engineering evaluation indicates a defect can remain in the pressure-retaining item, a risk-based inspection program shall be developed and implemented based on review and acceptance by the Inspector and, when required, the Jurisdiction. The risk-based inspection program shall be in accordance with the requirements in NBIC, Part 2, 4.4.
 - 3) The fitness-for-service condition assessment and risk-based inspection programs shall remain in effect for the pressure-retaining item until such time that the defect can be completely removed and the item repaired. The fitness-for-service condition assessment method, results of assessment, and method of weld repair, if applicable, shall be documented on a Report of Fitness for Service Assessment (FFSA) Form as described in NBIC Part 2, 4.4.1 and shall be filed with the Jurisdiction, when required.

- 4) When weld repairs are performed without complete removal of the defect(s), this shall be noted on the Form R-1 in the description of the work. The "R" Stamp Holder performing the weld repairs shall provide detailed information on the Form R-1, describing the method, extent, and include the specific location of the weld repair on the item.
- 5) The interval to re-inspect or remove the item from service or perform weld repair shall be determined based on a risk-based inspection program developed and implemented as required by NBIC Part 2, 4.5. The inspection interval shall not exceed the remaining life of the item, and shall be documented on the Form NB-403 and in the Remarks section of the Form R-1. The Form NB-403 shall be affixed to the Form R-1. A National Board Commissioned Inspector holding an "R" endorsement as described in NB-263, RCI-1 shall sign both the Form R-1 and the attached Form NB-403.
- 6) A copy of the completed Form R-1 with the completed Form NB-403 attached may be registered with the National Board, and when required, filed with the Jurisdiction where the item was installed.

3.3.4.9 TUBE PLUGGING IN FIRETUBE BOILERS

When the replacement of a tube in a firetube boiler is not practicable at the time the defective tube is detected, with the concurrence of the owner, Inspector, and when required, the Jurisdiction, the tube may be plugged using the following course of repair:

- a) The scope of work, type of plug and method of retention; whether welded or mechanical interface, shall be evaluated by the "R" Certificate Holder performing the repair and reviewed with the Inspector, and when required, the Jurisdiction.
- b) When the method of plugging is by welding, strength calculations for the size of the weld shall be in accordance with the original code of construction. The "R" Certificate Holder performing this repair shall weld the plug to the tube, or to the tube sheet, or a combination of both.
- c) Plugging a tube in a firetube boiler is recognized as an alternative to the replacement of a firetube and may be further limited as a method of repair by the number of tubes plugged and their location; scattered or clustered. The operational effects on the waterside pressure boundary or membrane and the effects on the combustion process throughout the boiler should be considered prior to plugging.
- d) The boiler may be returned to service for a period of time agreed upon by the owner, the Inspector, and when required, the Jurisdiction.
- e) The Form R-1 shall be completed for the plugging of firetubes, identifying the means of plug retention; mechanical or by welding.

3.3.5 REPAIR OF ASME SECTION VIII, DIVISION 2 OR 3, PRESSURE VESSELS

3.3.5.1 SCOPE

The following requirements shall apply for the repair of pressure vessels constructed to the requirements of Section VIII, Division 2 or 3, of the ASME Code.

3.3.5.2 REPAIR PLAN

The user shall prepare, or cause to have prepared, a detailed plan covering the scope of the repair.

- a) Engineer Review and Certification

The repair plan shall be reviewed and certified by an engineer meeting the criteria of ASME Section VIII, Division 2 or 3, as applicable, for an engineer signing and certifying a Manufacturer's Design

Report. The review and certification shall be such as to ensure the work involved in the repair is compatible with the User's Design Specification and the Manufacturer's Design Report. The certifying requirement may be waived for ASME Section VIII, Division 2, Class 1 vessels that did not require the Manufacturer's Design Report to be certified during initial construction.

Note: The engineer qualification criteria of the Jurisdiction where the pressure vessel is installed should be verified before selecting the certifying engineer.

b) Authorized Inspection Agency Acceptance

Following review and certification, the repair plan shall be submitted for acceptance to the Authorized Inspection Agency/Owner-User Inspection Organization whose Inspector will make the acceptance inspection and sign the Form R-1.

3.4 ALTERATIONS

3.4.1 RE-RATING

(23)

Except as provided for Yankee dryers in Supplement 5, this code does not provide rules for de-rating boilers or pressure vessels; however, when the MAWP and/or allowable temperature of a boiler or pressure vessel is reduced, the Jurisdiction, if applicable, where the object is installed shall be contacted to determine if specific procedures should be followed. Re-rating of a pressure-retaining item by increasing the maximum allowable working pressure (internal or external) or temperature or decreasing the minimum design metal temperature below which notch toughness testing is required by the original code of construction, shall be done only after the following requirements have been met to the satisfaction of the Jurisdiction at the location of the installation:

- a) Revised calculations verifying the new service conditions shall be prepared in accordance with the "R" Certificate Holder's Quality Control System. Establishing a higher joint efficiency to re-rate a pressure-retaining item is not permitted;
- b) All re-ratings shall be established in accordance with the requirements of the construction standard to which the pressure-retaining item was built;
- c) Current inspection records verify that the pressure-retaining item is satisfactory for the proposed service conditions;
- d) The pressure-retaining item has been pressure tested, as required, for the new service conditions. Any insulation, coatings, or coverings that may inhibit or compromise a meaningful pressure test shall be removed, to the extent identified by the Inspector. The pressure test may be waived if the original pressure test as recorded on the Manufacturer's Data Report is at least equal to the calculated test pressure required to verify the integrity of the pressure-retaining item for the new conditions. If the pressure test is waived it shall be documented on Form R-2 with this statement in the Remarks section: "Pressure test waived in accordance with NBIC Part 3, 3.4.1 d)";
- e) In lieu of pressure testing, alternative methods can be used to ensure the structural integrity of the re-rated pressure-retaining item. The alternative methods shall be documented and subject to review and approval by the Jurisdiction.

3.4.2 ALTERATIONS BASED ON ALLOWABLE STRESS VALUES

For re-rating or re-calculating a new minimum wall thickness for a pressure-retaining item using a later edition/addenda of the original code of construction or selected construction standard or code that permits use of higher allowable material stress values than were used in the original construction, the following requirements shall apply:

- a) The “R” Certificate Holder shall verify, by calculations and other means, that the re-rated item can be satisfactorily operated at the new service condition (e.g., stiffness, buckling, external mechanical loadings);
- b) The pressure-retaining item shall not be used in lethal service;
- c) The pressure-retaining item shall not be used in high-cycle operation or fatigue service (i.e., loadings other than primary membrane stress are controlling design considerations) unless the pressure-retaining item was originally designed for fatigue service and a fatigue analysis is performed;
- d) The pressure-retaining item shall have been constructed to the 1968 edition or later edition/addenda of the original code of construction;
- e) The pressure-retaining item shall be shown to comply with all relevant requirements of the edition/addenda of the code of construction, which permits the higher allowable stress values (e.g., reinforcement, toughness, examination, pressure testing);
- f) The pressure-retaining item shall have a satisfactory operating history and current inspection of the pressure-retaining item shall verify the item exhibits no unrepaired damage (e.g., cracks, corrosion, erosion). Areas of corrosion or erosion may be left in place provided the remaining wall thickness is greater than the minimum thickness for the new design conditions;
- g) The re-rating shall be acceptable to the Inspector and, where required, the Jurisdiction;
- h) All other requirements of Part 3, as applicable, and jurisdictional requirements shall be met; and
- i) Use of this paragraph shall be documented in the “Remarks” section of Form R-2.

(23) 3.4.3 ENCAPSULATION

Encapsulation is a method used to maintain the pressure retaining capability of piping and valves (with the exception of firetube boilers) by fabricating a new pressure containing boundary over the item in the form of a “welded leak box” as described by ASME PCC-2, Article 204.

- a) Except as required in 3.4.3 c) 1), ASME PCC-2 should be used as a guideline for the design of the welded leak box and fabrication shall be in accordance with the original code of construction, when practicable. Design of the encapsulation shall consider original design conditions, taking into account current service conditions and damage mechanisms. Use of this method shall be acceptable to the inspector and when required, the jurisdiction.
- b) The “R” Certificate Holder responsible for the design of the encapsulation shall ensure a Fitness for Service Assessment (FFSA) has been performed on the portion of the item being encapsulated in accordance with NBIC Part 2, 4.4.1, supporting the continued service of the item. The leak box shall not remain in place beyond the calculated remaining life of the encapsulated portion of the pressure retaining item.
 - 1) The remaining life of the encapsulated pressure retaining item shall be documented on the Report of FFSA in the Remarks section. The Report of FFSA Form shall be affixed to the Form R-2 and identified in the Remarks section.
 - 2) The leak box shall fully encapsulate the thinned or leaking area, as specified in the FFSA, to the distance where the minimum required metal thickness is verified. Wall thickness shall be verified in the area to be welded.
 - 3) A welded leak box shall not be used to encapsulate a crack unless it has been removed and repaired in accordance with Part 3, Paragraph 3.3.4.2 a).

- c) Hazards associated with welding on degraded components should be addressed with the Owner-User by the use of engineering controls, administrative controls, and personal protective equipment.
 - 1) When the pressure retaining item will remain in service while implementing this method, the requirements and limitations described within ASME PCC-2, Part-1 shall be used in conjunction with the Welded Leak Box Repair article in ASME PCC-2, Part-2, Article 210.
 - 2) API RP-2201, "Safe Hot Tapping Practices in the Petroleum and Petrochemical Industries" may be used as a guideline for identifying hazards associated with welding to a component that is under pressure, including service restrictions.
- d) Visual examination shall be in accordance with the NBIC Part 3, 4.4.1 e).
- e) Completion of the Form R-2 shall follow the requirements for preparation, distribution, and registration as described in Part 3, Section 5.

3.4.4 EXAMPLES OF ALTERATIONS

(23)

- a) An increase in the maximum allowable working pressure (internal or external) or temperature of a pressure-retaining item regardless of whether or not a physical change was made to the pressure-retaining item;
- b) A decrease in the minimum temperature;
- c) The addition of new nozzles or openings in a boiler or pressure vessel except those classified as repairs;
- d) A change in the dimensions or contour of a pressure-retaining item that decreases its pressure retaining capability;
- e) An increase in the steaming capacity by means of increasing heating surface, total heat input, firing rate, adjustment, or other modification to the primary or auxiliary heat source, resulting in the steaming capacity exceeding the original Manufacturer's Minimum Required Relieving Capacity (MRRC) as described on the nameplate and or Manufacturer's Data Report (MDR);
- f) The addition of a pressurized jacket to a pressure vessel;
- g) Except as permitted in NBIC Part 3, 3.3.3 s); replacement of a pressure retaining part in a pressure retaining item with a material of different allowable stress or nominal composition from that used in the original design;
- h) The addition of a bracket or an increase in loading on an existing bracket that affects the design of the pressure-retaining item to which it is attached;
- i) The replacement of a pressure relieving device (PRD) as a result of work completed on a pressure-retaining item (PRI) that changes the resultant capacity to exceed the minimum required relieving capacity (MRRC) required by the original code of construction as described on the original Manufacturer's Data Report;
- j) For plate heat exchangers, in addition to the applicable examples of alterations above, the following changes from what is listed on the MDR or described on the Original Equipment Manufacturer's (OEM)-drawing:
 - 1) For heat transfer plates:
 - a. A change in material grade or nominal thickness;
 - b. A reduction in number beyond any minimum, or when no minimum is specified;

- c. An increase in number beyond any maximum, or when no maximum is specified;
- d. A change in model type;
- 2) Any change in material whether described at 3.3.3 s) or as described at 3.4.4 g):
 - a. A change in connection bolt or frame compression bolt diameter or material grade;
 - b. A change in material grade or nominal dimensions of any end plates or nozzles.
- k) Performing postweld heat treatment where none was originally performed on the pressure retaining item; and
- l) The installation of a welded leak box.

3.4.5 ALTERATION OF ASME CODE SECTION VIII, DIVISION 2 OR 3, PRESSURE VESSELS

3.4.5.1 ALTERATION PLAN

a) Engineer Review and Certification

The alteration plan shall be reviewed and certified by an engineer meeting the criteria of ASME Section VIII, Division 2 or 3, as applicable, for an engineer signing and certifying a Manufacturer's Design Report. The review and certification shall be such as to ensure the work involved in the alteration is compatible with the User's Design Specification and the Manufacturer's Design Report.

Provided that the alteration does not introduce a condition that would require an engineer to sign the Manufacturer's Design Report for ASME Section VIII, Division 2, Class 1 vessels, the certifying requirement may be waived for vessels that did not require the Manufacturer's Design Report to be certified during initial construction.

Note: The engineer qualification criteria of the jurisdiction where the pressure vessel is installed should be verified before selecting the certifying engineer.

b) User's Design Specification

If the alteration is such that the work is not compatible with, or changes one or more requirement(s) of the original user's design specification, the user's design specification shall be revised by the user with the new parameters or changes. The revisions shall be certified by an engineer meeting the criteria of ASME Section VIII, Division 2 or 3, as applicable, for an engineer signing and certifying a Manufacturer's Design Report.

Note: The engineer qualification criteria of the Jurisdiction where the pressure vessel is installed should be verified before selecting the certifying engineer.

c) Manufacturer's Design Report

- 1) The "R" Certificate Holder shall prepare, or cause to have prepared a supplement to the *Manufacturer's Design Report* to reconcile the new parameters or changes with the user's design specification.
- 2) The supplement to the Manufacturer's Design Report shall be certified by an engineer meeting the criteria of ASME Section VIII, Division 2 or 3, as applicable, for an engineer signing and certifying a Manufacturer's Design Report.

Note: The engineer qualification criteria of the Jurisdiction where the pressure vessel is installed should be verified before selecting the certifying engineer.

d) Authorized Inspection Agency Acceptance

Following review and certification, the alteration plan shall be submitted for acceptance to the Authorized Inspection Agency/Owner-User Inspection Organization whose inspector will make the acceptance inspection and sign the Form R-2.

PART 3, SECTION 4

REPAIRS AND ALTERATIONS — EXAMINATION AND TESTING

4.1 SCOPE

This section provides requirements and guidelines for performing examinations and tests for repairs and alterations to pressure-retaining items.

(23) 4.2 NONDESTRUCTIVE EXAMINATION

- a) Nondestructive examination (NDE) requirements, including technique, extent of coverage, procedures, personnel qualification, and acceptance criteria, shall be in accordance with the original code of construction, standard, or specification selected for the repair or alteration of the pressure-retaining item (see NBIC Part 3, 1.2). Weld repairs and alterations shall be subjected to the same nondestructive examination requirements as the original welds. Where this is not possible or practicable, alternative NDE methods acceptable to the Inspector and the Jurisdiction where the pressure-retaining item is installed, where required, may be used, provided that all other requirements of this section are met.

Where the welds were subject to volumetric NDE during construction, repairs may be made to the base material and weld joints without volumetric examination under the following conditions:

- 1) The repair depth does not exceed the lesser of 1/8 inch (3 mm) or 25% of the nominal base material thickness;
 - 2) The aggregate repair length is no longer than 6 inches (150 mm);
 - 3) The repair cavity and each layer of deposited weld, including the final weld surface, have been examined by MT or PT.
- b) NDE personnel shall be qualified and certified in accordance with the requirements of the original code of construction. When this is not possible or practicable, NDE personnel may be qualified and certified in accordance with their employer's written practice. ASNT SNT-TC-1A, *Recommended Practice Non-destructive Testing Personnel Qualification and Certification* (2006 edition), or ANSI/ASNT CP-189, *Standard for Qualification and Certification of Nondestructive Testing Personnel* (2006 edition), shall be used as a guideline for employers to establish their written practice. Provisions for training, experience, qualification, and certification of NDE personnel shall be described in the "R" Certificate Holder's written quality system.

4.3 PRESSURE GAGES, MEASUREMENT, EXAMINATION, AND TEST EQUIPMENT

The calibration of pressure gages, measurement, examination, and test equipment, and documentation of calibration shall be performed, as required, by the applicable standard used for construction.

4.4 EXAMINATION AND TEST FOR REPAIRS AND ALTERATIONS

The following requirements shall apply to all repairs and alterations to pressure-retaining items:

- a) The integrity of repairs, alterations, and replacement parts used in repairs and alterations shall be verified by examination or test;
- b) Testing methods used shall be suitable for providing meaningful results to verify the integrity of the repair or alteration. Any insulation, coatings, or coverings that may inhibit or compromise a meaningful test method shall be removed, to the extent identified by the Inspector;

- c) The “R” Certificate Holder is responsible for all activities relating to examination and test of repairs and alterations;
- d) Examinations and tests to be used shall be subject to acceptance of the Inspector and, where required, acceptance of the Jurisdiction.

4.4.1 TEST OR EXAMINATION METHODS APPLICABLE TO REPAIRS

Based on the nature and scope of the repair activity, one or a combination of the following examination and test methods shall be applied to repairs and replacement parts used in repairs.

a) Liquid Pressure Test

Pressure testing of repairs shall meet the following requirements:

- 1) Pressure tests shall be conducted using water or other liquid medium. The test pressure shall be the minimum required to verify the leak tightness integrity of the repair. The test pressure shall not exceed the maximum liquid test pressure of the original code of construction. When original test pressure included consideration of corrosion allowance, the test pressure may be further adjusted based on the remaining corrosion allowance.
- 2) During a pressure test where the test pressure will exceed 90% of the set pressure of the pressure relief device, the device shall be removed whenever possible. If not possible, a spindle restraint may be used following the valve manufacturer’s instructions and recommendations. Extreme caution should be employed to ensure only enough force is applied to contain pressure. Excessive mechanical force applied to the spindle restraint may result in damage to the seat and/or spindle and may interfere with the proper operation of the valve. The spindle restraint shall be removed following the test.

The organization that performs the pressure test and applies a spindle restraint shall attach a metal tag that identifies the organization and date the work was performed to the pressure relieving device. If the seal was broken, the organization shall reseal the adjustment housing with a seal that identifies the responsible organization. The process shall be acceptable to the Jurisdiction where the pressure-retaining items are installed.

- 3) The metal temperature for the pressure test shall be in accordance with the original code of construction, but not less than 60°F (16°C) unless the owner provides information on the toughness characteristics of the material to indicate the acceptability of a lower test temperature. For thick walled pressure retaining items, it is recommended to seek technical guidance in establishing the notch toughness characteristics of the steel prior to pressure testing so that the metal temperature may be warmed above 60° F (16°C) to avoid brittle fracture. During close examination the metal temperature shall not exceed 120°F (49°C), unless the owner specified requirements for a higher test temperature, and it is acceptable to the Inspector.
- 4) Table 4.4.1 may be used for liquid pressure testing of steels supplied as coarse-grained under the following specifications:
 - a. ASME SA 212;
 - b. ASME SA 515; and
 - c. ASME SA 299.

If supplied as coarse-grained, the above steels can exhibit low toughness at room temperature and in lieu of conducting notch toughness tests, Table 4.4.1 and Table 4.4.1 M can be used to establish a temperature for the liquid to reduce the risk of brittle fracture. Table 4.4.1 and Table 4.4.1 M contain minimum liquid temperature requirements based on metal thickness of the pressure retaining part.

- 5) Hold-time for the pressure test shall be a minimum of 10 minutes prior to examination by the Inspector. Where the test pressure exceeds the MAWP of the item, the test pressure shall be reduced to the MAWP for close examination by the Inspector. Hold-time for close examination shall be as necessary for the Inspector to conduct the examination.

TABLE 4.4.1

Minimum Liquid Temperature for Pressure Testing (°F)	Thickness (inches) of Pressure-Retaining Object (Note 1)
60	$t \leq 0.5$
70	$t > 0.5 \leq 1$
85	$t > 1 \leq 2$
100	$t > 2 \leq 4$
110	$t > 4$

Note 1:

Thickest section of the pressure-retaining object.

TABLE 4.4.1 M

Minimum Liquid Temperature for Pressure Testing (°C)	Thickness (mm) of Pressure-Retaining Object (Note 1)
15	$t \leq 13$
20	$13 < t \leq 25$
29	$25 < t \leq 50$
38	$50 < t \leq 100$
43	$t > 100$

Note 1:

Thickest section of the pressure-retaining object

b) Pneumatic Test

A pneumatic test may be conducted. Concurrence of the owner shall be obtained in addition to that of the Inspector and Jurisdiction where required. The test pressure shall be the minimum required to verify leak tightness integrity of the repair, but shall not exceed the maximum pneumatic test pressure of the original code of construction. Precautionary requirements of the original code of construction shall be followed;

c) Initial Service Leak Test

When an initial service leak test is permitted by the original code of construction, such testing may also be used to verify the leak tightness integrity of repairs;

d) Vacuum Test

A vacuum test may be conducted. Vacuum test methods used shall be suitable to verify the leak tightness integrity of the repair;

e) Nondestructive Examination (NDE)

NDE may be conducted. NDE methods used shall be suitable for providing meaningful results to verify the integrity of the repair. Exclusive use of visual examination (VT) is only permitted with the following considerations:

- 1) When a pressure test or alternative NDE methods other than visual examination, are not practicable the exclusive use of direct VT as an NDE method shall be limited to routine repairs, as identified in NBIC Part 3, 3.3.2.
- 2) For each repair being considered, the exclusive use of direct VT as an NDE method shall be acceptable to the Inspector, and where required, the Jurisdiction.
- 3) As a minimum, direct VT shall be performed after the root weld layer or first-pass is deposited, and the final weld surface. Other weld layers shall be examined as identified by the Inspector and, where required, the Jurisdiction.
- 4) Personnel completing direct VT shall be qualified and certified in accordance with paragraph NBIC Part 3, 4.2- b), AWS QC-1, or any nationally recognized standard acceptable to the Jurisdiction. Visual acuity shall be demonstrated using as a minimum, standard J-2 letters on standard Jaeger test type charts for near vision.
- 5) Direct VT shall be performed in accordance with a written procedure meeting the procedure and reporting requirements listed in the original code of construction or ASME Section V, Article 9.

4.4.2 TEST OR EXAMINATION METHODS APPLICABLE TO ALTERATIONS

(23)

Based on the nature and scope of the alterations activity, one or a combination of the following examination and test methods shall be applied to alterations (unless waived in accordance with 3.4.1 d) of this Part) and replacement parts used in alterations.

a) Liquid Pressure Test

Pressure testing of alterations shall meet the following requirements:

- 1) A pressure test in accordance with the original code of construction shall be conducted. When the original test pressure included consideration of corrosion allowance, the test pressure may be further adjusted based on the remaining corrosion allowance. The pressure test for replacement parts may be performed at the point of manufacture or point of installation;
- 2) As an alternative to pressure testing connecting welds in accordance with the original code of construction, connecting welds may be tested or examined in accordance with the rules for repairs (see NBIC Part 3, 4.4.1). Connecting welds are defined as welds attaching the replacement part to the pressure-retaining item;
- 3) During a pressure test where the test pressure will exceed 90% of the set pressure of the pressure relief device, the device shall be removed whenever possible. If not possible, a spindle restraint may be used following the valve manufacturer's instructions and recommendations. Extreme caution should be employed to ensure only enough force is applied to contain pressure. Excessive mechanical force applied to the spindle restraint may result in damage to the seat and/or spindle and may interfere with the proper operation of the valve. The spindle restraint shall be removed following the test.

The organization that performs the pressure test and applies a spindle restraint shall attach a metal tag that identifies the organization and date the work was performed to the pressure relieving device. If the seal was broken, the organization shall reseal the adjustment housing with a seal that identifies the responsible organization. The process shall be acceptable to the Jurisdiction where the

pressure-retaining items are installed;

- 4) The metal temperature for the pressure test shall be in accordance with the original code of construction, but not less than 60°F (16°C), unless the owner provides information on the toughness characteristics of the material to indicate the acceptability of a lower test temperature. For thick walled pressure-retaining items, it is recommended to seek technical guidance in establishing the notch toughness characteristics of the steel prior to pressure testing so that the metal temperature may be warmed above 60°F (16°C) to avoid brittle fracture. During close examination, the metal temperature shall not exceed 120°F (49°C), unless the owner specifies requirements for a higher test temperature and it is acceptable to the Inspector;
- 5) Unless it can be demonstrated that the material has been supplied as fine grained, it is recommended that Table 4.4.1 or 4.4.1 M be followed for pressure testing of steels supplied under the following specifications:
 - a. ASME SA 212;
 - b. ASME SA 515; and
 - c. ASME SA 299.
- 6) Hold-time for the pressure test shall be a minimum of 10 minutes prior to examination by the Inspector. Where the test pressure exceeds the MAWP of the item, the test pressure shall be reduced to the MAWP for close examination by the Inspector. Hold-time for close examination shall be as necessary for the Inspector to conduct the examination.

b) Pneumatic Test

A pneumatic test may be conducted when contamination of the pressure-retaining item by liquids is possible or when liquid pressure testing is not practicable. Concurrence of the owner shall be obtained in addition to the Inspector and Jurisdiction where required. Pneumatic test requirements and precautions shall be in accordance with the original code of construction.

c) Nondestructive Examination

NDE may be conducted when contamination of the pressure-retaining item by liquids is possible or when pressure testing is not practicable. Concurrence of the owner shall be obtained in addition to the Inspector, and where required, the Jurisdiction. Exclusive use of Visual Examination (VT) shall not be permitted. In all cases NDE methods or combination of methods used shall be suitable for providing meaningful results to verify the integrity of the alteration.

PART 3, SECTION 5 REPAIRS AND ALTERATIONS — CERTIFICATION/DOCUMENTATION AND STAMPING

5.1 SCOPE

This section provides requirements for certification, stamping, and documentation of repairs and alterations to pressure-retaining items. Applicable forms are provided in this section for reference. Forms may be obtained from the National Board website.

5.2 DOCUMENTATION

(23)

- a) Repairs that have been performed in accordance with the NBIC shall be documented on a Form R-1, *Report of Repair*, as shown in Supplement S9.2. A Form R-4, *Report Supplement Sheet*, as shown in Supplement S9.5, shall be used as needed to record additional data when the space provided on Form R-1 is not sufficient.
- b) Alterations performed in accordance with the NBIC shall be documented on a Form R-2, *Report of Alteration*, as shown in Supplement S9.3. A Form R-4, *Report Supplement Sheet*, as shown in Supplement S9.5, shall be used as needed to record additional data when the space provided on Form R-2 is not sufficient.
- c) The organization performing repairs and alterations shall retain a copy of the completed Form “R” Report on file and all records and documentation substantiating the summary of work as described throughout Section 5, and as identified in the “R” Certificate Holder’s Quality System Manual.
- d) Unless otherwise required by the Jurisdiction, Form R Reports shall be completed and certified by the Certificate Holder and the Inspector no more than 90 days following the completion of construction activities or the completion of design activities when no construction work is performed.

5.2.1 PREPARATION OF FORM R-1 (REPORT OF REPAIR)

- a) Using the instructions found in Table S9.2 of Supplement 9, preparation of Form R-1 shall be the responsibility of the “R” Certificate Holder performing the repair.
- b) Information describing the scope of work used to repair a pressure-retaining item (PRI) shall be documented on a Form R-1 and extended to a Form R-4 as needed to fully describe the repair activities completed per the instructions at in Table S9.2 of Supplement 9.
- c) An Inspector shall indicate acceptance by signing Form R-1, and Form R-4, if attached.
- d) The Form R-3, *Report of Parts Fabricated by Welding*, Manufacturer’s Data Reports, and Certificates of Compliance described in this section shall be a part of the completed Form R-1 and shall be attached thereto.

5.2.2 PREPARATION OF FORM R-2 (REPORT OF ALTERATION)

- a) Using the instructions found in Table S9.3 of Supplement 9, initial preparation of Form R-2 shall be the responsibility of the “R” Certificate Holder responsible for the design portion of the alteration. The design organization shall complete and sign the “Design Certification” section of the Form R-2. An Inspector shall indicate acceptance of the design by signing the “Certificate of Design Change Review” section of the Form R-2.

- b) The information describing an alteration to a pressure-retaining item shall be identified on Form R-2 with a complete description of the scope of work for physical or non-physical changes. When the scope of work represents a change that will increase the Minimum Required Relieving Capacity (MRRC) of a pressure-retaining item, such as a change in heating surface, Maximum Designed Steaming Capacity (MDSC), or BTU/hr (W) heating capacity, the new MRRC shall be documented on Form R-2 and indicated on the appropriate nameplate of NBIC Part 3, Figure 5.7.5-b or NBIC Part 3, Figure 5.7.5-c.
- c) Final preparation of Form R-2, including gathering and attaching supporting reports, shall be the responsibility of the “R” Certificate Holder that performed the construction portion of the alteration. The construction organization shall complete the Form R-2 provided by the design organization, including the “Construction Certification” section of the form. An Inspector shall indicate that the work complies with the applicable requirements of this code by completing and signing the “Certificate of Inspection” section of the form. When no construction work is performed (e.g., a re-rating with no physical changes), the “R” Certificate Holder responsible for the design shall prepare the Form R-2, including gathering and attaching of supporting documentation.
- d) The following shall be attached to and become a part of completed Form R-2:
 - 1) For ASME boilers and pressure vessels, a copy of the original Manufacturer’s Data Report, when available;
 - 2) Form R-3, Report of Parts Fabricated by Welding, Manufacturer’s Partial Data Reports, or Certificates of Compliance, if applicable; and
 - 3) For other than ASME, the manufacturer’s reports (i.e., reports required by the original code of construction, etc.), when available.

5.2.3 PREPARATION OF FORM R-3 REPORT OF PARTS FABRICATED BY WELDING

Using the instructions found in Table S9.4 of Supplement 9, preparation of Form R-3 shall be the responsibility of the “R” Certificate Holder responsible for performing the work.

5.2.4 PREPARATION OF FORM R-4 REPORT SUPPLEMENT SHEET

Using the instructions found in Table S9.5 of Supplement 9, preparation of Form R-4 shall be the responsibility of the “R” Certificate Holder responsible for performing the work.

5.2.5 PREPARATION OF FORM NR-1, REPORT OF REPAIR/REPLACEMENT ACTIVITIES FOR NUCLEAR FACILITIES

Using the instructions found in Table S9.6 of Supplement 9, preparation of Form NR-1 shall be the responsibility of the “NR” Certificate Holder responsible for performing the work.

5.2.6 PREPARATION OF FORM NVR-1, REPORT OF REPAIR/REPLACEMENT ACTIVITIES FOR NUCLEAR PRESSURE RELIEF DEVICES

Using the instructions found in Table S9.7 of Supplement 9, preparation of Form NVR-1 shall be the responsibility of the “NR” Certificate Holder, possessing the “VR” Certificate denoting the repair of nuclear pressure relief valves, responsible for performing the work.

(23)

5.3 DISTRIBUTION OF FORM R-1

- a) Legible copies of completed Form R-1, together with attachments, shall be distributed to the owner or user and Jurisdiction, if required, and shall be provided to the Inspector and the inservice Authorized Inspection Agency of the pressure retaining item upon request.
- b) Distribution of Form R-1 and attachments shall be the responsibility of the organization performing the repair.

5.4 DISTRIBUTION OF FORM R-2

- a) Distribution of completed Form R-2 shall be the responsibility of the “R” Certificate Holder who performed the construction portion of the alteration. When no construction work is performed (e.g., a re-rating with no physical changes), the “R” Certificate Holder responsible for the design shall distribute the form.
- b) Legible copies of the completed Form R-2, together with attachments, shall be distributed to the owner-user, the “R” Certificate Holder responsible for design, and the Jurisdiction, if required, and shall be provided to the Inspector and inservice Authorized Inspection Agency of the pressure retaining item upon request.

5.5 REGISTRATION OF FORMS — GENERAL

- a) When registration of the forms is required, the Certificate Holder performing a repair or alteration shall submit the completed form, meeting the requirements of the NBIC, to the National Board no more than 30 days following certification.
- b) When registration of the forms is not required, the Certificate Holder may register the completed form, meeting the requirements of the NBIC, with the National Board.
- c) The “R” or “NR” Certificate Holder should be aware that some Jurisdictions may require registration of repairs and alterations with the National Board.

5.5.1 REGISTRATION FOR REPAIRS

Form R-1 may be registered with the National Board as noted in NBIC Part 3, 5.5.

5.5.2 REGISTRATION FOR ALTERATIONS

- a) If the pressure-retaining item is originally registered with the National Board, an original Form R-2, together with attachments, shall be registered with the National Board.
- b) If the item was not registered with the National Board, one original Form R-2, together with attachments, may be registered with the National Board or retained as required by the Quality System Manual.

5.5.3 REGISTRATION FOR FIBER-REINFORCED VESSELS

Organizations performing repairs or alterations under an “R” stamp program shall register such repairs or alterations with the National Board.

5.5.4 REGISTRATION FOR NUCLEAR REPAIR/REPLACEMENT ACTIVITIES

Organizations performing repair/replacement activities under the “NR” or “NVR” stamp program shall register forms with the National Board.

5.5.5 REGISTRATION FOR GRAPHITE VESSELS

Organizations performing repair/replacement activities under the “R” stamp program shall register such repairs or alterations with the National Board.

5.6 FORM REGISTRATION LOG

“R” or “NR” Certificate Holders shall maintain a log or multiple logs documenting unique and sequentially numbered Form “R” Reports that are registered with the National Board. The logs shall include, as a minimum, each form’s unique registration number, type (R-1, R-2, NR-1, etc.), description of work performed, date of acceptance by the Authorized Inspection Agency, and date the report was submitted to the National Board. As an alternative to the above requirement, the log may be maintained electronically in the National Board Electronic Data Transfer (EDT) System.

5.7 STAMPING REQUIREMENTS FOR REPAIRS AND ALTERATIONS

5.7.1 GENERAL

The stamping of or attachment of a nameplate to a pressure-retaining item shall indicate that the work was performed in accordance with the requirements of this code. Such stamping or attaching of a nameplate shall be done only with the knowledge and authorization of the Inspector. The “R” Certificate Holder responsible for repair or the construction portion of the alteration shall apply stamping. For a re-rating where no physical changes are made to the pressure-retaining item, the “R” Certificate Holder responsible for design shall apply stamping.

5.7.2 STAMPING REQUIREMENTS FOR REPAIRS

- a) Pressure-retaining items repaired in accordance with the NBIC shall be stamped as required by this section.
- b) Subject to the acceptance of the Jurisdiction and the concurrence of the Inspector, nameplates and stamping may not be required for routine repairs (see NBIC Part 3, 3.3.2). In all cases, the type and extent of repairs necessary shall be considered prior to waiving the requirement.
- c) Stamping or nameplate shall be applied adjacent to the original manufacturer’s stamping or nameplate. A single repair nameplate or stamping may be used for more than one repair to a pressure-retaining item, provided each is carried out by the same certificate holder. The date of each repair, corresponding with the date on associated Form R-1, shall be stamped on the nameplate.

5.7.3 STAMPING REQUIREMENTS FOR ALTERATIONS

Pressure-retaining items altered in accordance with this code shall have a nameplate or stamping applied adjacent to the original manufacturer’s stamping or nameplate in accordance with this section. For an alteration where physical changes are made to the pressure-retaining item, the “R” Certificate Holder responsible for the construction portion of the alteration shall apply the stamping or nameplate. For an alteration where no physical changes are made to the pressure-retaining item (e.g., a re-rating) the “R” Certificate Holder, assuming responsibility for the design, shall apply the stamping or nameplate.

5.7.4 STAMPING REQUIREMENTS FOR PARTS

Stamping or nameplate shall be applied in a conspicuous location on the part.

5.7.5 SPECIFIC REQUIREMENTS FOR STAMPING AND NAMEPLATES

- a) Required data shall be in characters of at least 5/32 in. (4 mm) high, except that characters for pressure relief valve repair nameplates may be smaller. Markings may be produced by casting, etching, embossing, debossing, stamping, or engraving. The selected method shall not result in any harmful contamination, or sharp discontinuities to, the pressure-retaining item. See NBIC Part 3, Figures 5.7.5-a through 5.7.5-e.
- b) The National Board Code Symbols (“R”, “VR”, and “NR”) are to be stamped; do not emboss.
- c) Stamping directly on items, when used, shall be done with blunt-nose continuous or blunt-nose interrupted dot die stamps. If direct stamping would be detrimental to the item, required markings may appear on a nameplate affixed to the item.
- d) The certificate holder shall use its full name as shown on the *Certificate of Authorization* or an abbreviation acceptable to the National Board.
- e) The letters “RP” shall be stamped below the “R” Symbol Stamp to indicate organizations accredited for performing repairs or alterations to fiber-reinforced plastic items.
- f) The letter “G” shall be stamped below the “R” Symbol Stamp to indicate organizations accredited for performing repairs or alterations to graphite pressure equipment.
- g) The subject nameplate shall be securely attached using a method compatible with the structure or stand-off bracket supporting the nameplate, in a manner that will impede easy removal. The method of attaching this nameplate, as permitted by the original code of construction, may include, but is not limited to:
 - 1) Welding
 - 2) Adhesive, bonding or cementing
 - 3) Tamper-resistant mechanical fasteners of suitable metal construction

FIGURE 5.7.5-a

REQUIRED MARKINGS FOR REPAIRS, WITH USE OF NATIONAL BOARD FORM R-1

REPAIRED BY



CERTIFICATE HOLDER

NATIONAL BOARD “R”
CERTIFICATE NUMBER

DATE REPAIRED

FIGURE 5.7.5-b

REQUIRED MARKINGS FOR ALTERATIONS, WITH USE OF NATIONAL BOARD FORM R-2

ALTERED BY	_____	
	CERTIFICATE HOLDER	
	M.A.W.P. _____	P.S.I. _____
	AT _____	°F _____

NATIONAL BOARD "R" CERTIFICATE NUMBER	DATE ALTERED	

FIGURE 5.7.5-c

REQUIRED MARKINGS FOR RE-RATINGS, WITH USE OF NATIONAL BOARD FORM R-2

RE-RATED BY	_____	
	CERTIFICATE HOLDER	
	M.A.W.P. _____	P.S.I. _____
	AT _____	°F _____

NATIONAL BOARD "R" CERTIFICATE NUMBER	DATE ALTERED	

FIGURE 5.7.5-d

REQUIRED MARKINGS FOR PARTS FABRICATED BY WELDING, WITH USE OF NATIONAL BOARD FORM R-3

PART	_____	
	CERTIFICATE HOLDER	
	P.S.I. AT _____	°F _____
	M.A.W.P. _____	

	MANUFACTURER'S SERIAL NO.	
NATIONAL BOARD "R" CERTIFICATE NUMBER	YEAR BUILT	

Note 1: To be indicated only when changed.

FIGURE 5.7.5-e**REQUIRED MARKINGS FOR NUCLEAR REPAIRS OR REPLACEMENTS**

NR[®]

CERTIFICATE HOLDER

NATIONAL BOARD "NR"
CERTIFICATE NUMBER

UNIQUE IDENTIFIER

REPAIR ☐

REPLACEMENT ☐

DATE OF REPAIR OR REPLACEMENT

5.8 STAMPING FOR FIBER-REINFORCED VESSELS

The attachment of a nameplate to a repaired or altered vessel or tank shall indicate that work was performed in accordance with requirements of this code. The attachment of a nameplate shall be done only with knowledge and authorization of the Inspector. The certificate holder responsible for repair or alteration shall apply the stamping nameplate. Required stamping and nameplate information are shown in NBIC Part 3, 5.7.

5.8.1 STAMPING FOR REPAIRS

Pressure-retaining items repaired in accordance with the NBIC shall have a nameplate as required by NBIC Part 3, 5.7. Subject to the acceptance of the Jurisdiction and the concurrence of the Inspector, nameplates may not be required for routine repairs (See NBIC Part 3, 5.7.2 b). In all cases, the type and extent of repairs necessary shall be considered prior to waiving the requirement.

5.8.2 STAMPING FOR ALTERATIONS

The nameplate shall be applied in accordance with NBIC Part 3, 5.7. Location of nameplate shall be documented under "Remarks" on NBIC Form R-2 line 9.

5.9 STAMPING REQUIREMENTS FOR YANKEE DRYERS

- a) Stamping is not required for repairs that do not affect pressure-retaining capability of the Yankee shell, as indicated on the De-rate Curve, or other pressure-retaining parts, as indicated on the original Manufacturer's Data Report.
- b) Stamping is required for repairs that affect pressure-retaining capability of the Yankee Dryer shell, as indicated on the De-rate Curve, or other pressure-retaining parts as indicated on the original Manufacturer's Data Report.
- c) Stamping is required for alterations as listed in NBIC Part 3, S5.7.2.
- d) Stamping, when required, shall meet the requirements for stamping in NBIC Part 3, 5.7.2. The location of stamping shall be described in the "Remarks" section of Form R-2.

5.10 ALTERNATIVE MARKING AND STAMPING FOR GRAPHITE PRESSURE EQUIPMENT

a) General Requirements

- 1) This procedure may be used in lieu of the stamping and nameplate requirements defined in this section.
- 2) The required data as defined in this section shall be 5/32 in. (4 mm) high, minimum.
- 3) The National Board Code Symbol "R" shall be used to make the impression in the cement.

b) Application of the "R" Code Symbol

- 1) The graphite surface shall be clean and smooth.
- 2) Apply a thin coating of cement onto the code part. The cement should have the consistency of toothpaste.
- 3) Apply sufficient heat to the cement so that it begins to form a skin.
- 4) Apply a coating of a thinned release agent, such as "anti-seize," to the tip of the "R" stamp with a brush.
- 5) Press the coated stamp all the way to the bottom of the cement and remove by pulling straight out before the cement hardens.
- 6) Cure or heat the impression as required.
- 7) When cured, the part may be washed to remove any excess release agent.

c) Application of characters directly to graphite

- 1) Use a very thin template of a flexible material (stainless steel; flexible and easily cleaned).
- 2) Place the template over a clean smooth surface.
- 3) Hold the template securely and trowel over with approved cement to fill all of the template area.
- 4) Carefully lift the template from the graphite part and examine the detail of the characters.
- 5) If acceptable, cure the cement.
- 6) If the characters are incorrect or damaged, wipe off the cement with a compatible solvent and reapply.

Note: The preceding methods can be applied jointly to identify the graphite part and to transfer the "R" stamp.

5.11 REMOVAL OF ORIGINAL STAMPING OR NAMEPLATE

If it becomes necessary to remove original stamping, the Inspector shall, subject to the approval of the Jurisdiction, witness making of a facsimile of stamping, the obliteration of old stamping, and transfer of stamping to the new item. When stamping is on a nameplate, the Inspector shall witness transfer of nameplate to the new location. Any relocation shall be described on the applicable NBIC "R" Form. The re-stamping or replacement of a code symbol stamp shall be performed only as permitted by the governing code of construction.

PART 3, SECTION 6

REPAIRS AND ALTERATIONS — SUPPLEMENTS

SUPPLEMENT 1

STEAM LOCOMOTIVE FIRETUBE BOILER REPAIRS

S1.1 SCOPE

This supplement provides requirements and guidelines for repair and alteration of steam locomotives operating on track gaged 24 in. (610 mm) or greater, or for steam locomotives under the requirements of the Federal Railroad Administration (FRA). These rules shall be used in conjunction with the applicable rules of the NBIC.

S1.1.1 FEDERAL RAILROAD ADMINISTRATION (FRA)

The Federal Railroad Administration (FRA) rules for steam locomotive boilers are published in the *Code of Federal Regulations* (CFR) 49CFR Part 230, dated November 17, 1999, which may be obtained on the FRA website. All locomotives under FRA jurisdiction are documented on FRA Form 4 as defined in 49CFR Part 230. This document is the formal documentation of the steam locomotive boiler and is required to be completed prior to the boiler being placed in service. This document shall be used as the data report for the boiler, applicable to all repairs and alterations performed. National Board “R” Certificate Holders shall document their repairs and/or alterations on National Board Forms R-1 or R-2. These reports shall be distributed to the owner-user of the boiler, who is required to incorporate them into an FRA Form 19, which becomes an attachment to the FRA Form 4. The design margin for all such repairs or alterations shall not be less than four, based on ultimate tensile strength of the material.

S1.1.2 REQUIREMENTS FOR WELDING ACTIVITIES

- a) Before performing any welding activities, consideration shall be given to ensure the weldability of locomotive boiler materials.
- b) Special jurisdictional approval may be required prior to starting welding activity on locomotive boilers.

S1.1.3 MATERIALS

- a) The older steels used in riveted construction were frequently rimmed steels, high in carbon, sulfur, phosphorus and hydrogen. The older steels were not melted to a fine grain practice and will typically have poor toughness properties.
- b) If welding is to be used to repair a pressure-retaining item that was manufactured using riveted construction, the repair organization should perform a chemical composition analysis on the steel plate base metal and rivet material to determine weldability. Specific quantities of carbon, manganese, sulfur, phosphorus, and aluminum shall be identified and included in the analysis. The result of the analysis shall be acceptable to the Inspector and Jurisdiction when required.

S1.1.3.1 MATERIAL LIST FOR STEAM LOCOMOTIVE BOILERS

(23)

Table S1.1.3.1 is intended as a basic guideline only and covers basic carbon steel and some alloy steel material specifications. Other alloy materials may be available for these applications if necessary.

- a) SA-516 steel is recommended for firebox repairs. It is a fine grain steel that accepts flanging and bending with less tendency to crack than coarse grain steels such as SA-515 or SA-285 Grade C. Coarse

grain steels have, on occasion, been found to crack or split after complicated flanging, bending, and forming.

- b) SA-36 shall not be used to make any pressure-retaining part such as shells, staybolt sleeves, or caps.
- c) When rivets are made from SA-675, the finished rivets must meet the physical requirements of the original rivet specification or SA-31 Grade A or B.
- d) When staybolt material tensile strength is greater than that of the firebox sheets, the firebox sheets deflect instead of the staybolts, which can result in the sheets developing cracks and leaking staybolts. In addition, high tensile strength steels are difficult to drive. Maximum allowable tensile stress shall be 7,500 psi (51.71 MPa).

TABLE S1.1.3.1

Application	Specification
Boiler Tubes & Flues, Arch Tubes Superheater Units	SA-178 Grade A, SA-192, SA-210
Boiler & Firebox Plate, Pressure Retaining Plate	SA-285 Grade C, SA-515, SA-516, SA-203, SA-204
Welded Staybolts	SA-675, SA-36, SA-31
Threaded Staybolts and Patch Bolts	SA-31 Grade A, SA-675 grade 45, 50, 55
Staybolt Sleeves and Caps	SA-105 Forging, SA-675, SA-696, SA-216 WCA, SA-217 WC1
Boiler Braces	SA-675, SA-36
Rivets	SA-675, SA-31
Forged Parts & Fittings	SA-105, SA-181
Pressure-Retaining Steel Castings	SA-216, A-217
Hollow Cylindrical Pressure-Retaining Parts	SA-105 Forgings, SA-675 Bar Stock, SA-696
Superheater Unit Bolts & Nuts	Bolts - SA-193, Nuts - SA-194
Pipe Flanges	SA-181, SA-105
Bolts & Studs	SA-307 Grades A&B, SA-675 grade 60, 65, 70
Pipe	SA-106, SA-53 seamless
Bronze Castings & Washout Plugs	SB-61, SB-62, SB-148, SA-696

S1.1.4 FORMULA AND CALCULATIONS FOR STEAM LOCOMOTIVE BOILERS

- a) Most steam locomotive boilers were manufactured in the first half of the 20th century or before. The calculations, formula, and shop practices used are now distant history and quite difficult to obtain. The rules for riveted construction were last published by ASME in Section I Code, 1971 Edition. Currently, ASME, Section I, Part PR and Part PL, govern riveted construction and steam locomotive boiler construction, and these Parts may be referenced for repairs and alterations if appropriate for the boiler under repair/alteration.
- b) This supplement herein, is based in part on the ASME Code, Section III, 1952 Edition, which was the last published edition of the Steam Locomotive Code. The railroad industry has attempted to collect the old formula and some shop practices. These have been published by The Engineering Standards Committee for Steam Locomotives, Inc. (ESC) as Compendium, Volume 1, Compilation of Calculations, which may be obtained from the Strasburg Rail Road, P.O. Box 96, Strasburg, PA 17579 (717) 687-7421.

S1.2 LOCOMOTIVE FIRETUBE BOILER REPAIRS

S1.2.1 REPAIR OF STAYBOLT HOLES

- a) Staybolt holes may be repaired by welding, reaming, or retapping to a larger size or by installing a flush patch.
- b) If the staybolt hole was threaded and is to be repaired by welding, the threads shall be removed prior to welding.

S1.2.2 THREADED STAYBOLTS

- a) All threaded staybolts shall have a pitch between 10 and 13 threads per inch inclusive, (2 mm to 2.5 mm). Staybolt threads shall have a good close fit in sheets. Changing the staybolt thread pitch from any pitch within the allowed range to another pitch within the allowed range shall be considered a repair.
- b) All staybolts shorter than 8 in. (200 mm) in length shall have telltale holes. Staybolt telltale holes in existing staybolts shall be 3/16 in. (5 mm) to 7/32 in. (5.5 mm) in diameter and at least 1-1/4 in. (32 mm) deep in the outer end. When staybolts 8 in. (200 mm) or less in length are replaced, they shall be replaced with staybolts that have a telltale hole 3/16 in. (5 mm) to 7/32 in. (5.5 mm) in diameter their entire length, or with ones that have a 3/16 in. (5 mm) to 7/32 in. (5.5 mm) diameter hole in each end, drilled a minimum of 1-1/4 in. (32 mm) deep. On reduced body staybolts, the telltale hole shall extend beyond the fillet and into the reduced section of the staybolt. Ball socket-type flexible staybolts may have telltale holes that extend from the threaded end of the bolt into the bolt head for a distance of one-third the spherical bolt head diameter.
- c) Telltale holes shall be reopened after driving and riveting heads.
- d) Staybolt length shall be sized so the length of bolt projecting through the sheet is not less than 1/8 in. (3 mm) and is sufficient to produce a full head after driving and riveting the head.
- e) The thread lead of both bolt ends and both firebox sheets shall be synchronized to permit the staybolt to be installed without stripping the threads.
- f) When riveting staybolt heads, the bolt's opposite end shall be bucked or braced to prevent damaging the staybolt's threads. Bracing can be done several ways, such as using a pneumatic holder or a heavy steel bucking bar. Driving the heads on both ends of the staybolt simultaneously, using two pneumatic rivet hammers (double gunning), is acceptable. Staybolts are to be driven in such a manner as to expand radially the staybolt body and threads into the sheet prior to forming the head. Merely driving over the head is not acceptable.
- g) Ball socket-type flexible staybolts shall not be braced by inserting a spacer under the cap.
- h) Installation of different diameter staybolts shall be considered a repair provided the stay stress does not exceed 7500 psi (52.5 MPa). Cautionary Note: Larger diameter staybolts will transfer stresses to other structures and will be subject to higher extreme fiber stresses.
- i) If the ends of staybolts are heated to facilitate forming the head or expanding the threads into the sheet, the lower critical temperature of the sheet and staybolt material shall not be exceeded.
- j) The minimum height of the staybolt head measured at its highest point shall be 1/16 in. (1.5 mm).
- k) When the diameter of the staybolt head has been reduced to the major diameter of the staybolt thread at any location either because of erosion during service or problems during installation, the staybolt shall be replaced. Repair is prohibited.

FIGURE S1.2.2-a
THREADED STAYBOLTS

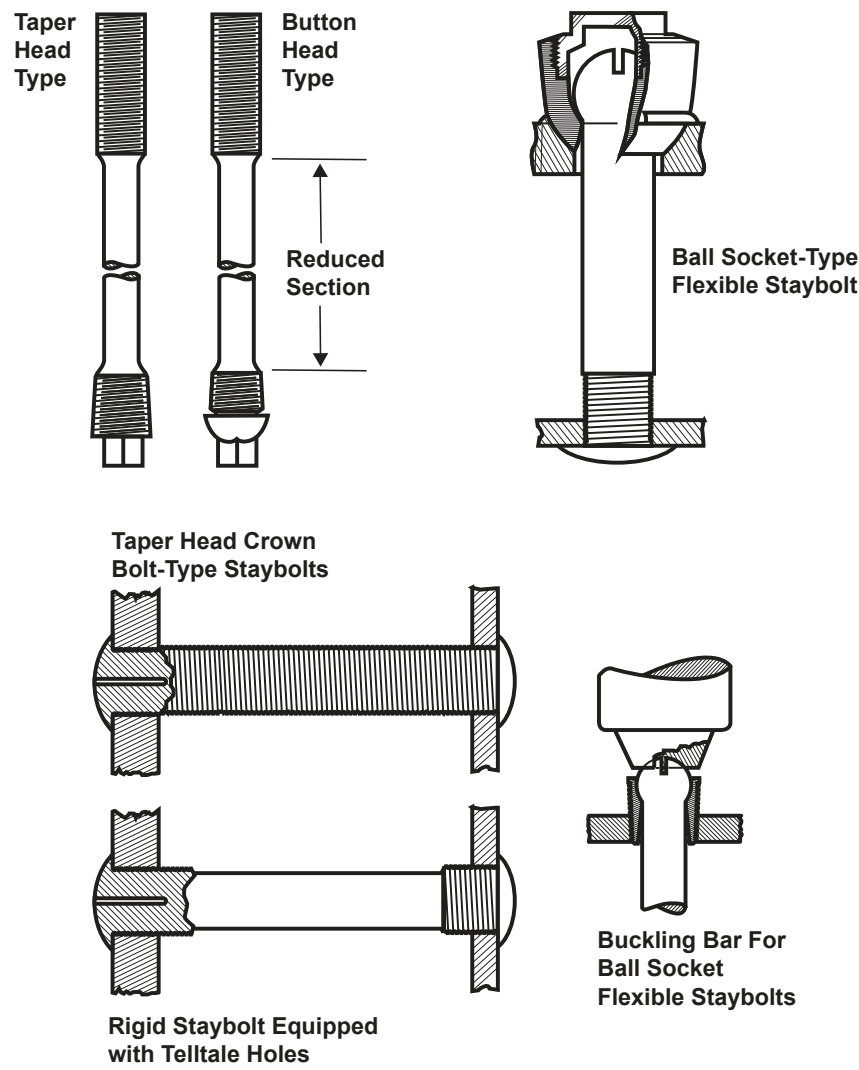
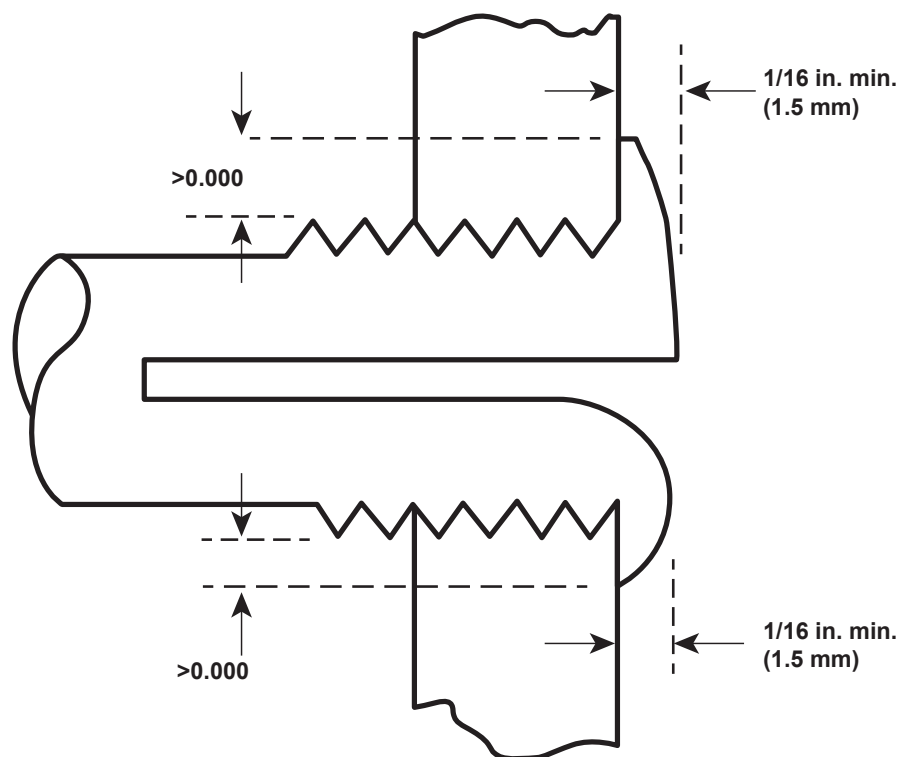


FIGURE S1.2.2-b
RIVETED STAYBOLT HEAD DIMENSIONS



Minimum diameter of staybolt riveted or upset head shall be greater than the staybolt major thread diameter at all points.

S1.2.3 BALL SOCKET-TYPE FLEXIBLE STAYBOLTS, SLEEVES, AND CAPS

- Welded flexible staybolt sleeves shall be applied as shown in NBIC Part 3, Figures S1.2.3-a through S1.2.3-e. Sleeve axis shall be in alignment with centerline through holes in wrapper and firebox sheets.
- Welded sleeves and welded caps that leak at the welds or the sleeve shall be repaired.
- Wasted caps and sleeves shall not be repaired by weld buildup.
- Welded sleeves that have damaged cap threads shall be repaired or replaced. If the sleeve has wasted to less than 60% of the original thickness at the threaded cap section, it may be repaired by cutting off the threaded section and welding on a replacement section using full penetration welds.
- Threaded or welded sleeves that are cracked or have wasted to less than 60% of the original thickness at any section other than the threaded cap section shall be replaced.
- Threaded sleeves that leak where screwed into the boiler shell or wrapper sheet shall be repaired. Seal welding of one pass not exceeding $3/16 \text{ in. (5 mm)}$ leg size is permissible for caulking purposes only. If seal welding is applied, the sleeve threads in the weld zone shall be removed prior to welding.
- New threaded sleeves seal welded after installation shall have the threads removed from the weld zone of the sleeve prior to welding.
- Threaded staybolt caps that leak shall not be seal welded.

- i) Substitution of one type of flexible staybolt sleeve by another type shall be considered a repair.
- j) Where necessary for boiler expansion, ball socket-type flexible staybolts shall be positioned in such a manner as to not interfere with boiler expansion. Where individual bolts are replaced, care should be taken to ensure that the stress load of the new bolt is compatible to the loading on adjacent bolts.

Note: Some locomotive boiler designs positioned the bolts by backing the bolt head away from the sleeve socket bottom a certain amount.

FIGURE S1.2.3-a

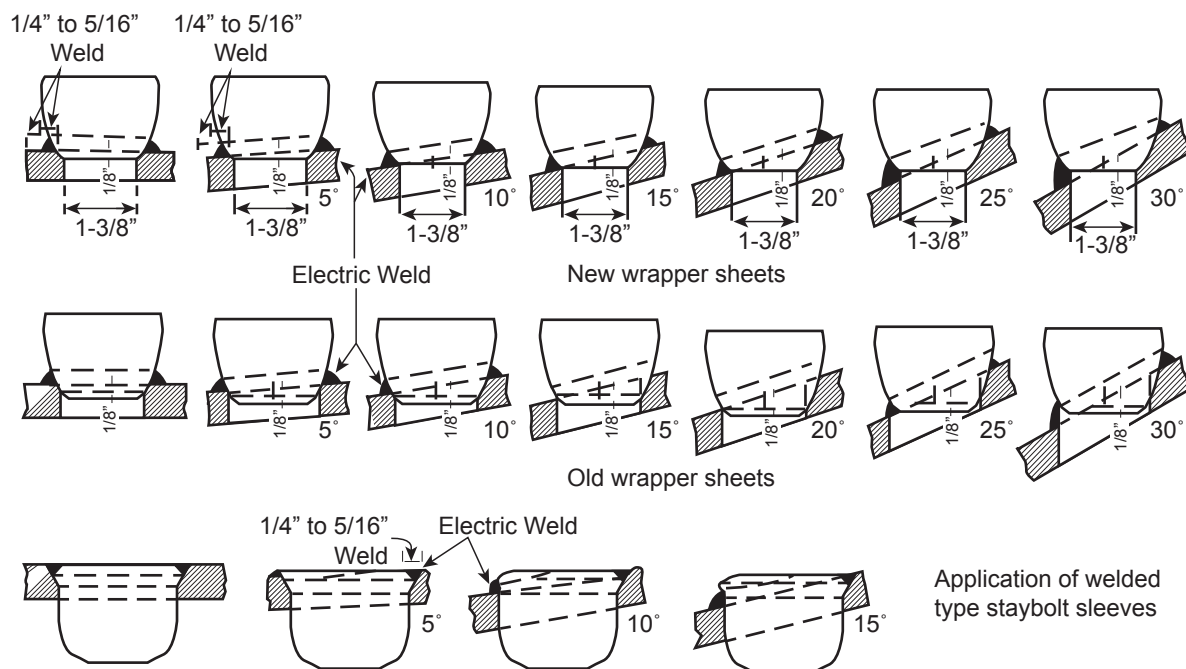
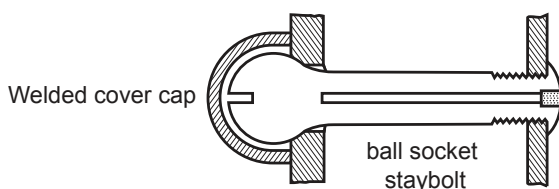


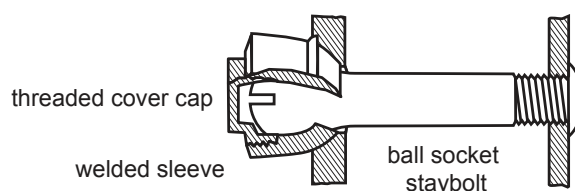
FIGURE S1.2.3-b

BALL SOCKET-TYPE FLEXIBLE STAYBOLTS

Welded cover cap type



Welded Sleeve with Threaded Cover Cap Type



Threaded Sleeve with Threaded Cover Cap Type

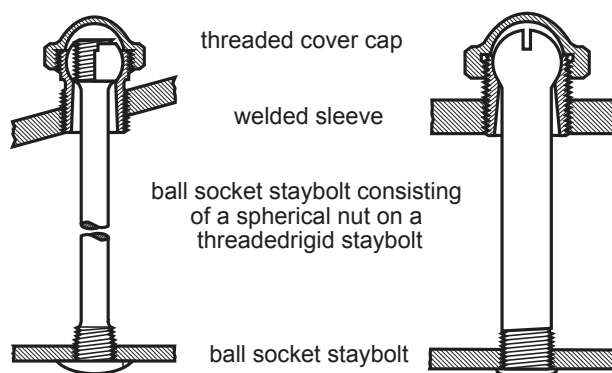
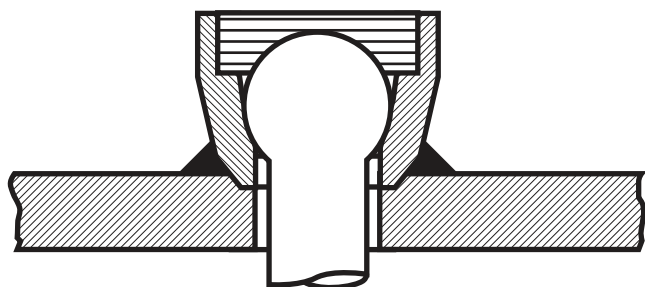
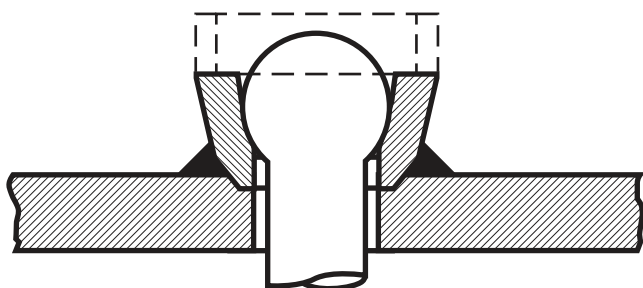


FIGURE S1.2.3-c**HALF SLEEVE REPAIR PROCEDURE FOR DAMAGED BALL SOCKET FLEXIBLE STAYBOLT WELDED SLEEVE**

welded sleeve damaged at threaded section



Remove threaded section down to gasket surface



Do not remove existing flexible staybolt

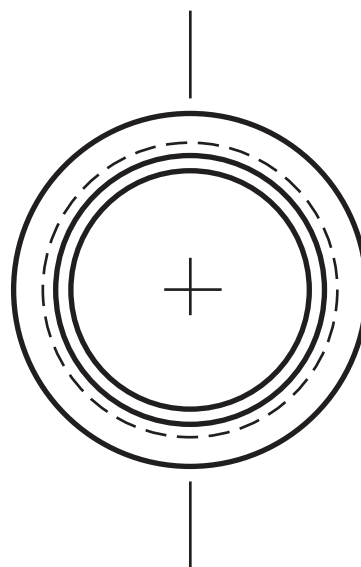
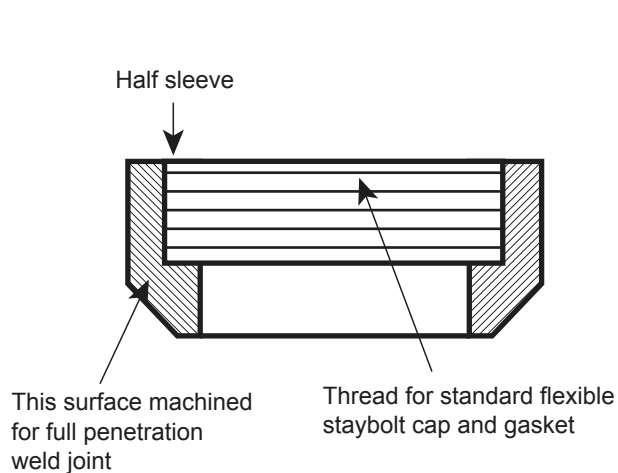
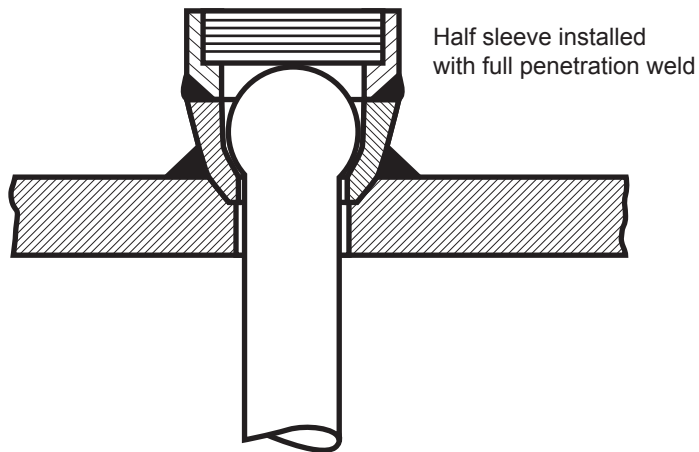
FIGURE S1.2.3-d**HALF SLEEVE REPAIR PROCEDURE FOR DAMAGED BALL SOCKET FLEXIBLE STAYBOLT WELDED SLEEVE**

FIGURE S1.2.3-e

HALF SLEEVE REPAIR PROCEDURE FOR DAMAGED BALL SOCKET FLEXIBLE STAYBOLT
WELDED SLEEVE

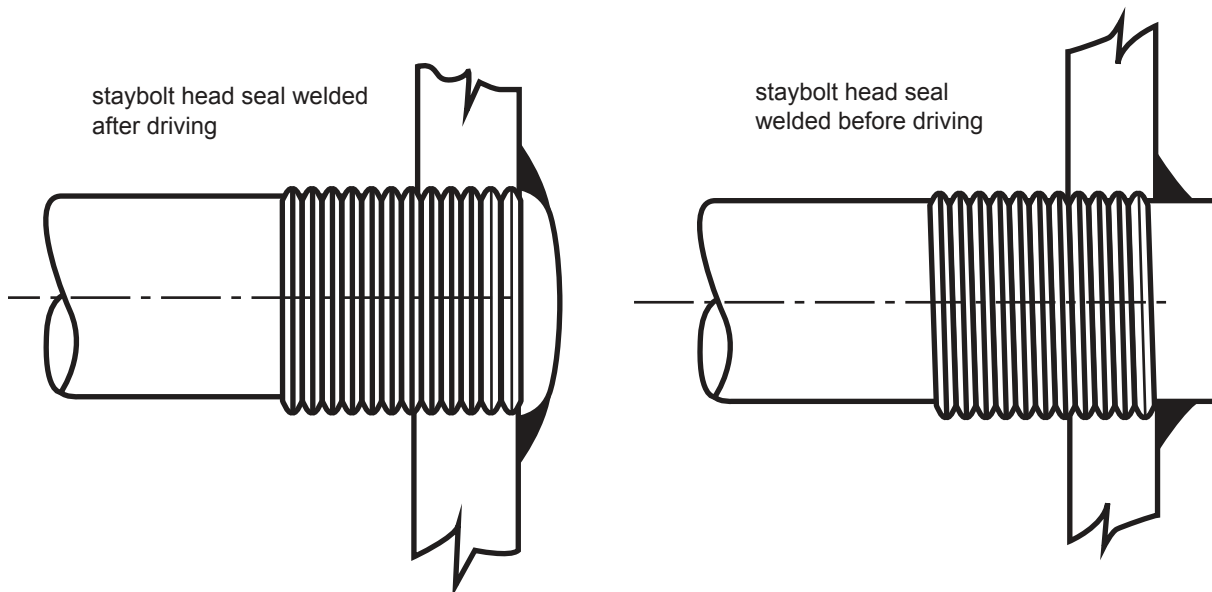


S1.2.4 SEAL WELDED STAYBOLTS

- Replacement threaded staybolts may be seal welded before or after driving.
- Existing threaded staybolts that leak shall be repaired and may be seal welded. When used, seal welding shall not be the sole means of repair.

FIGURE S1.2.4

SEAL WELDED STAYBOLTS



S1.2.5 WELDED INSTALLATION OF STAYBOLTS

- a) The installation of unthreaded staybolts using full penetration welds is permissible.
- b) All staybolts shorter than 8 in. (200 mm) in length shall have telltale holes. Telltale hole diameter shall be 3/16 in. (5 mm) to 7/32 in. (5.5 mm) in diameter and at least 1-1/4 in. (32 mm) deep in the outer end. On reduced body staybolts, the telltale hole shall extend beyond the fillet and into the reduced section of the staybolt. Staybolts should have through telltale holes, which are preferred. Ball socket-type flexible staybolts may have telltale holes that extend from the welded end of the bolt into the bolt head for a distance of one-third the spherical bolt head diameter.
- c) Where necessary for boiler expansion, ball socket-type flexible staybolts shall be positioned in such a manner as to not interfere with boiler expansion. Where individual bolts are replaced, care should be taken to ensure that the stress load of the new bolt is compatible to the loading of adjacent bolts.

Note: Some locomotive boiler designs positioned the bolts by backing the bolt head away from the sleeve socket bottom a certain amount.

- d) Installation of different diameter staybolts shall be considered a repair provided the stay stress does not exceed 7500 psi (52.5 MPa). Cautionary Note: Larger diameter staybolts will transfer stresses to other structures and will be subject to higher extreme fiber stresses.

S1.2.5.1 UN-THREADED FILLET-WELDED STAYBOLTS

The replacement of threaded staybolts with fillet welded staybolts is permissible. The work shall be done in accordance with the ASME BPVC, Section I, Part PL-30 and Figure PL-30.4.2-1. When replacing a threaded staybolt with a fillet welded staybolt, the existing threads in the sheets must be removed prior to installation. Cautionary Note: Larger minimum diameter staybolts will transfer stresses to other structures and will be subject to higher extreme fiber stresses.

Repairs to un-threaded fillet welded staybolts shall be performed in accordance with the original code of construction. If the original code of construction is not known, repairs shall be performed as follows in accordance with an appropriate code of construction that allows fillet welded staybolts:

- a) The replacement of un-threaded fillet-welded staybolts is permissible.
- b) Existing un-threaded fillet-welded staybolts that leak shall be repaired by re-welding after mechanically removing the entire weld. Only the leaking stays are to be re-welded.
- c) Minor leakages (sweat pores) may be repaired by gently caulking the fillet weld. However, identifiable cracks shall be removed before re-welding.

S1.2.6 DIAGONAL BRACES, GUSSET BRACES, AND THROAT SHEET/TUBESHEET BRACES

- a) Loose or damaged braces shall be repaired or replaced.
- b) Only steel braces may be repaired by welding. All such welds shall be full penetration. Wrought iron braces shall not be repaired by welding. When repairs or alterations are completed, the tightness and condition of the braces and their staybolts, rivets, clevises, eyes, and pins shall be verified.
- c) For pins that are fitted with nuts, the pin length shall be sized so that all threads of the nut are engaged upon completion of installation.
- d) Replacement of diagonal stays having loop-type ends shall be considered a repair.

FIGURE S1.2.6-a
DIAGONAL BRACES, GUSSET BRACES, AND THROAT SHEET/TUBESHEET BRACES

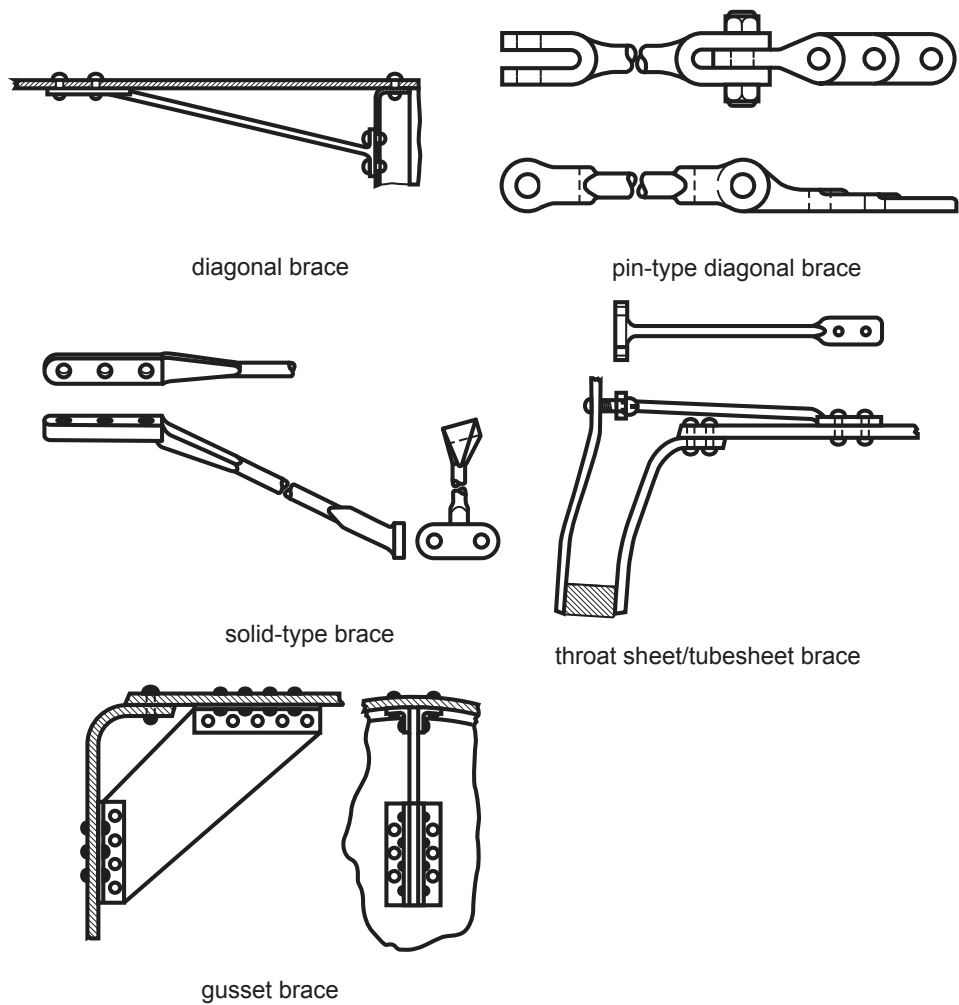
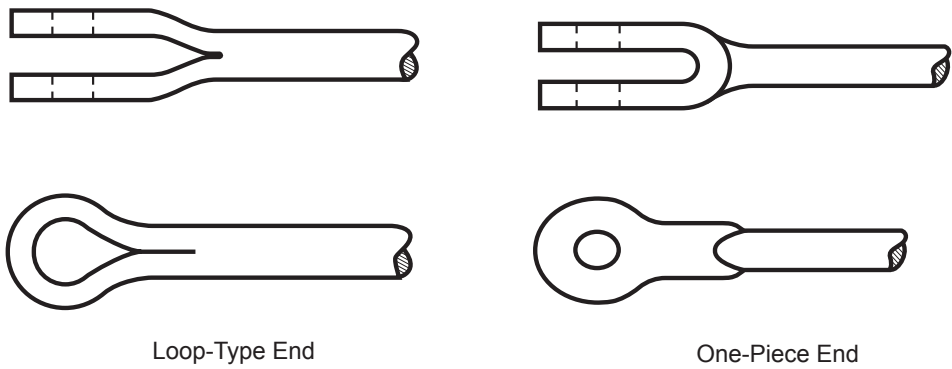


FIGURE S1.2.6-b
DIAGONAL BRACE ENDS

Diagonal Brace Ends



S1.2.6.1 GIRDER STAYS AND CROWN BARS

- a) When repairs or alterations are completed, the installation and condition of the crown bars or girder stays and all associated fittings, including stays, rivets, pins, washers, nuts, thimbles, spacers and retainers, shall be verified.
- b) Crown bars, girder stays and associated parts shall have the correct fit, alignment and bearing to the firebox and boiler sheets.
- c) Wrought iron crown bars and girder stays, and all associated fittings, shall not be repaired by welding or application of riveted or bolted patches.
- d) Steel crown bars, steel girder stays and associated steel brackets may be repaired or fabricated by welding. Welded repairs and components shall be made and examined in accordance with the ASME Boiler and Pressure Vessel Code, Section I.
- e) Steel crown bars, steel girder stays and associated steel brackets, wasted or worn to less than 60% of original thickness, shall not be repaired by weld buildup.
- f) On stays and pins that are fitted with nuts, the stay or pin length shall be sized so that all threads of the nut are engaged upon completion of installation.
- g) When driving crown bolts, the opposite bolt end shall be bucked or braced to prevent damaging the bolt threads in the firebox sheet. Bracing can be done several ways such as using a pneumatic holder-on or heavy steel bucking bar. The crown bolt head is to be driven in such a manner as to expand radially the crown bolt body and threads into the sheet prior to forming the head. Merely driving over the head is not acceptable.
- h) Telltale holes shall be reopened after driving.
- i) Crown bolts shall have either 11- or 12- thread pitch in the firebox sheets. Stay threads shall have good close fit in the firebox sheet. Changing the thread pitch from 11 to 12, or the reverse, shall be considered a repair.

FIGURE S1.2.6.1-a

GIRDER STAY

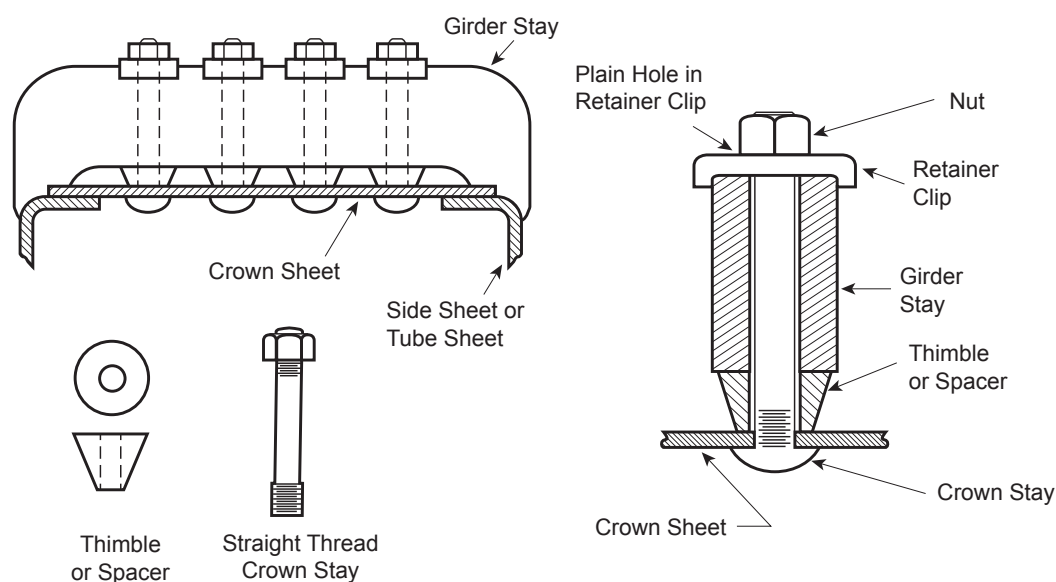
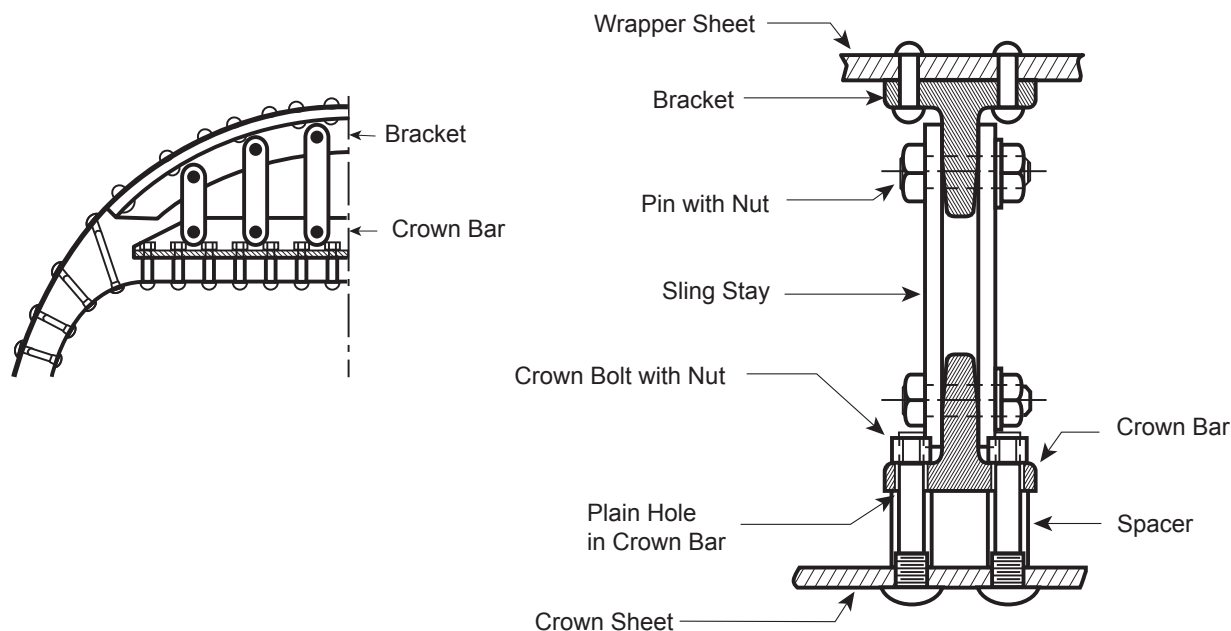


FIGURE S1.2.6.1-b
CROWN BAR WITH SLING STAYS



S1.2.6.2 SLING STAYS

- a) When repairs or alterations are completed, the installation and condition of the sling stays and all associated fittings, including brackets, rivets, pins, washers, nuts, thimbles and spacers, shall be verified.
- b) Sling stays and the associated parts shall have the correct fit, alignment, and bearing to the crown bars, girder stays, firebox sheets and boiler sheets.
- c) On pins that are fitted with nuts the pin length shall be sized so that all threads of the nut are engaged upon completion of installation.
- d) Sling stays fabricated or repaired by welding shall be welded and examined in accordance with the ASME Boiler and Pressure Vessel Code Section I.
- e) Holes and slots in sling stays should have all edges rounded off.
- f) When driving sling-stay eye brackets, the opposite bracket end shall be bucked or braced to prevent damaging the threads. Bracing can be done several ways such as using a pneumatic holder-on or heavy steel bucking bar. The head of the sling stay eye bracket is to be driven in such a manner as to expand radially the body and threads into the sheet prior to forming the head. Merely driving over the head is not acceptable.
- g) All sling stays, nuts, and pins shall be retained mechanically or have mechanical retainers installed when renewed or replaced.

FIGURE S1.2.6.2-a
EYE-TYPE SLING STAY

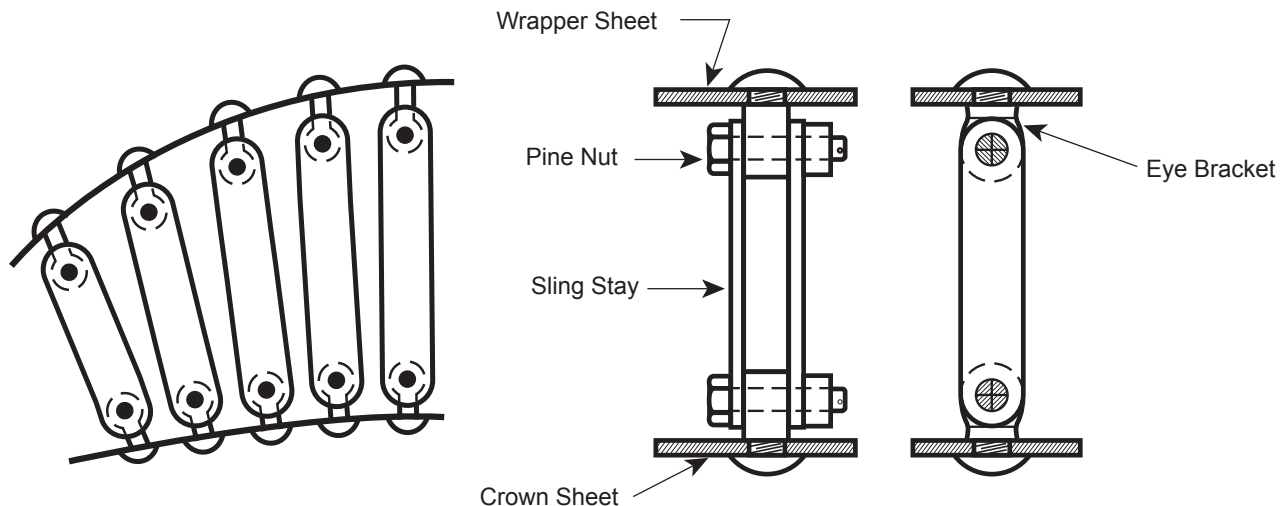
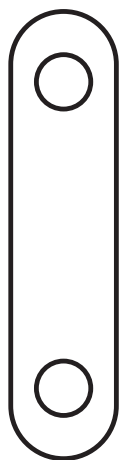


FIGURE S1.2.6.2-b



Sling Stay With
Round Pin Holes



Sling Stay With
Expansion Slot For Pin

S1.2.6.3 EXPANSION STAYS

- When repairs or alterations are completed, the installation and condition of the expansion stays and all associated fittings, including brackets, rivets, pins, washers, nuts, thimbles and spacers, shall be verified.
- Wrought iron expansion stay brackets shall not be repaired by welding.
- Expansion stays shall not be repaired by welding.

- d) Worn pin holes and expansion slots of steel expansion stay brackets may be repaired by welding.
- e) On stays and pins that are fitted with nuts, the stay or pin length shall be sized so that all threads of the nut are engaged upon completion of installation.
- f) Stay length shall be sized so the length of the stay projecting through the sheet is not less than 1/8 in. (3.2 mm) and is sufficient to produce a full head after driving.
- g) Stays shall have either 11 or 12 thread pitch. Stay threads shall have good close fit in the sheet. Changing the thread pitch from 11 to 12 or the reverse, shall be considered a repair.
- h) Installation of expansion stays that have a different diameter in the firebox sheet shall be considered a repair.
- i) Installation of expansion stays that have a different diameter in the bracket shall be considered a repair, provided the changes are within the stress limits of the original code of construction.
- j) When driving expansion stay heads, the opposite end shall be bucked or braced to prevent damaging the threads. Bracing can be done several ways, such as using a pneumatic holder-on or heavy steel bucking bar. The stay head is to be driven in such a manner as to expand radially the stay body and threads into the sheet prior to forming the head. Merely driving over the head is not acceptable.
- k) Telltale holes shall be reopened after driving.

FIGURE S1.2.6.3-a
EXPANSION STAY

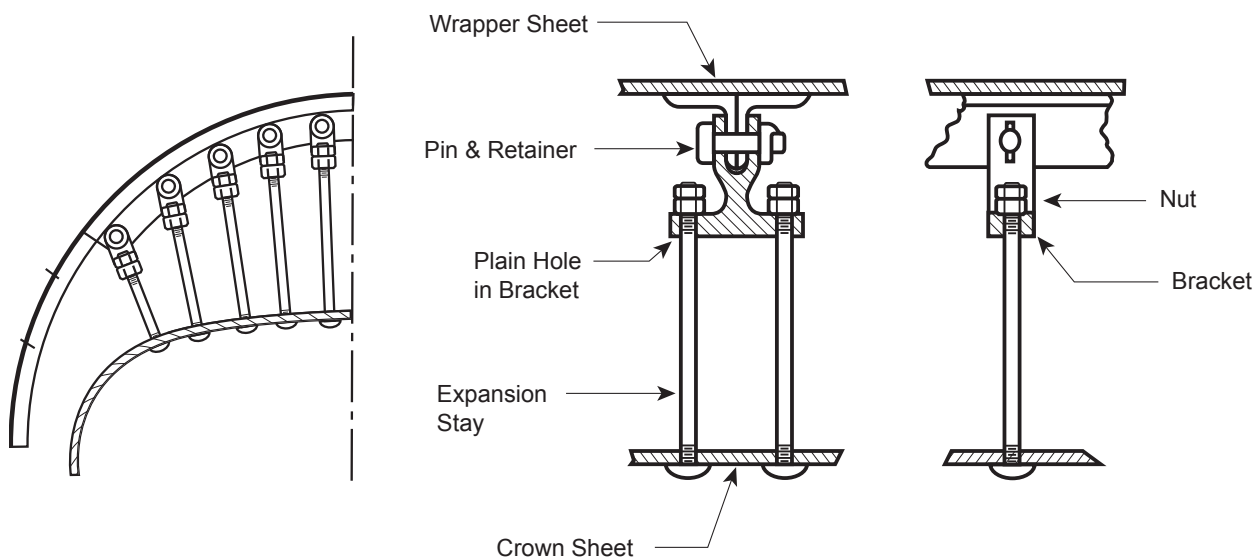
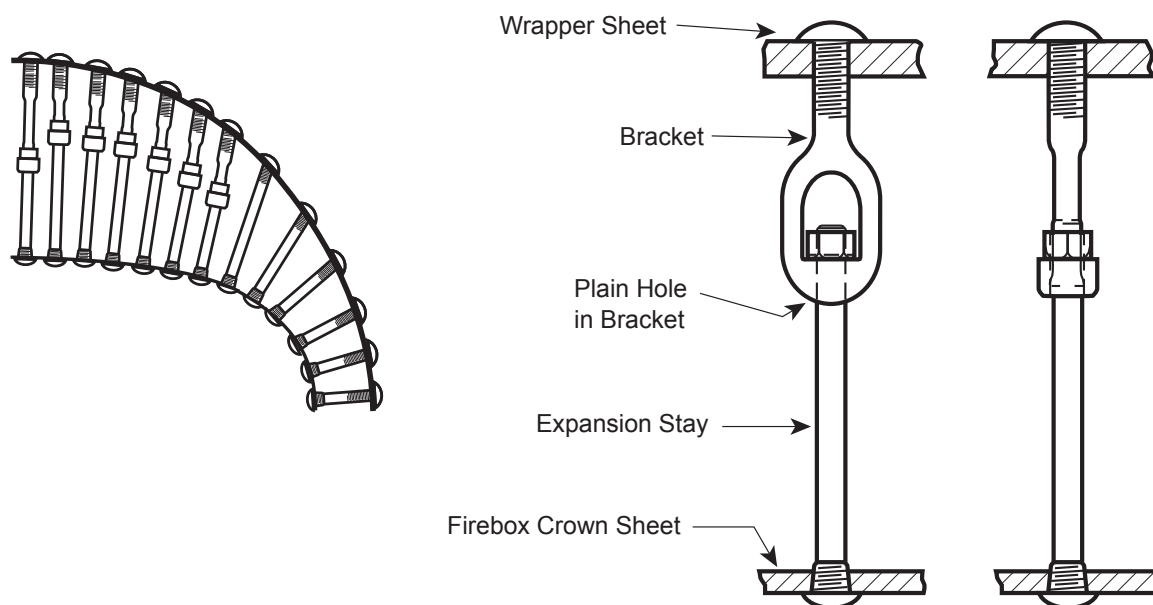


FIGURE S1.2.6.3-b
BALDWIN-TYPE EXPANSION STAY



S1.2.7 THREADED STUDS

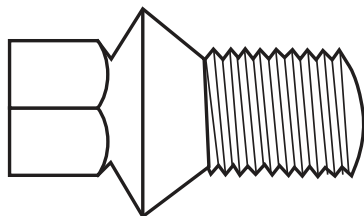
Studs threaded into the boiler or firebox sheets shall not be seal welded.

S1.2.8 PATCH BOLTS

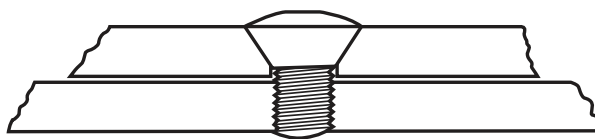
- ASME Section I, Part PL may be used for application of patch bolts.
- Patch bolts may be replaced in kind.
- Seal welding of bolts is permitted.
- Patch bolts shall have either 11 or 12 thread pitch. Patch bolt threads shall be fit to support the structure to which the bolt is applied. Changing the patch bolt thread from 11 to 12, or the reverse, shall be considered a repair.
- A patch bolt applied in place of a rivet shall be considered an alteration.

FIGURE S1.2.8
PATCH BOLTS

Typical patch bolt



Typical patch bolt application



S1.2.9 FLUES, ARCH TUBES, CIRCULATORS, THERMIC SYPHONS**TABLE S1.2.9.1**

MAXIMUM ALLOWABLE WORKING PRESSURES FOR STEEL TUBES OR FLUES FOR FIRETUBE BOILERS FOR DIFFERENT DIAMETERS AND GAGES OF TUBES CONFORMING TO THE REQUIREMENTS OF SPEC. SA-178, SA-192, SA-209, OR SA-210*

Outside diameter of tube, inches D	Minimum gage, Birmingham Wire Gage (BWG), inches									
	13 t = 0.095	12 t = 0.109	11 t = 0.120	10 t = 0.134	9 t = 0.148	8 t = 0.165	7 t = 0.180	6 t = 0.203	5 t = 0.220	4 t = 0.238
1	470	690	—	—	—	—	—	—	—	—
1-1/2	320	460	570	720	860	—	—	—	—	—
1-3/4	270	400	490	620	740	890	—	—	—	—
2	240	350	430	540	650	780	900	—	—	—
2-1/4	210	310	380	480	580	690	800	960	—	—
2-1/2	190	280	350	430	520	620	720	860	970	1,080
3	160	230	290	360	430	520	600	720	810	900
3-1/4	—	210	270	330	400	480	550	660	740	830
3-1/2	—	200	250	310	370	450	510	620	690	770
4	—	180	220	270	330	390	450	540	610	680
4-1/2	—	160	190	240	290	350	400	480	540	600
5	—	—	180	220	260	310	360	430	490	540
5-3/8	—	—	160	200	240	290	340	400	450	500
5-1/2	—	—	—	200	240	290	330	390	440	490
6	—	—	—	180	220	260	300	360	410	450
$P = \{(t-0.065)/D\} \times 15550$ where P = maximum allowable working pressure, pounds per square inch, t = minimum wall thickness, inches, D = outside diameter of tubes, inches.										
For pressures below those given in the table, the gage thickness shall be not less than the minimum given in the table.										
* Calculated values of pressure have been rounded to the next higher unit of 10 psi.										

TABLE S1.2.9.1 M

MAXIMUM ALLOWABLE WORKING PRESSURES FOR STEEL TUBES OR FLUES FOR FIRETUBE BOILERS FOR DIFFERENT DIAMETERS AND GAGES OF TUBES CONFORMING TO THE REQUIREMENTS OF SPEC. SA-178, SA-192, SA-209, OR SA-210*

Outside diameter of tube, mm D	Minimum gage, Birmingham Wire Gage (BWG), to mm									
	13 t = 2.4	12 t = 2.8	11 t = 3.0	10 t = 3.4	9 t = 3.8	8 t = 4.2	7 t = 4.6	6 t = 5.2	5 t = 5.6	4 t = 6.0
25	3,250	4,950	—	—	—	—	—	—	—	—
40	2,150	3,250	3,850	4,950	6,100	—	—	—	—	—
45	1,850	2,800	3,300	4,300	5,250	6,250	—	—	—	—
50	1,650	2,450	2,850	3,700	4,550	5,350	6,200	—	—	—
60	1,450	2,200	2,550	3,300	4,050	4,800	5,550	6,700	—	—
65	1,300	1,950	2,300	2,950	3,600	4,300	4,950	5,950	6,650	7,300
75	1,100	1,650	1,950	2,500	3,050	3,600	4,200	5,000	5,600	6,150
85	—	1,500	1,750	2,300	2,800	3,300	3,850	4,600	5,100	5,650
90	—	1,400	1,650	2,150	2,600	3,100	3,550	4,300	4,750	5,250
100	—	1,250	1,450	1,850	2,300	2,700	3,100	3,750	4,150	5,600
115	—	1,100	1,300	1,650	2,050	2,400	2,800	3,300	3,750	4,100
125	—	—	1,150	1,500	1,850	2,200	2,500	3,000	3,350	3,700
135	—	—	1,100	1,400	1,700	2,000	2,350	2,800	3,100	3,400
140	—	—	—	1,350	1,650	2,000	2,300	2,750	3,050	3,350
150	—	—	—	1,250	1,550	1,800	2,100	2,500	2,800	3,100
$P = \{(t-1.65)/D\} \times 107000$ where P = maximum allowable working pressure, kilopascals (kPa), t = minimum wall thickness, mm, D = outside diameter of tubes, mm.										
For pressures below those given in the table, the gage thickness shall be not less than the minimum given in the table.										
* Calculated values of pressure have been rounded to the next higher unit of 50 kPa.										

S1.2.9.1 FLUE AND TUBE RE-ENDING

- Each boiler tube or flue that is repaired by welding is limited to not more than three circumferential welded joints.
- Re-ending is permitted provided, the thickness of the tube or flue to be re-ended is not less than 90% of that required by NBIC Part 3, Table S1.2.9.1.
- Re-end pieces shall be new material and meet the thickness requirements of NBIC Part 3, Table S1.2.9.1.

S1.2.9.2 ARCH TUBES

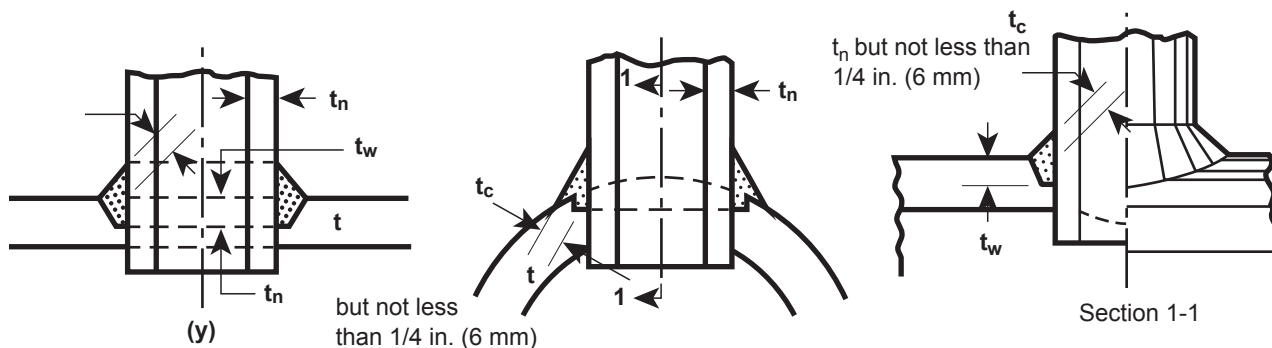
- Arch tubes that are damaged or reduced to less than minimum required wall thickness shall be replaced in entirety by new one-piece arch tubes. Welded repairs or partial replacement is not permitted. Damage includes defects such as bulging, burns, and cracks.
- When arch tubes are installed by rolling, the tube end shall project through the firebox sheet not less than 1/4 in. (6 mm) nor more than 3/4 in. (19 mm) before flaring. At a minimum, the tube shall be

expanded and flared at least 1/8 in. (3 mm) greater than the diameter of the tube hole. Additionally, the tube may be beaded and/or seal welded provided the throat of the seal weld is not more than 3/8 in. (10 mm), and the tube is finished rolled after welding.

- c) An arch tube installed by welding shall be considered a welded nozzle. Some acceptable weld joints are shown in NBIC Part 3, Figure S1.2.9.2-a (Ref. ASME Section I, Part PW 16.1).
- d) A change in tube attachment from rolled-to-welded or welded-to-rolled shall be considered an alteration.

FIGURE S1.2.9.2-a

WELDED INSTALLATION OF ARCH TUBE



t = thickness of vessel shell or head, in.

t_n = thickness of nozzle wall, in.

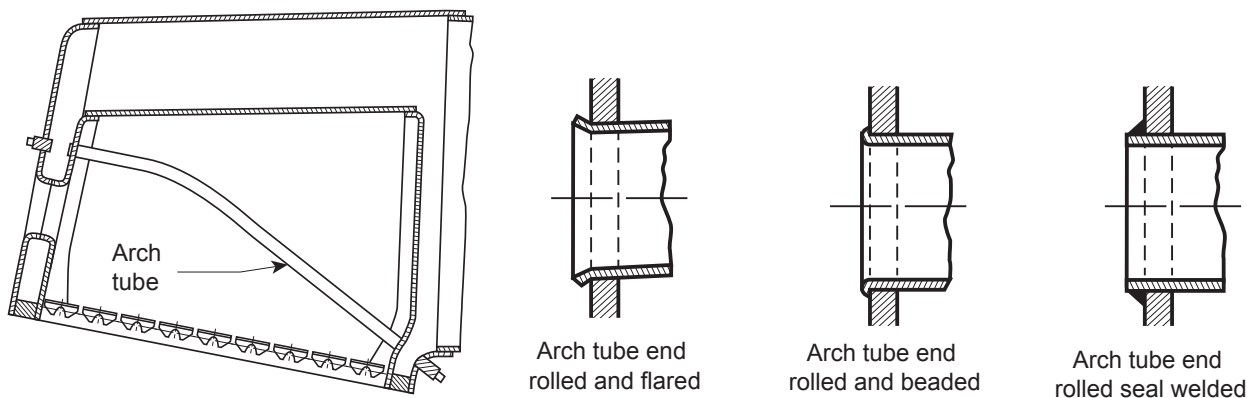
t_w = dimension of partial penetration attachment welds (fillet, single bevel, or single J), measured as shown in ASME Section I, Figure PW-16.1, in.

t_c = not less than the smaller of 1/4 in. (6 mm) or $0.7 t_{min}$ (inside corner welds may be further limited by a lesser length of projection of the nozzle wall beyond the inside face of the vessel wall)

t_{min} = the smaller of 3/4 in. (19 mm) or the thickness of either of the weld parts joined by a fillet, single bevel, or single J-weld, in.

FIGURE S1.2.9.2-b

EXAMPLE OF ARCH TUBE INSTALLATION



S1.2.9.3 TUBE WALL THICKNESS FOR ARCH TUBES

The minimum wall thickness of replacement arch tubes shall be as determined by the following formulas:

(U.S. Customary Units)

$$t = \frac{PD}{16,000} + 0.125$$

(SI Units)

$$t = \frac{PD}{111} + 3.175$$

where

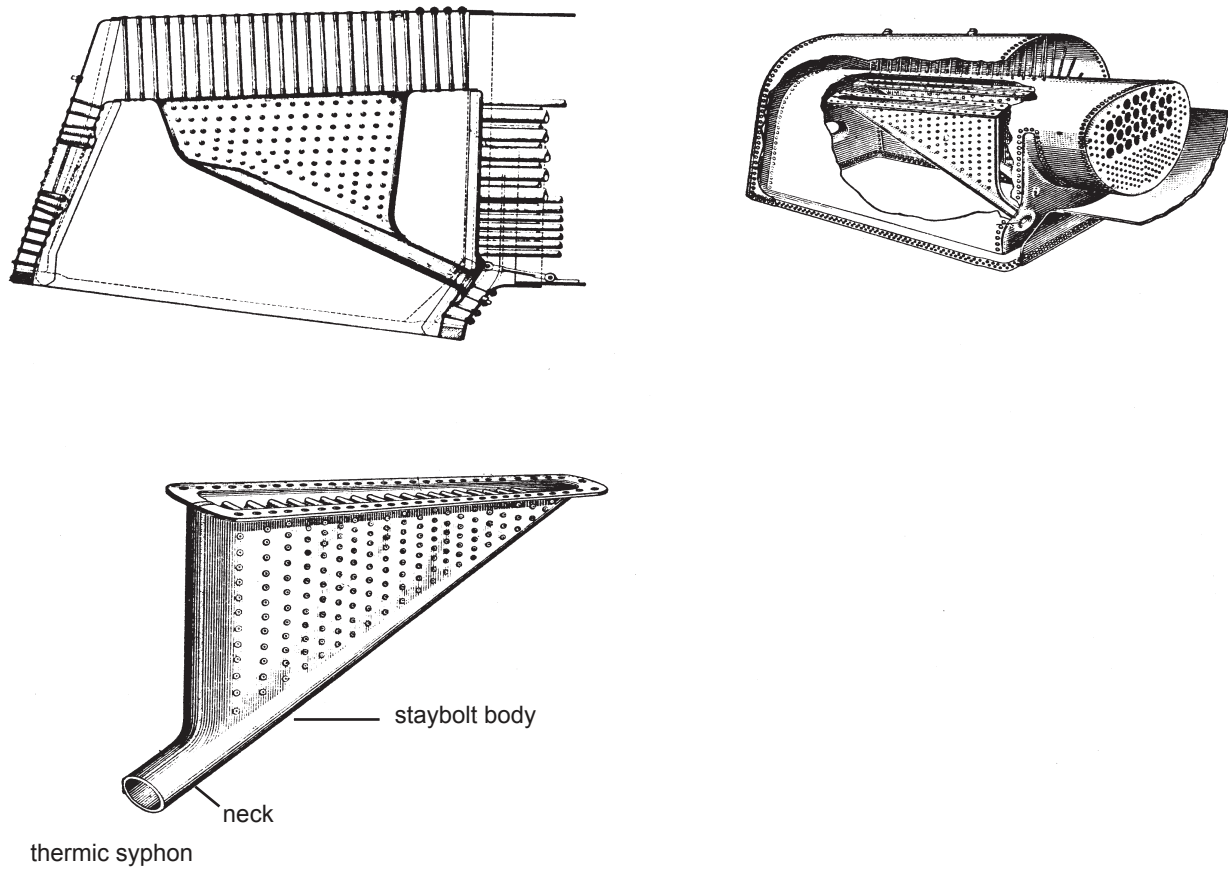
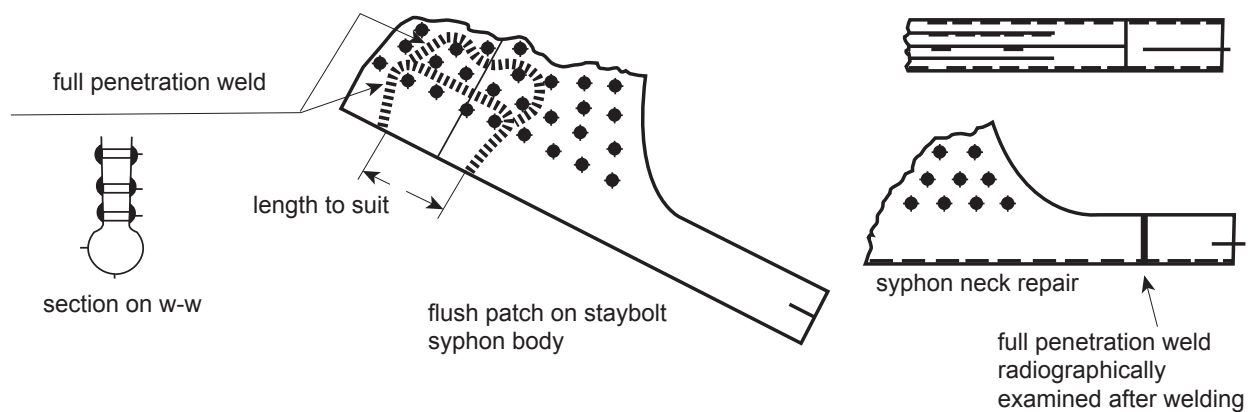
D = outside diameter of tube, in. (mm)

P = maximum allowable working pressure, psi (MPa)

t = thickness of tube wall, in. (mm)

S1.2.9.4 THERMIC SYPHONS

- a) For repairs to syphon knuckles see *Repair of Firebox and Tubesheet Knuckles*, and NBIC Part 3, Figures S1.2.11.5-a and S1.2.11.5-b.
- b) Except for the attachment weld to the throat sheet, welds on the thermic syphon unit shall be full penetration, and the unit shall be stress relieved in accordance with ASME, Section I, PW-39. Volumetric examination is not required.

FIGURE S1.2.9.4-a**LOCOMOTIVE FIREBOX THERMIC SYPHON INSTALLATION****FIGURE S1.2.9.4-b****THERMIC SYPHON REPAIR**

S1.2.9.5 CIRCULATORS

- a) All butt welds on circulators shall be radiographically examined.
- b) Welds applied to the circulator/firebox sheet joint shall be in accordance with the weld requirements for arch tubes. (See NBIC Part 3, Figure S1.2.9.2-a).

S1.2.9.6 INSTALLATION OF BOILER FLUES

- a) Maximum allowable working pressure and nominal wall thickness for flues shall be determined using Table S1.2.9.1 and Table S1.2.9.1M.
- b) Except as otherwise specified in this Part, per the requirements of ASME Section I, PFT-12.2. Flues shall not be attached by welding alone.
- c) All flues smaller than 3 in. (75 mm) O.D. shall be expanded and beaded, with or without seal welding, or expanded and welded on the firebox end. At least 1 in 10 distributed evenly on the front flue sheet shall be expanded and beaded or expanded and welded. All flues 3 in. (75 mm) O.D. and larger shall be expanded and beaded, with or without seal welding, or expanded and welded at both ends. All adjacent flues smaller than 3 in. (75 mm) O.D. that are within the area occupied by the larger superheater flues shall be expanded and beaded or expanded and welded at both ends. At least 1 in 10 of the remaining flues smaller than 3 in. (75 mm) O.D. shall be beaded and/or welded on the front flue sheet, in addition to expanding. Where less than all flues are welded or beaded on the front flue sheet, those welded or beaded shall be distributed as evenly as practicable throughout the flue pack.
- d) Flues shall be re-expanded upon completion of seal welding or beading, or both. The new reduced wall thickness of the enlarged flue end shall be reviewed to confirm that upon completion of the flue expansion process the new wall thickness will be sufficient for the MAWP.
- e) When stipulated by the original design, the ends of boiler flues may be swaged to a smaller or larger diameter as required to fit the tube sheet holes. The swaging shall create smooth surfaces, smooth curves, and a uniform diameter reduction across the entire swaged length. Swaging or not swaging is considered a repair.
- f) When flues are applied by expanding and seal welding, the seal weld shall protrude beyond the sheet a distance of 1/8 in. to 1/4 in. (3 mm to 6 mm) inclusive [see Figure S1.2.9.2-b] and the end of the flue shall not protrude past the weld. The end of the flue shall be ground or polished to eliminate any sharp edges.
- g) Prior to welding, beading, or both, ensure that the flue is satisfactorily seated in the sheet. Seal welding may be done with water in the boiler, provided the water is heated to between 100°F and 120°F (38°C and 50°C).
- h) Ferrous or nonferrous ferrules may be used on either or both ends of flues. When seal welding over ferrous ferrules used in straight-expanded and seal-welded flues, the weld shall attach to the sheet and not just to the ferrule. Care shall be taken to avoid contamination of seal welds when nonferrous ferrules are used.

Cautionary Note:

Boiler flues shall be cut to or made to the correct length required for installation when the boiler and flues are at equal temperature. The use of heating or stretching the flue during installation to obtain the required length by thermal or mechanical expansion is prohibited.

S1.2.9.7 FERRULES

- a) Ferrous or non-ferrous ferrules may be used on either or both ends of flues and arch tubes.
- b) If ferrules are recessed, the recess depth shall not exceed 1/16 in. (1.6 mm) measured from the flue sheet fireside edge.
- c) Protrusion of the ferrule beyond the edges of either flue sheet is permitted provided the ferrule does not interfere with any further attachment procedures.
- d) For steel ferrules, if the flue is installed by expanding it straight and seal welding it to the flue sheet, the seal weld shall be arranged to contact the flue sheet and the flue. Seal welding the flue to the ferrule only is prohibited.
- e) The applications of ferrules where none were used before shall be considered a repair.
- f) The application with ferrules, where none were used before shall be considered a repair.

S1.2.10 REPAIRS AND ALTERATIONS TO BOILER BARREL UNSTAYED AREAS

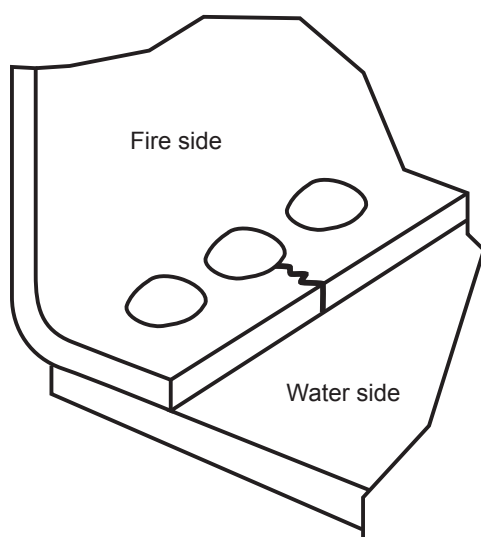
- a) Except as provided in NBIC Part 3, 3.4.4.8, a repair of a defect in a welded joint or base material shall not be made until the defect is removed. A suitable nondestructive examination (NDE) method such as magnetic particle (MT) or liquid penetrant (PT) may be necessary to ensure complete removal of the defect. If the defect penetrates the full thickness of the material, the repair shall be made with a full penetration weld such as a double butt weld or a single butt weld with or without backing. Where circumstances indicate that the defect is likely to recur, consideration should be given to removing the defective area and installing a flush patch or taking other corrective measures acceptable to the Inspector, and when required by the Jurisdiction.
- b) Weld buildup shall not be used if the affected section of plate has wasted below 60% of the minimum required thickness.
- c) If the cracked section of plate is retained and is to be repaired by installation of a riveted patch, the crack may be stopped by drilling stop holes at each end or removed by a method such as grinding, cutting, or machining. Results of stop drilling or crack removal shall be verified by NDE.
- d) Welded repairs at or near riveted seams requiring preheating or postweld heat treatment shall be carefully made in order to prevent loosening in the riveted seams, especially when localized heating is used. Where necessary to control expansion or to gain access for welding, rivets at the defective section and to each side of it may be removed. Reuse of rivets and staybolts is prohibited.
- e) All welded repairs to boiler barrel unstayed areas shall be radiographically examined in accordance with ASME Code, Section I when the size of the repaired area is greater than the maximum size of an unreinforced opening as calculated in accordance with the latest edition of ASME Code, Section I.
- f) Riveted patches may be any shape or size provided the lowest patch efficiency is equal to or greater than the lowest equivalent seam efficiency of the boiler course to which it is applied. Ref: ASME Code, Section I.
- g) The factor of safety of all riveted patches shall not be less than four for locomotives operating under Federal Railroad Administration regulations.

S1.2.11 REPAIRS AND ALTERATIONS TO BOILER BARREL STAYED AREA

S1.2.11.1 FIREBOX SHEET REPAIR

- a) Cracks in all stayed firebox sheets may be repaired by welding or the installation of a flush patch.
- b) If the crack extends into a staybolt or rivet hole, the staybolt or rivet shall be removed prior to making the repair.
- c) Fire cracks or thermal fatigue cracks in riveted seams located in the firebox that run from the edge of the plate into the rivet holes may be left in place provided they do not leak and there is no indication that the seam or rivets are loose. (See NBIC Part 3, Figure S1.2.11.1).

FIGURE S1.2.11.1
EXAMPLE OF THERMAL FIRE CRACK



S1.2.11.2 FIREBOXES AND OTHER STAYED AREA PATCHES

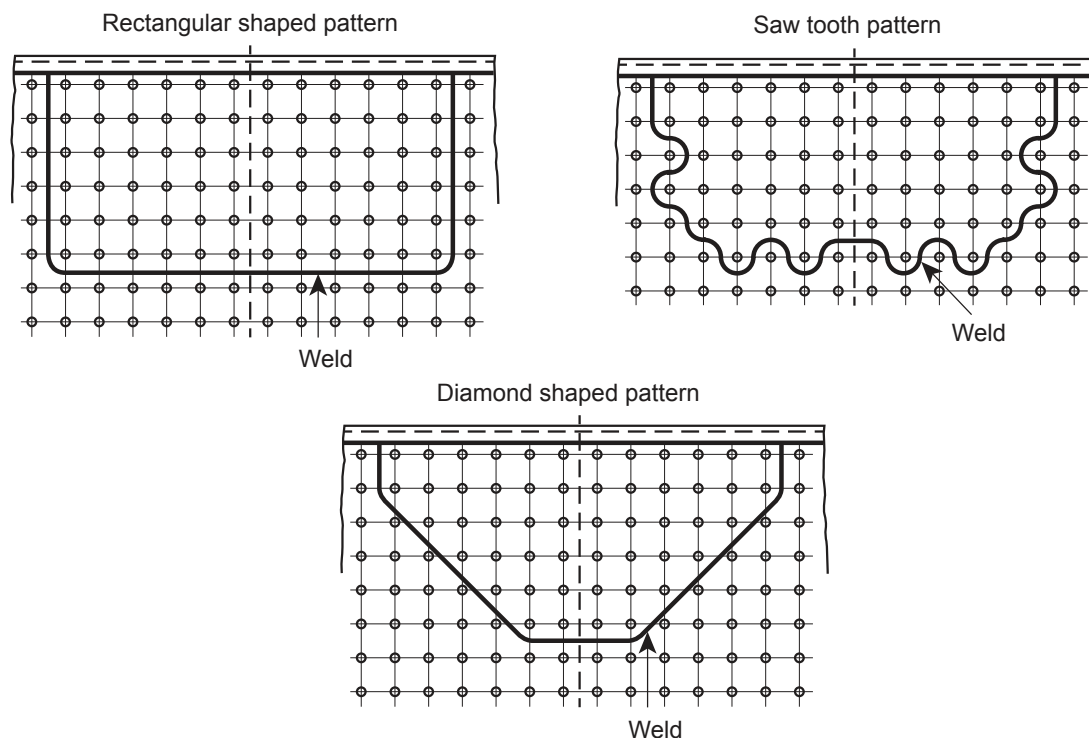
- a) Patches may be any shape provided they are adequately supported by staybolts, rivets, tubes, or other forms of construction. Patches on stayed surfaces should be designed so weld seams pass between staybolt rows. (See NBIC Part 3, Figure S1.2.11.2).
- b) Patches are to be flush type, using full penetration welds. If the load on the patch is carried by other forms of construction, such as staybolts, rivets, or tubes, radiographic examination and postweld heat treatment of the welds are not required.
- c) If the patch includes an existing riveted seam, the patch shall be riveted at that seam. Changing a riveted seam to a welded seam is considered an alteration.
- d) All rectangular or angled patches shall have adequate radius at all corners. Minimum radius to be not less than three times plate thickness.
- e) Patches shall fit flush on the waterside of the sheet. Misalignment shall not exceed one-quarter plate thickness on edge alignment with the sheet water side.

- f) Staybolts and rivets should be installed after welding of patch is completed. Reuse of staybolts and rivets is prohibited.
- g) Weld seams parallel to a knuckle shall be located no closer to the knuckle than the point of tangency of the knuckle unless the weld is radiographically examined. Weld seams not located in the knuckle are preferred. (See NBIC Part 3, Figure S1.2.11.5-b).
- h) Patches shall be made from material that is at least equal in quality and thickness to the original material.

FIGURE S1.2.11.2

TYPICAL FIREBOX PATCHES

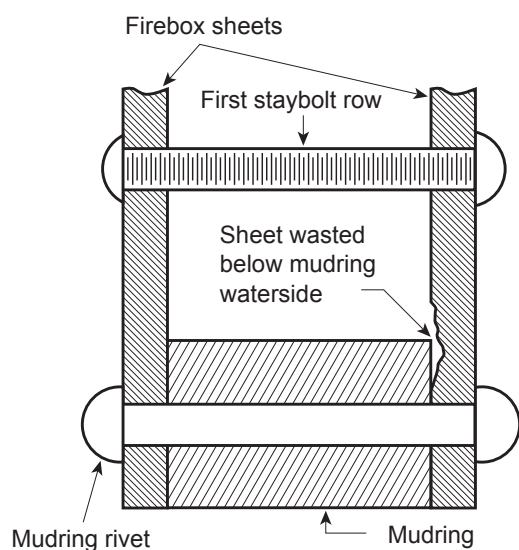
This figure illustrates what would be considered a saw-tooth patch. Its advantage is that a maximum amount of welding is obtained for securing a given patch and by zig-zagging the weld, the weld is supported by three rows of staybolts instead of two. Its disadvantage is its irregular shape which causes greater difficulty in fitting and applying. Rectangular and diamond shaped patches are illustrated for comparison.



S1.2.11.3 REPAIR OF STAYED FIREBOX SHEETS GROOVED OR WASTED AT THE MUDRING

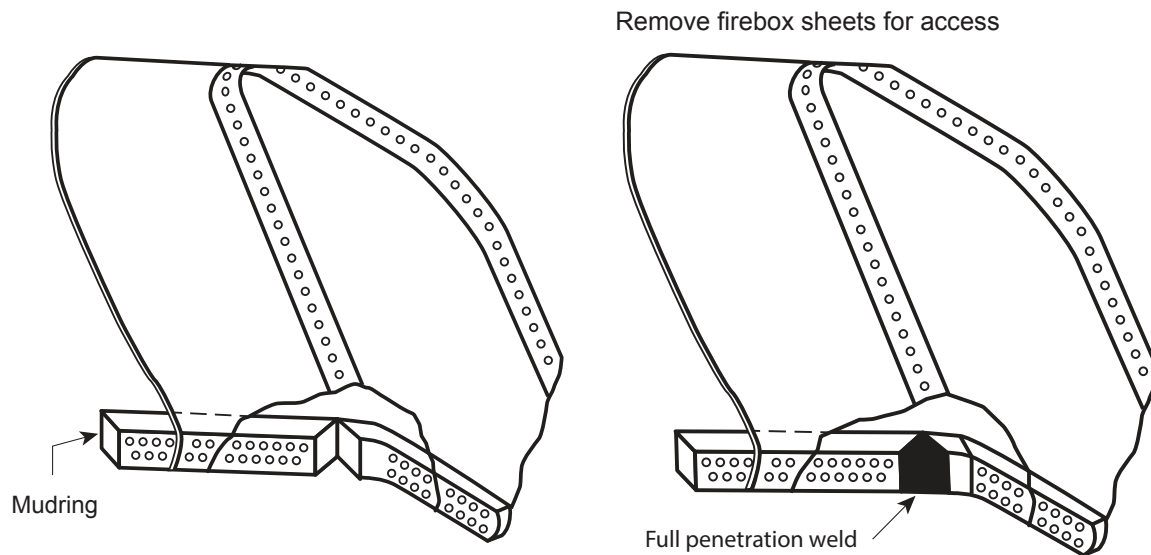
- a) Grooved or wasted firebox sheets having greater than 60% of the minimum required thickness remaining may be repaired by weld buildup provided the wastage does not extend below the waterside surface of the mudring and the strength of the structure will not be impaired. If extensive welding is required, the affected area shall be removed and replaced with a flush patch.
- b) If the sheet thickness has been reduced to less than 60% of the minimum required thickness, the affected section shall be removed and replaced with a flush patch.

- c) If wastage and grooving extends below the mudring waterside surface and if the plate thickness remaining has been reduced to less than the minimum required thickness, the affected section shall be removed and replaced with a flush patch.
- d) Flush patches shall be arranged to include the mudring rivets and at least the first row of staybolts above the mudring.

FIGURE S1.2.11.3**STAYED FIREBOX SHEET GROOVED OR WASTED AT MUDRING****S1.2.11.4 MUDRING REPAIRS**

- a) Pitted and wasted sections of mudrings may be built up by welding provided the strength of the mudring will not be impaired. Where extensive weld buildup is employed, the Inspector may require an appropriate method of NDE for the repair.
- b) Cracked or broken mudrings may be repaired by welding or installation of flush patches using full penetration welds. Patches shall be made from material that is at least equal in quality and thickness to the original material. Patches shall fit flush on waterside surfaces. Where necessary, firebox sheets on both sides of the defect may be removed to provide access for inspection and welding.

FIGURE S1.2.11.4
MUDRING REPAIRS



(23) S1.2.11.5 REPAIR OF FIREBOX, WRAPPER, AND TUBESHEET KNUCKLES

- a) Welds within the points of tangency of a knuckle are permitted. Welds with angles of less than 45 degrees to the longitudinal axis of the knuckle shall be radiographically examined. (See NBIC Part 3, Figures S1.2.11.5-a through S1.2.11.5-g).
- b) Any patch not supported by means other than the weld, such as rivets, staybolts, tubes, or other forms of construction, shall have all weld seams radiographically examined.
- c) Patches shall be formed to proper shape and curvature.
- d) Wasted sections of knuckles that have not wasted below 60% of the minimum required thickness may be repaired by weld buildup provided the strength of the structure will not be impaired. Where weld buildup is employed, the Inspector may require an appropriate method of NDE for the repair.
- e) Wasted sections of knuckles that have wasted below 60% of the minimum required thickness shall be replaced.
- f) Flanges shall be made so as to avoid stress intensifiers such as abrupt ridges and grooves.
- g) Flanges shall be made smooth and free of ridges, valleys and grooves.
- h) Flanges may be welded in accordance with this section and all applicable sections of this code.
- i) For one-piece flange knuckle joint patches in portions of a riveted lap joint or in mud ring corners with a lap joint in the firebox, the knuckle patch shall be supported on at least one of the two planes adjacent to the flange, by means other than the weld. See Figure S1.2.11.5-c1. The weld shall be at least the full thickness of the new plate being installed. The taper of the weld in the transition area may be greater than the limitation(s) given in the original code of construction. Volumetric examination is not required. This type of repair shall be considered a repair.

Cautionary note: Where a double-riveted lap joint is replaced with a seamless plate, stay pitch and stress must be considered since the doubling effect of the lap seam is being eliminated.

FIGURE S1.2.11.5-a
FIREBOX TUBESHEET KNUCKLE REPAIR

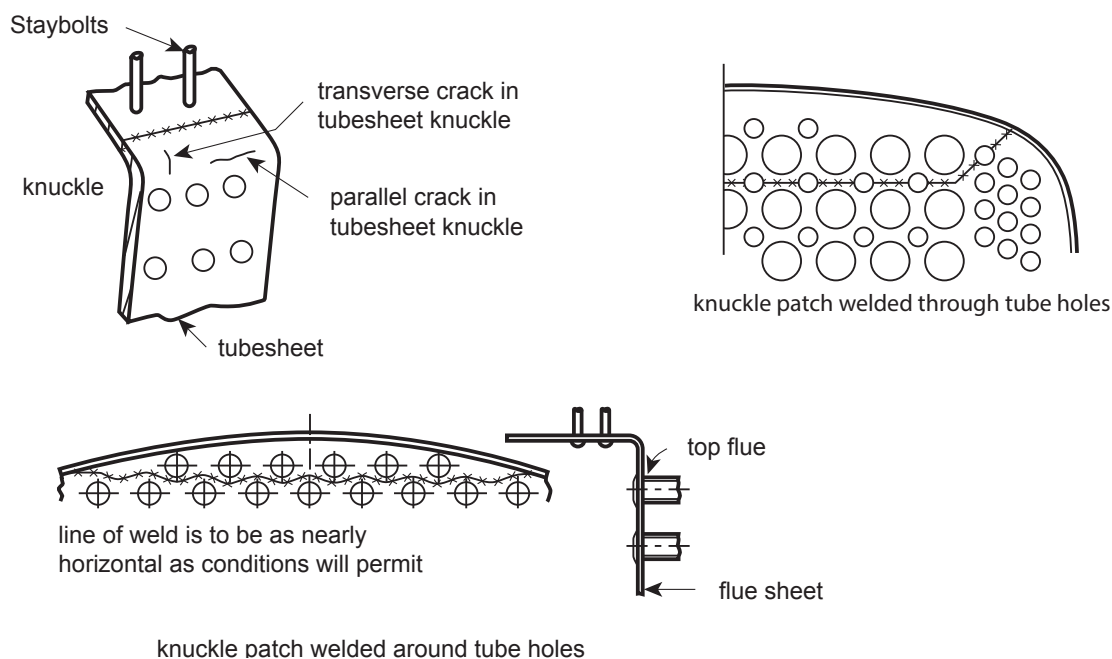


FIGURE S1.2.11.5-b
REPAIR OF FIREBOX AND TUBESHEET KNUCKLES

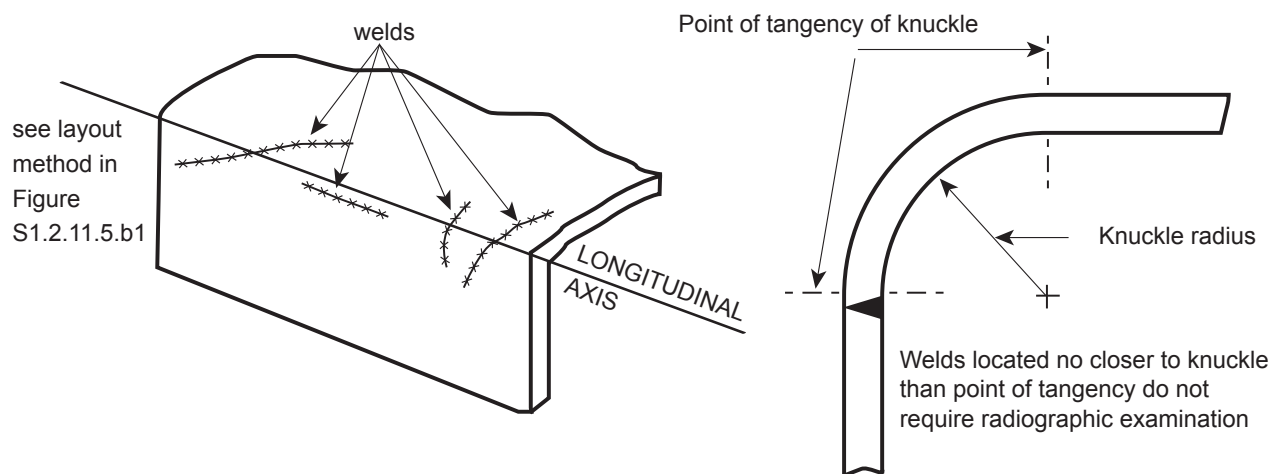
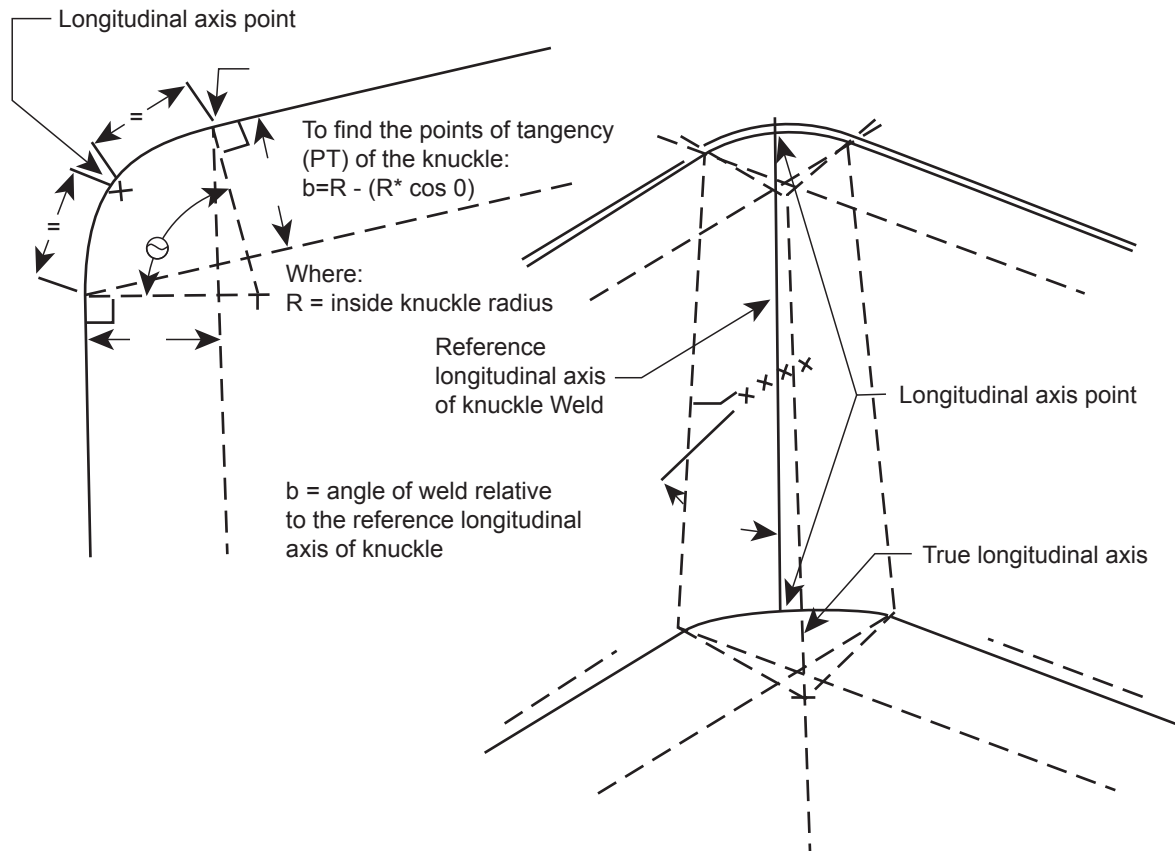


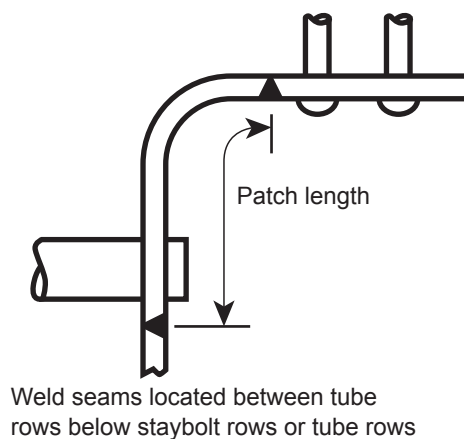
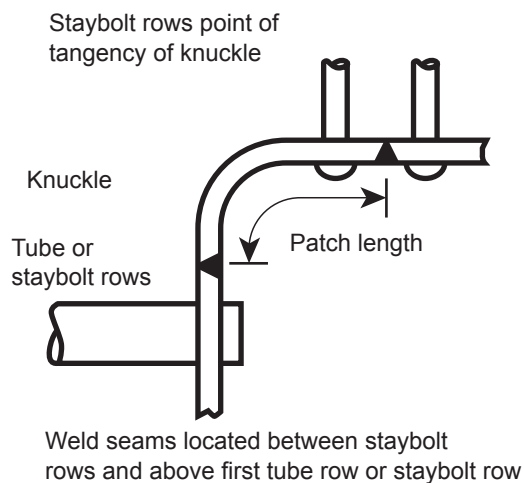
FIGURE S1.2.11.5-b1
LAYOUT METHOD OF DETERMINING KNUCKLE WELD ANGLE



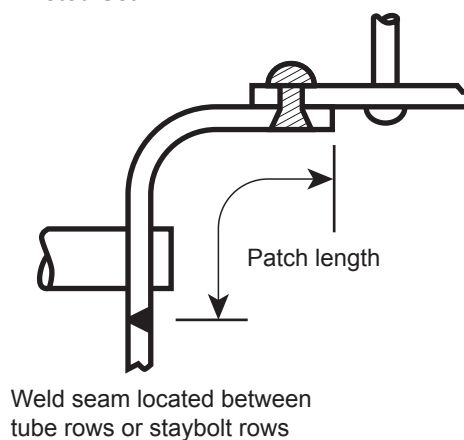
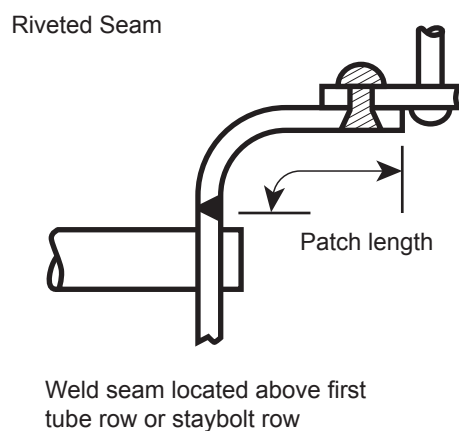
Illustrations are of inside surface of knuckle

FIGURE S1.2.11.5-c
REPAIR OF FIREBOX AND TUBESHEET KNUCKLES

Stayed Patch Applied to Buttwelded Seam



Stayed Patch Applied to Riveted Seam



Repairs Requiring Radiographic Examination of Weld Seams

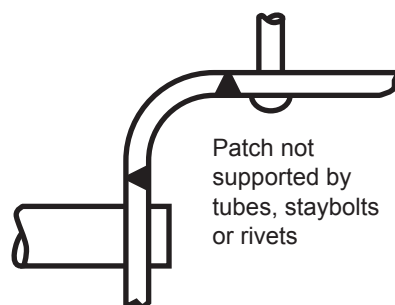
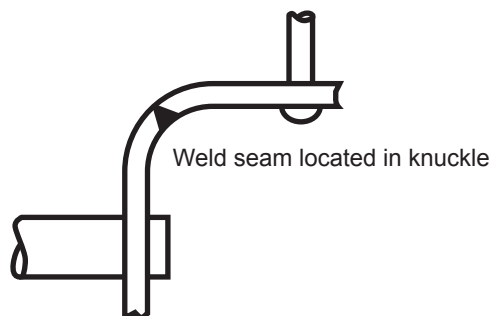


FIGURE S1.2.11.5-c1
NEW PATCH ALIGNMENT WITH ORIGINAL MATERIAL

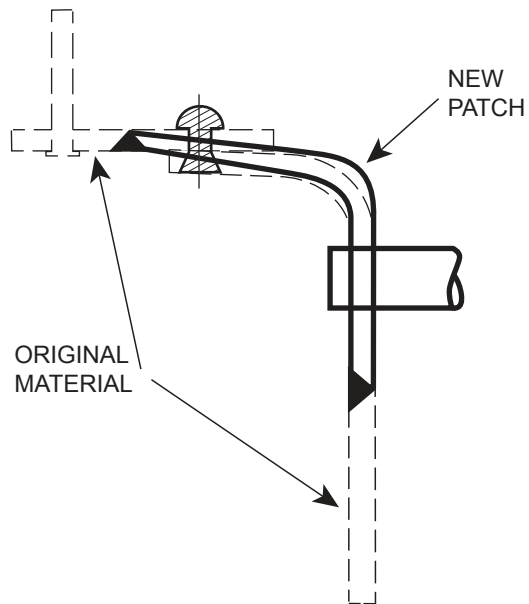
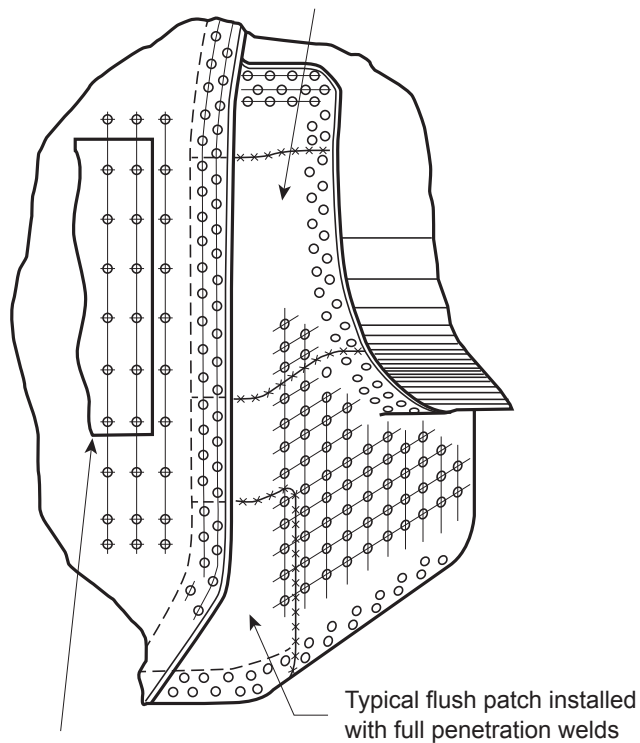


FIGURE S1.2.11.5-d
FIREBOX THROAT SHEET KNUCKLE

Typical flush patch installed with full penetration welds



If access for welding or riveting is required,
remove section of exterior or interior sheets

FIGURE S1.2.11.5-e
BACKHEAD KNUCKLE REPAIRS

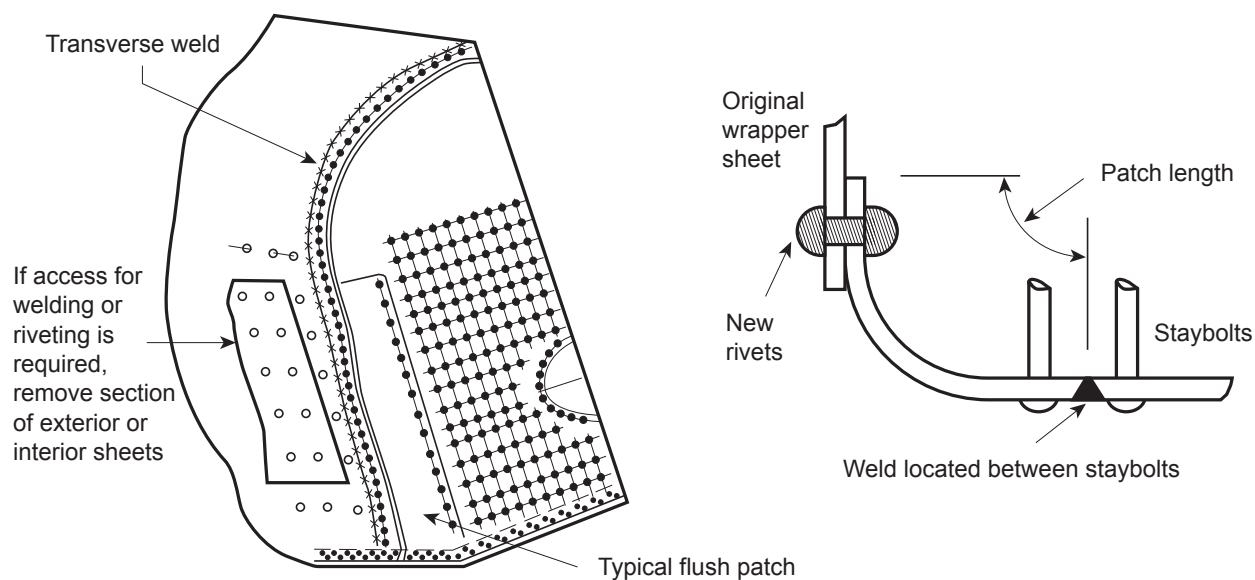


FIGURE S1.2.11.5-f
FIRE DOOR OPENING REPAIR

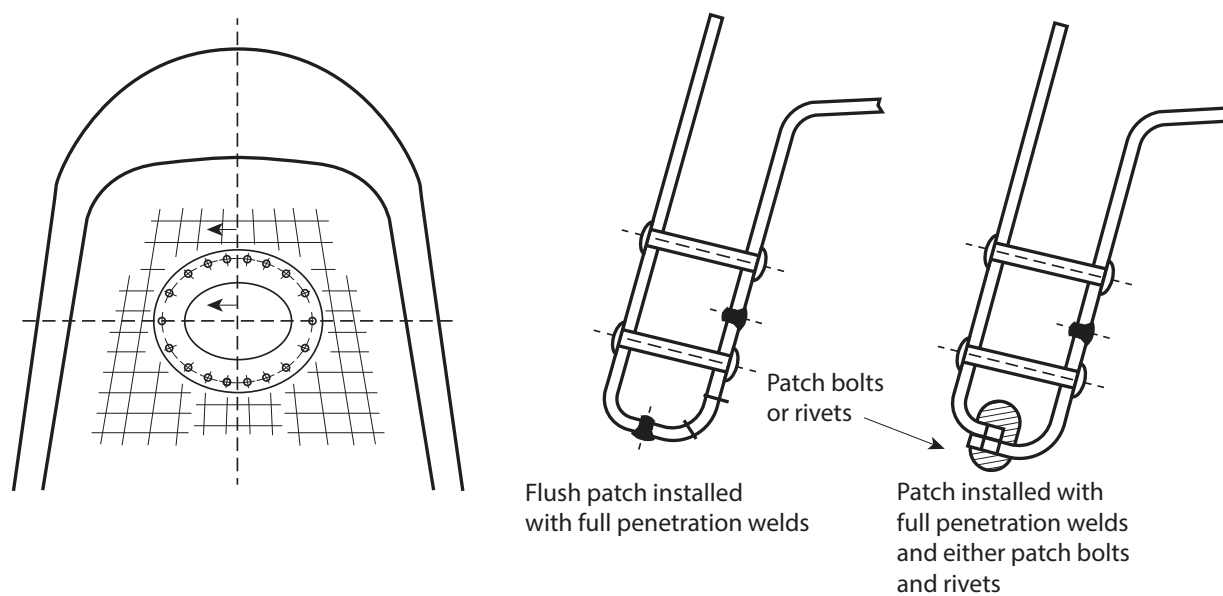
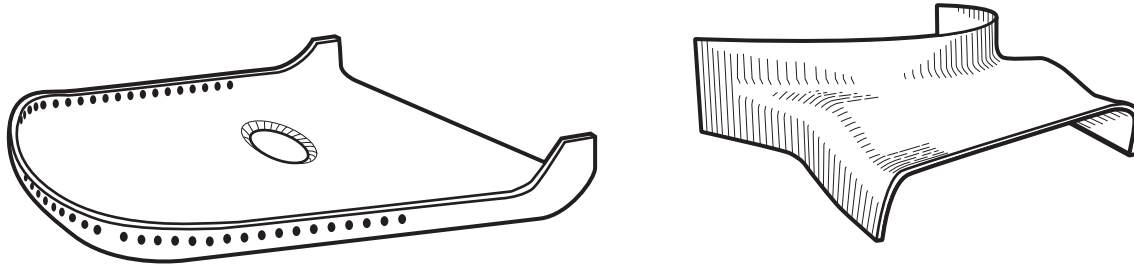


FIGURE S1.2.11.5-g
TYPICAL FLANGED SHEETS



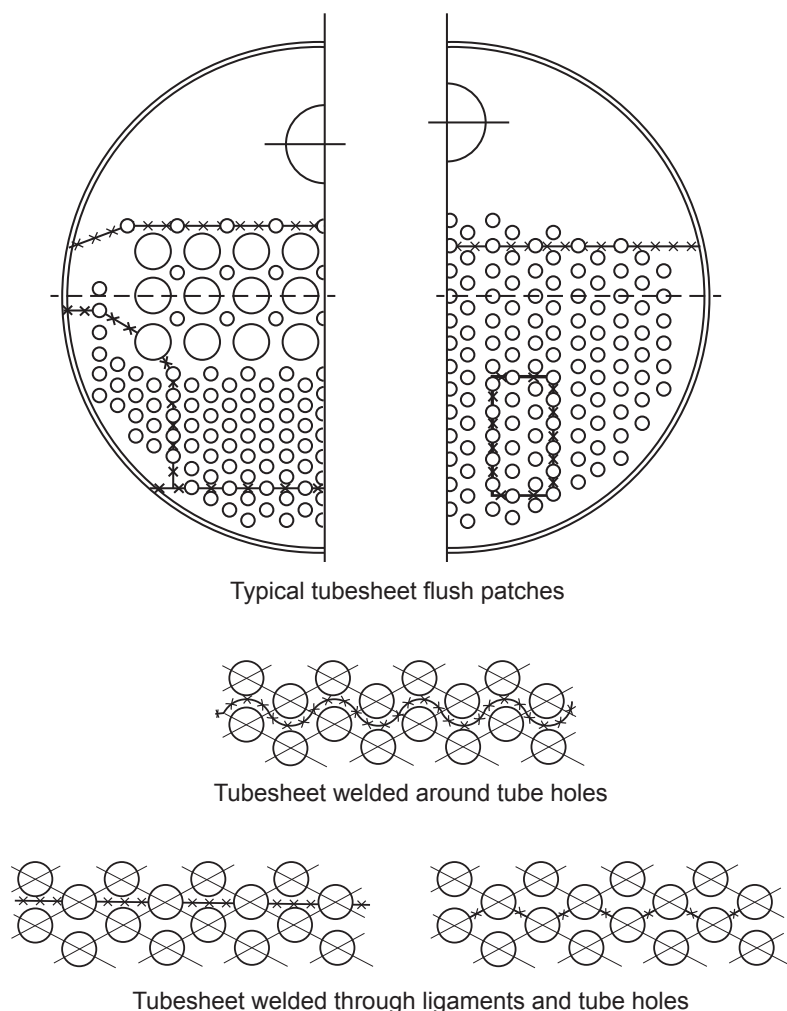
Typical Flanged Sheets

1. Flanges shall be made smooth and free of ridges, valleys and grooves
2. Flanges may be welded in accordance with this section and all applicable sections of this code.

S1.2.11.6 TUBESHEET REPAIRS

- a) Cracked tubesheet ligaments may be repaired by welding using full penetration welds.
- b) Damaged tubesheet holes may be repaired by welding.
- c) Sections of tubesheets damaged or wasted to less than 60% minimum required thickness shall be repaired by installing a flush patch using full penetration welds.
- d) Sections of tubesheets that have not wasted below 60% minimum required thickness may be repaired by weld buildup, provided the strength of the structure will not be impaired. Where weld buildup is employed, the Inspector may require an appropriate method of NDE for the repair.
- e) Maximum diameter of flue holes shall be 1/4 in. (6.3 mm) greater than the diameter of the flue. Holes shall be made round if they equal or exceed 1/8 in. (3.2 mm) out of the round. See NBIC Part 3, S1.2.9.7.

FIGURE S1.2.11.6
TUBESHEET REPAIRS

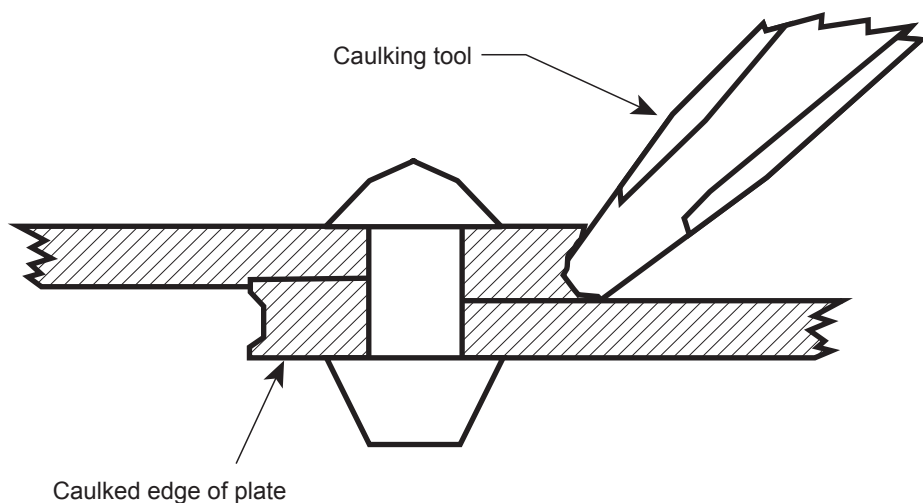


S1.2.12 SEAMS AND JOINTS

S1.2.12.1 CAULKING RIVETED SEAMS AND RIVET HEADS

- Replacement rivets shall have heads of sufficient size to conform to NBIC Part 2, S1.4.2.1 I). Changing the rivet head style at either end shall be considered a repair, changing the rivet body diameter or changing the rivet hole diameter shall be an alteration.
- Rivet heads shall completely cover the perimeter of the hole in the plate or entirely fill the countersink.
- During driving of rivets, where the factory head moves away from the sheet because of insufficient bucking, such rivets shall be removed and discarded.
- Rivets shall be heated sufficiently to be driven completely with the equipment being used.
- Reheating of rivets above 600°F (316°C) after the original installation is prohibited. When seal welding rivet heads, inter or post-pass head temperature shall be kept below 600°F (316°C).

- f) Each rivet head shall contact the plate over the entire circumference upon completion of the installation. Rivets on which either head does not have contact with the plate over the entire area of the driven head, not including any excess washer (excess material at the base of the rivet head), shall be replaced. Repair is prohibited.
- g) Caulking refers to the sealing of plate seams and rivet heads by driving the edge of one surface onto the other by using an impact tool.
- h) Caulked rivet seams and rivet heads shall be in accordance with ASME Code Section I.

FIGURE S1.2.12.1

S1.2.12.2 THREADED OPENINGS IN VESSEL WALLS, BUSHINGS, AND WELDED NOZZLES (WASHOUT PLUG HOLES AND OTHER CONNECTIONS)

- a) Threaded openings in vessel walls and welded nozzles with damaged threads that cannot be repaired by retapping or rethreading should be repaired by welding a nozzle in the sheet. The nozzle shall be of such a size as to not interfere with proper washout and inspection.
- b) Threaded bushings and nozzles found to be defective shall be replaced. Seal welding is not permitted.
- c) New threaded bushings equipped with shoulders may be seal welded at the shoulder.
- d) New threaded bushings without shoulders that are seal welded after installation shall have the threads removed from the weld zone of the bushing prior to welding.
- e) Threaded holes with damaged threads may be repaired by weld buildup and re-tapping. The threads shall be removed prior to welding.

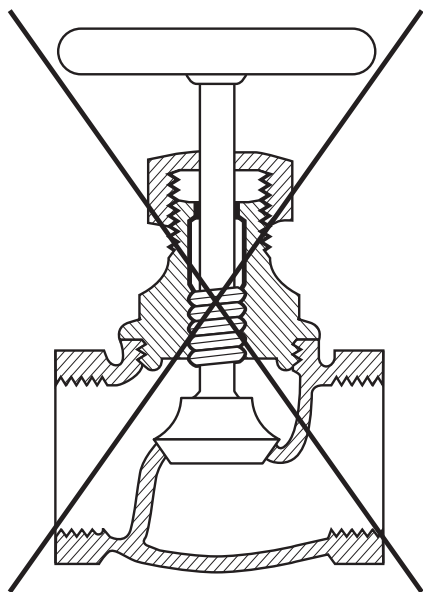
S1.2.13 FITTINGS AND GAGES

S1.2.13.1 WATER GAGE CONNECTION

- a) Water gage glasses shall be applied so that the lowest water reading in the water glass gage glass of a horizontal firetube boiler on level track shall be not less than 3 inches (75 mm) above the highest point of the crownsheet.
- b) The bottom mounting for water gage glass (and for water column if used) must not extend less than 1-1/2 in. (38 mm) inside the boiler and beyond any obstacle immediately above it. The passage must be straight and approximately horizontal. Connections must be applied without pockets, traps, sags, or syphons. Tubular water gage glasses must be equipped with a protection shield.
- c) Locomotive water gage glasses shall be provided with one top and one bottom shutoff cock and a means to illuminate each glass. Each top and bottom shutoff cock or valve shall be of such through flow construction as to prevent stoppage by deposits of sediments. Straight run globe valve of the ordinary type shall not be used on such connections. (See NBIC Part 3, Figure S1.2.13.1). The water gage glass connection and pipe connection shall be fitted with a drain cock or valve having an unrestricted opening of not less than 3/8 in. (10 mm) in diameter to facilitate cleaning.
- d) The top and bottom water gage glass fittings are to be aligned, supported, and secured so as to maintain the alignment of the water gage glass.
- e) The lower edge of the steam connection to a water column or water gage glass in the boiler shall not be below the highest visible water level in the water gage glass. There shall be no pockets, traps, sags, or syphons in the piping that will permit the accumulation of sediments.
- f) The upper edge of the water connection to a water gage glass and the boiler shall not be above the lowest visible water level in the water gage glass. There shall be no pockets, traps, sags, or syphons in the connection.

FIGURE S1.2.13.1

STRAIGHT RUN GLOBE VALVE NOT PERMITTED



S1.2.14 THROTTLE PIPES, DRY PIPES, SUPERHEATER HEADERS & FRONT END STEAM PIPES

- a) Cracks in throttle pipes, dry pipes, superheater headers, and front end steam pipes made from steel may be repaired by welding. All welded repairs shall be done in accordance with NBIC Part 3.
- b) Throttle castings, dry pipes, super heater headers, and front end steam pipes constructed of cast iron may be repaired by brazing provided the components are internal to the boiler shell or smokebox shell. Brazing shall be done in accordance with NBIC Part 3, appropriate to the type of repair, and shall be acceptable to the Inspector and the jurisdiction if applicable. Cast iron shall not be fusion welded.
- c) Weld build-up may be used for repair of steel components in accordance with NBIC Part 3.
- d) Throttle pipes, dry pipes and superheater headers, should be supported by hangers, brackets or other structural methods as needed.

SUPPLEMENT 2

HISTORICAL BOILERS

S2.1 SCOPE

- a) This supplement provides requirements and guidelines for repair and alteration of historical steam boilers of riveted and/or welded construction not falling under the scope of Supplement 1. These historical steam boilers would include: steam tractors, traction engines, hobby steam boilers, portable steam boilers, and other such boilers that are being preserved, restored and maintained for demonstration, viewing, or educational purposes.

Note: This supplement is not to be used for steam locomotive boilers falling under the requirements of the Federal Railroad Administration (FRA). FRA rules for steam locomotive boilers are published in 49 CFR 230. Specific rules and special requirements for inspection, repairs, alterations, and storage of steam locomotive boilers are identified in NBIC Parts 2 and 3, Supplement 1.

- b) The rules specified in this supplement shall be used in conjunction with the applicable rules in this Code. References specified or contained in this supplement may provide additional information to assist the user when applying the requirements of this supplement.

S2.2 INTRODUCTION

- a) The following repair and alteration rules are minimum requirements for safe and satisfactory operation of historical boilers. Users of this supplement are cautioned that where complete details are not provided, the user is advised to seek technical guidance to provide good sound engineering evaluations and practices.
- b) Where adopted by a Jurisdiction, these requirements are mandatory. Where a Jurisdiction establishes different requirements for historical boilers or where a conflict exists, the rules of the Jurisdiction prevail.

S2.3 RESPONSIBILITIES

The owner, user and/or operator are responsible for ensuring that the boiler meets all the requirements of the Jurisdiction where the boiler is operated, including inspections, repairs, licensing, operating certificates, permits, and operator training.

Note: It should be recognized that safety of these boilers is dependent upon the knowledge and training of the operator in proper use, repair, maintenance, and safe operation of each specific boiler proposed to be operated (See NBIC Part 2, Supplement 2).

S2.4 REPAIRS AND ALTERATIONS

Repairs and alterations to boilers of historical nature should be performed with consideration towards preserving the authenticity of original design, while at the same time ensuring that the boiler is safe to operate at the pressure allowed by NBIC Part 2, Supplement 2.

S2.5 CONSTRUCTION STANDARDS

Repairs and alterations shall conform to the requirements of the original construction standard insofar as possible. If the original construction standard is unknown or unavailable, the boiler shall be considered a boiler of locomotive design and subject to the construction standard most applicable. The construction standard selected for the repair or alteration must meet the approval of the Jurisdiction.

S2.6 ACCREDITATION

- a) Organizations performing welded repairs shall be accredited as described in NBIC Part 3, 1.5.
- b) Organizations and/or individuals performing non-welded repairs do not need to have an “R” stamp unless required by the Jurisdiction. However, they must be competent in the type of repair they are performing.

S2.7 MATERIALS

- a) Materials used in making repairs shall conform to the original construction standard, if known, or to a construction standard acceptable to the Jurisdiction. Carbon or alloy steels having carbon content greater than 0.35% shall not be welded. The repair organization is responsible for verifying identification of existing and replacement materials.
- b) The older steels used in historical boiler construction could have been supplied as either rimmed steel, flange or firebox quality steel. Rimmed steel may be higher in carbon, sulfur, phosphorus and hydrogen contents that will adversely affect weldability.
- c) If welding is to be used to repair a pressure-retaining item where the existing material cannot be verified (unknown), the requirements of NBIC Part 3, 3.2.1 shall be met. Specific quantities of carbon, manganese, sulfur, phosphorus, and aluminum shall be identified and included in the analysis. The result of the analysis shall be acceptable to the Inspector and, when required, the Jurisdiction.

S2.7.1 MATERIAL LIST FOR HISTORICAL BOILERS REPAIRS

Table S2.7.1 is intended as a basic guideline only and covers just the basic carbon steel and some alloy steel material specifications. Other alloy materials may be available for these applications if necessary.

Note: See ASME Section II for Other Acceptable Section I Materials.

TABLE S2.7.1

MATERIALS LIST FOR HISTORIC BOILERS

Application	Specification
Boiler Tubes & Flues	SA-178 Grade A, SA-192, SA-210
Boiler & Firebox Plate	SA-285 Grade C, SA-515, SA-516
Staybolts & Patch Bolts	SA-675, SA-36, ASTM A-31
Boiler Braces	SA-675, SA-36
Rivets	SA-675, SA-31
Forged Parts & Fittings	SA-105, SA-217
Hollow Cylindrical Pressure Retaining Parts	SA-105 Forgings SA-675 Bar Stock,
Pipe Flanges	SA-181, SA-105
Flange Bolts, Studs & Nuts	SA-193-B7, SA-194-2H
Bronze Castings & Washout Plugs	SB-61, SB-62

- a) SA-516 steel is recommended for firebox repairs. It is a fine grain steel that accepts flanging and bending with less tendency to crack than coarse grain steels such as SA-515 or SA-285 Grade C. Coarse grain steels have, on occasion, been found to crack or split after complicated flanging, bending, and forming.
- b) SA-36 is not to be used to make any pressure-retaining part such as shells.
- c) When rivets are made from SA-675, the finished rivets must meet the physical and test requirements of the original ASME rivet specification ASTM A-31 Grade A or B.
- d) When staybolt material tensile strength is greater than that of the firebox sheets, the firebox sheets deflect instead of the staybolts, which can result in the sheets developing cracks and leaking staybolts. In addition, high tensile strength steels are difficult to drive.

S2.7.2 REPLACEMENT PARTS

Replacement pressure parts shall be in accordance with NBIC Part 3, 3.2.2.

S2.8 WELDED REPAIR INSPECTION

Prior to commencing any welded repairs to the pressure boundaries of historical boilers, the repair organization shall obtain an Inspector's approval of the proposed repair. The Inspector shall be an employee of either a Jurisdiction, as defined in NBIC Part 3, Section 9, *Glossary*, or of the Authorized Inspection Agency contracted by the repair organization. The Inspector shall ensure the repairs are performed in accordance with the approved construction standard, and shall verify any nondestructive examinations or witness pressure testing of the completed repair.

S2.9 WELDING

Welding shall be performed in accordance with the requirements of the approved construction standard in consultation with the Inspector. A repair organization accredited as described in NBIC Part 3, 1.5 may use the Standard Welding Procedure Specifications shown in 2.3, as applicable. Welders shall be qualified for the welding processes used. Qualification shall be in accordance with the approved construction standard, or ASME Section IX.

S2.10 HEAT TREATMENT

- a) Preheat and postweld heat treatment may be used to assist in completion of the welded joint. Consideration should be given to the percentage of carbon content and to the thickness of the boiler materials to be welded. Required preheat and PWHT temperatures shall be specified on the qualified Welding Procedure Specification being used.
- b) Postweld heat treatment shall be performed as required by the accepted construction standard, in accordance with written procedures acceptable to the Inspector.
- c) Alternative postweld heat treatment methods may be used with the Inspector's approval. Welding methods that may be used as alternatives to postweld heat treatment when PWHT cannot be performed are limited to increased preheat temperatures and controlled temper bead methods. (See NBIC Part 3, 2.5.3)

S2.11 NONDESTRUCTIVE EXAMINATION AND TESTING

- a) The Inspector may require nondestructive examination (RT, PT, MT, UT) as necessary to ensure satisfactory welded repairs and alterations have been accomplished. (See NBIC Part 3, 4.2).
- b) The nondestructive examination (NDE) requirements, including technique, extent of coverage, procedures, personnel qualification, and acceptance criteria, shall be in accordance with the original code of construction for the pressure-retaining item. Weld repairs and alterations shall be subjected to the same nondestructive examination requirements as the original welds.
- c) Where the original code of construction is unknown or the NDE method is not possible or practicable, alternative NDE methods may be used. These methods shall be acceptable to the owner, the Inspector and where required, the Jurisdiction of the pressure-retaining item.
- d) NDE methods used shall be suitable for providing meaningful results to verify the integrity of the repair and or alteration.
- e) Exclusive use of visual examination (VT) is only permitted when performing final examination for routine repairs in accordance with Part 3, 4.4.1 e).
- f) The integrity of repairs and alterations shall be verified by examination or test as required by Part 3, 4.4.

S2.12 DOCUMENTATION

Organizations performing repairs to historic boilers shall document the repair or alteration on Form R-1 or R-2, as applicable. Job records shall be retained in accordance with NBIC Part 3, 1.5.1 t). Additionally, documentation detailing repairs or alterations shall be retained by the owner in permanent boiler records such as an operator log book.

S2.13 REPAIR METHODS

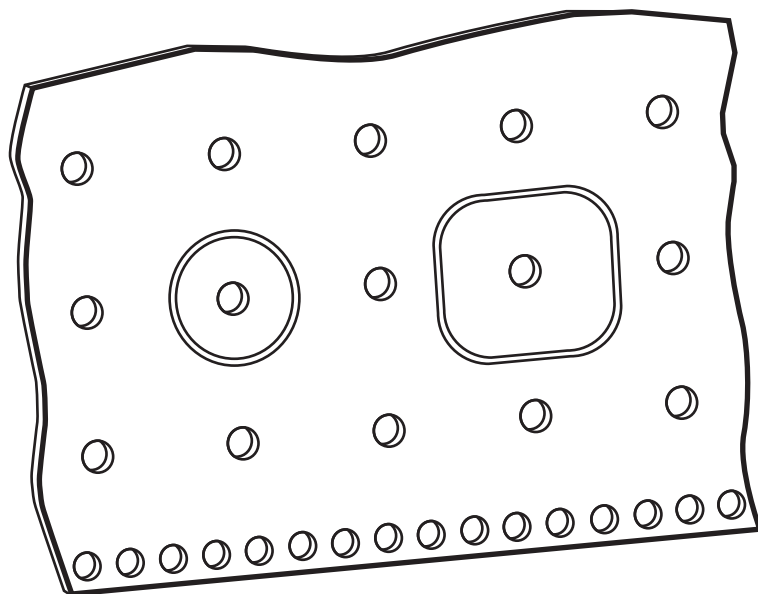
- a) Before performing any welding activity, consideration shall be given to ensure the weldability of historical boiler materials. Materials used for patches shall be made from material that is at least equal in quality and strength to the original material.
- b) Before a repair is made to a defect in a welded joint or base metal, care should be taken to investigate its cause and to determine its extent and likelihood of recurrence.
- c) Except as provided in NBIC Part 3, 3.3.4.8, a repair of a defect, such as a crack in a welded joint or base material, shall not be made until the defect has been removed. A suitable nondestructive examination method such as magnetic particle (MT) or liquid penetrant (PT) may be necessary to assure complete removal of the defect. If the defect penetrates the full thickness of the material, the repair shall be made with a complete penetration weld such as a double butt weld or a single butt weld with or without backing. Where circumstances indicate that the defect is likely to recur, consideration should be given to removing the defective area and installing a flush patch or taking other corrective measures acceptable to the Inspector, and when required, the Jurisdiction.
- d) Welded repairs at or near riveted seams requiring preheating or postweld heat treatment shall be carefully made to prevent loosening in the riveted seams, especially when localized heating is used. Where necessary to control expansion or to gain access for welding, rivets at the defective section and to each side of it may be removed. Reuse of rivets is prohibited.

S2.13.1 REPAIR OF THREADED STAYBOLT HOLES

Staybolt holes may be repaired by welding, reaming, re-tapping to a larger size, or by installing a flush patch. (See NBIC Part 3, Figure S2.13.1). If the staybolt hole was threaded and is to be repaired by welding, the threads shall be removed prior to welding.

FIGURE S2.13.1

SINGLE STAYBOLT FLUSH PATCH



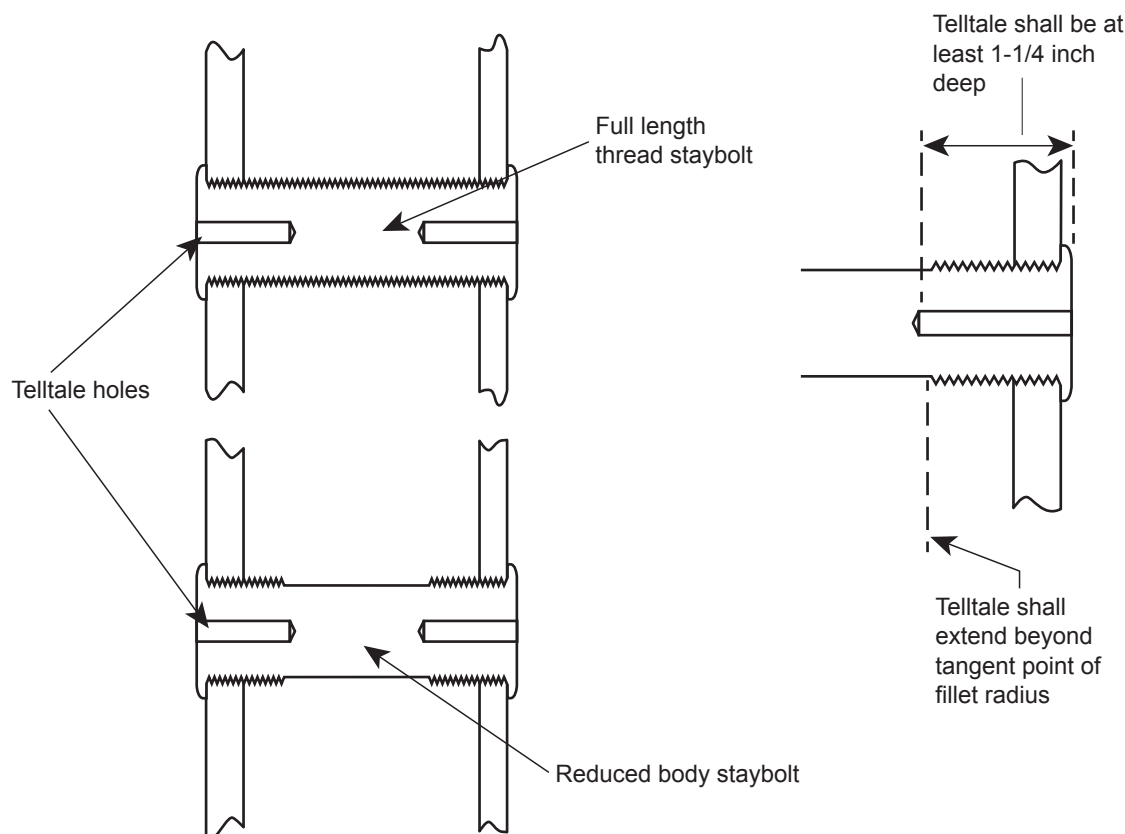
S2.13.2 INSTALLATION OF THREADED STAYBOLTS

- a) Threaded staybolts shall have either 11 or 12 thread pitch. Staybolt threads shall have a close fit in sheets. Changing the staybolt thread pitch from 11 to 12 or the reverse shall be considered a repair.
- b) Replacement of staybolts 8 in. (200 mm) and less in length shall have telltale holes when required by the original code of construction or when replacing staybolts with telltale holes. Telltale hole diameter shall be 3/16 in. (5.0 mm) to 7/32 in. (5.5 mm) in diameter and at least 1-1/4 in. (31 mm) deep in the outer end. On reduced body staybolts, the telltale hole shall extend beyond the fillet and into the reduced section of the staybolt. Staybolts should have through telltale holes, which are preferred. (see Figure S2.13.2)
- c) Telltale holes shall be reopened after driving.
- d) Staybolt length shall be sized so the length of bolt projecting through the sheet is not less than 1/8 in. (3 mm) and is sufficient to produce a full head after driving.
- e) The thread lead of both bolt ends and both firebox sheets shall be synchronized to permit the bolt to be installed without stripping the threads.
- f) When driving staybolt heads, the bolt's opposite end shall be bucked or braced to prevent damaging the bolt's threads. Bracing can be done several ways, such as using a pneumatic holder or a heavy steel bucking bar. Driving the heads on both ends of the staybolt simultaneously using two pneumatic rivet hammers (double gunning), is acceptable. Bolts are to be driven in such a manner as to expand radially

the bolt body and threads into the sheet prior to forming the head. Merely driving over the head is not acceptable.

- g) Reuse of threaded staybolts is prohibited.
- h) Installation of different diameter staybolts shall be considered a non-welded (mechanical) repair.

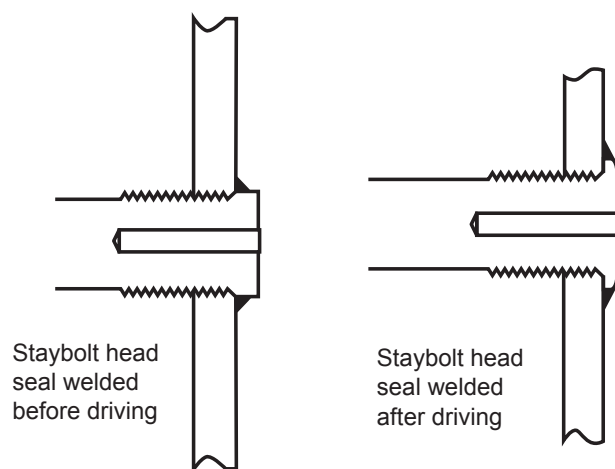
FIGURE S2.13.2
THREADED STAYBOLT



S2.13.3 SEAL WELDING OF THREADED STAYBOLTS

- a) Replacement threaded staybolts may be seal welded before or after driving. (See NBIC Part 3, Figure S2.13.3).
- b) Existing threaded staybolts that leak shall be repaired and may be seal welded. When used, seal welding shall not be the sole means of repair. Inspection must be done to ensure the material adjacent to the staybolt has not been materially weakened by deterioration or wasting away before welding can be performed.

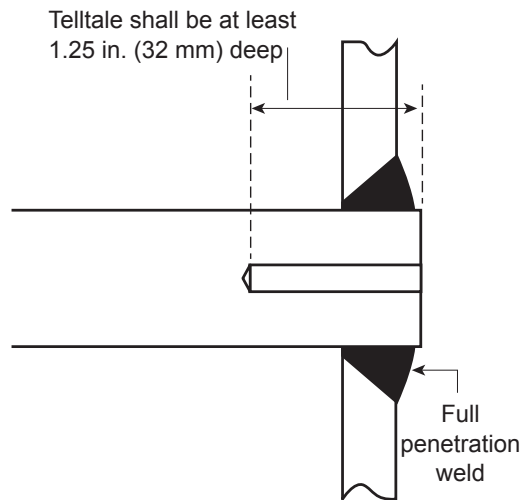
FIGURE S2.13.3
SEAL WELDING STAYBOLTS



S2.13.4 INSTALLATION OF WELDED STAYBOLTS

- a) The installation of unthreaded staybolts using full penetration welds is permissible. (See NBIC Part 3, Figure S2.13.4).
- b) Threaded stays may be replaced by welded-in stays provided that, in the judgement of the Inspector, the material adjacent to the staybolt has not been materially weakened by deterioration or wasting away. If staybolt hole is threaded, the threads shall be removed prior to welding.
- c) Replacement of staybolts 8 in. (200 mm) and less in length shall have telltale holes when required by the original Code of construction or when replacing staybolts with telltale holes. Telltale hole diameter shall be 3/16 in. (5 mm) to 7/32 in. (5.5 mm) in diameter and at least 1-1/4 in. (31 mm) deep in the outer end. On reduced body staybolts, the telltale hole shall extend beyond the fillet and into the reduced section of the staybolt. Staybolts should have through telltale holes, which are preferred. (See Figure S2.13.4)
- d) Reuse of welded staybolts is prohibited.
- e) Installation of different diameter staybolts shall be considered a repair.

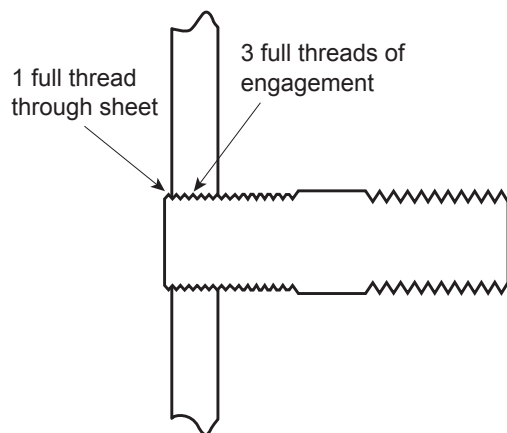
FIGURE S2.13.4
WELDED STAYBOLTS



S2.13.5 THREADED STUDS

- a) Studs threaded into the boiler or firebox sheets shall not be seal welded (See NBIC Part 3, Figure S2.13.5).
- b) When studs are replaced, they shall extend at least one full thread through the sheet on the opposite side of installation. Replacement studs shall have a minimum of three threads of engagement.

FIGURE S2.13.5
THREADED STUDS

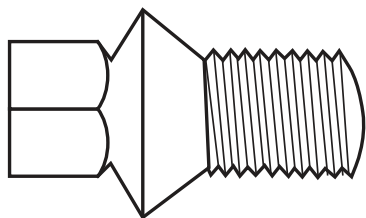


S2.13.6 PATCH BOLTS

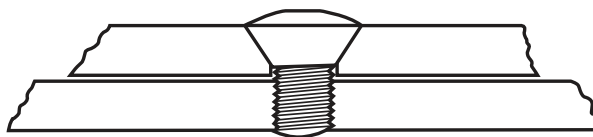
- a) Patch bolts may be replaced in kind. (See NBIC Part 3, NBIC Part 3, Figure S2.13.6)
- b) Seal welding of patch bolts is permitted.

FIGURE S2.13.6**PATCH BOLTS**

Typical patch bolt



Typical patch bolt application

**S2.13.7 FLUE AND TUBE RE-ENDING**

- a) Each boiler tube or flue that is repaired by welding is limited to not more than three circumferential welded joints.
- b) Re-ending is permitted provided the thickness of the tube or flue to be re-ended is not less than 90% of that required by NBIC Part 3, Table S2.13.7. Re-end pieces shall be new material and meet the thickness requirements of NBIC Part 3, Table S2.13.7.

TABLE S2.13.7

MAXIMUM ALLOWABLE WORKING PRESSURES FOR STEEL TUBES OR FLUES FOR FIRETUBE BOILERS FOR DIFFERENT DIAMETERS AND GAGES OF TUBES CONFORMING TO THE REQUIREMENTS OF SPEC. SA-178, SA-192, SA-209, OR SA 210

Outside diameter of tube, inches D	Minimum gage, Birmingham Wire Gage (BWG), inches									
	13 t = 0.095	12 t = 0.109	11 t = 0.120	10 t = 0.134	9 t = 0.148	8 t = 0.165	7 t = 0.180	6 t = 0.203	5 t = 0.220	4 t = 0.238
1	470	690	—	—	—	—	—	—	—	—
1-1/2	320	460	570	720	860	—	—	—	—	—
1-3/4	270	400	490	620	740	890	—	—	—	—
2	240	350	430	540	650	780	900	—	—	—
2-1/4	210	310	380	480	580	690	800	960	—	—
2-1/2	190	280	350	430	520	620	720	860	970	1,080
3	160	230	290	360	430	520	600	720	810	900
3-1/4	—	210	270	330	400	480	550	660	740	830
3-1/2	—	200	250	310	370	450	510	620	690	770
4	—	180	220	270	330	390	450	540	610	680
4-1/2	—	160	190	240	290	350	400	480	540	600
5	—	—	180	220	260	310	360	430	490	540
5-3/8	—	—	160	200	240	290	340	400	450	500
5-1/2	—	—	—	200	240	290	330	390	440	490
6	—	—	—	180	220	260	300	360	410	450
$P = \{(t-0.65)/D\} \times 15550$ where P = maximum allowable working pressure, pounds per square inch, t = minimum wall thickness, inches, D = outside diameter of tubes, inches.										
For pressures below those given in the table, the gage thickness shall be not less than the minimum given in the table. Calculated values of pressure have been rounded to the next higher unit of 10 psi.										

TABLE S2.13.7M

MAXIMUM ALLOWABLE WORKING PRESSURES FOR STEEL TUBES OR FLUES FOR FIRETUBE BOILERS FOR DIFFERENT DIAMETERS AND GAGES OF TUBES TO THE REQUIREMENTS OF SPEC. SA-176, SA-192, OR SA 210

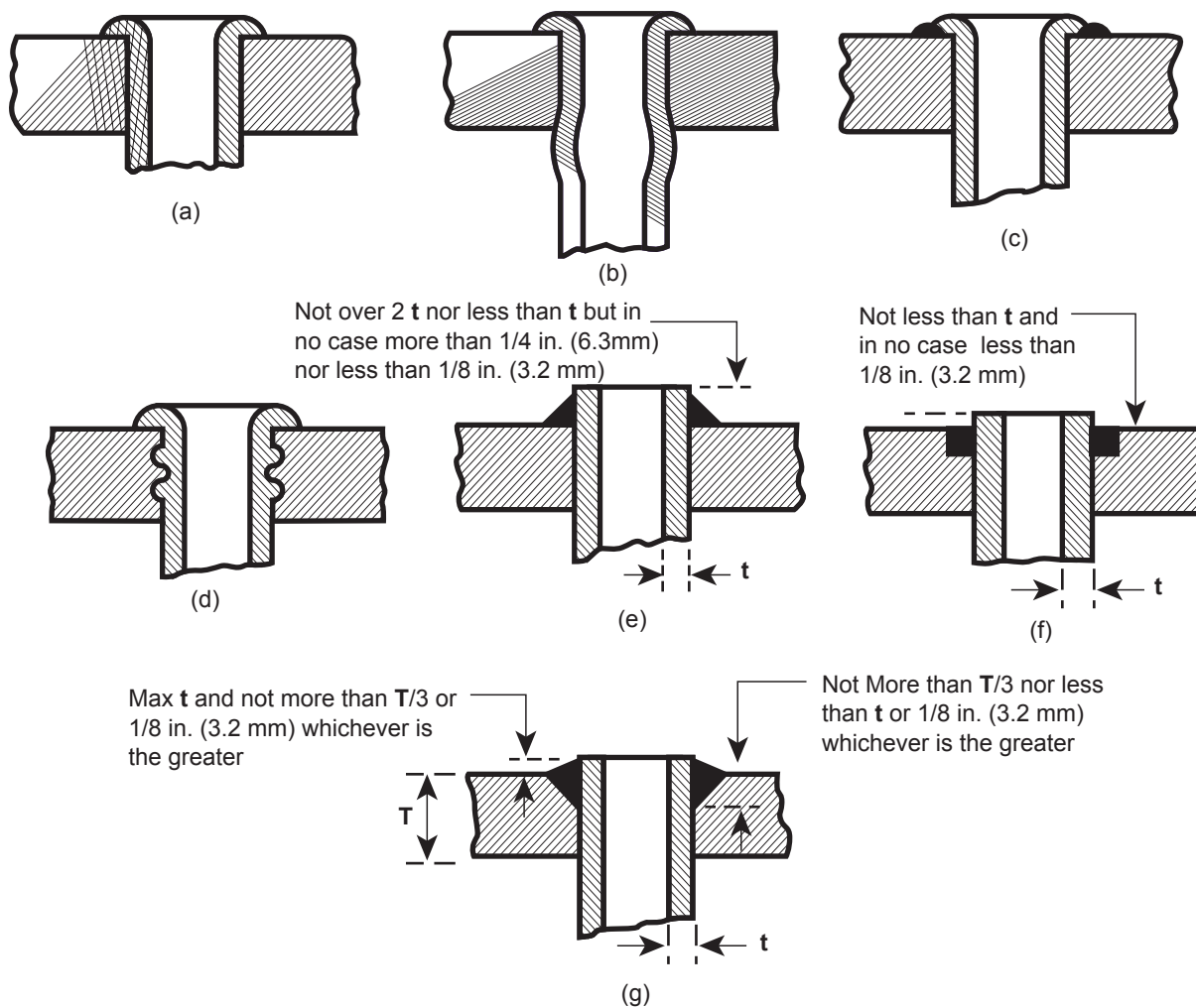
Outside diameter of tube, mm D	Minimum gage, Birmingham Wire Gage (BWG), to mm									
	13 t = 2.4	12 t = 2.8	11 t = 3.0	10 t = 3.4	9 t = 3.8	8 t = 4.2	7 t = 4.6	6 t = 5.2	5 t = 5.6	4 t = 6.0
25	3,250	4,950	—	—	—	—	—	—	—	—
40	2,150	3,250	3,850	4,950	6,100	—	—	—	—	—
45	1,850	2,800	3,300	4,300	5,250	6,250	—	—	—	—
50	1,650	2,450	2,850	3,700	4,550	5,350	6,200	—	—	—
60	1,450	2,200	2,550	3,300	4,050	4,800	5,550	6,700	—	—
65	1,300	1,950	2,300	2,950	3,600	4,300	4,950	5,950	6,650	7,300
75	1,100	1,650	1,950	2,500	3,050	3,600	4,200	5,000	5,600	6,150
85	—	1,500	1,750	2,300	2,800	3,300	3,850	4,600	5,100	5,650
90	—	1,400	1,650	2,150	2,600	3,100	3,550	4,300	4,750	5,250
100	—	1,250	1,450	1,850	2,300	2,700	3,100	3,750	4,150	5,600
115	—	1,100	1,300	1,650	2,050	2,400	2,800	3,300	3,750	4,100
125	—	—	1,150	1,500	1,850	2,200	2,500	3,000	3,350	3,700
135	—	—	1,100	1,400	1,700	2,000	2,350	2,800	3,100	3,400
140	—	—	—	1,350	1,650	2,000	2,300	2,750	3,050	3,350
150	—	—	—	1,250	1,550	1,800	2,100	2,500	2,800	3,100
$P = \{(t-1.65)/D\} \times 107000$ where P = maximum allowable working pressure, kilopascals (kPa), t = minimum wall thickness, mm, D = outside diameter of tubes, mm.										
For pressures below those given in the table, the gage thickness shall be not less than the minimum given in the table. Calculated values of pressure have been rounded to the next higher unit of 50 kPa.										

S2.13.8 FLUE AND TUBE INSTALLATION

- a) When boiler tubes and flues are replaced, the MAWP of the boiler must not exceed the MAWP of the tube or flue per Table S2.13.7.
- b) The boiler shall have the ends of the tubes firmly rolled and beaded, or rolled and welded around the edge of the tube. (See NBIC Part 3, Figure S2.13.8). Tube ends attached by rolling and welding are subject to the following provisions:
 - 1) The tube sheet hole may be beveled or recessed to a depth at least equal to the thickness of the tubes. Where the hole is beveled or recessed, the projection of the tube beyond the tube sheet shall not exceed a distance equal to the tube thickness. The depth of any bevel or recess shall not be less than the tube thickness or 1/8 in. (3 mm), whichever is greater, nor more than one-third of the tube sheet thickness. (See NBIC Part 3, Figure S2.13.8 f) and g))
 - 2) Where no bevel or recess is employed, the tube shall extend beyond the tube sheet not less than a distance equal to the tube thickness, nor more than twice the tube thickness. (See NBIC Part 3, Figure S2.13.8 e))

- 3) On welded attachments, the tubes shall be rolled before welding and again rolled lightly after the welding procedure.
- c) Expanding of tubes by the Prosser method (see NBIC Part 3, Figure S2.13.8 b) in lieu of rolling may be employed in combination with any beaded or welded attachment method.
- d) Seal welding is permissible on any type of beaded attachment. Where seal welding is employed, a single hydrostatic test of the boiler after seal welding shall be performed.
- e) The inner surface of the tube hole in any form of attachment may be grooved or chamfered.
- f) The sharp edges of tube holes shall be taken off on both sides of the plate with a file or other tool.

FIGURE S2.13.8
ACCEPTABLE FORMS OF TUBE ATTACHMENTS



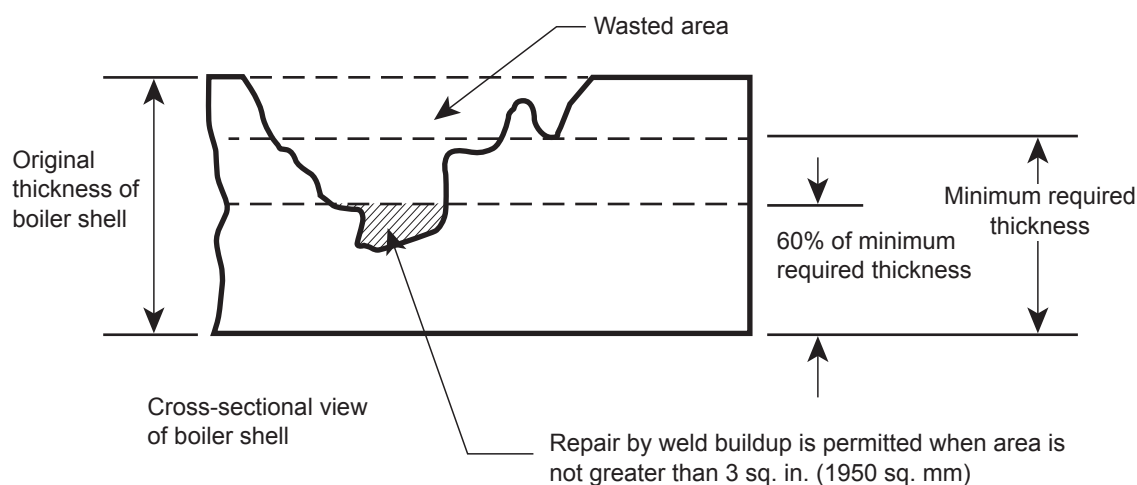
S2.13.9 REPAIRS AND ALTERATIONS TO UNSTAYED AREAS

S2.13.9.1 WELD BUILDUP OF WASTAGE AND GROOVING IN UNSTAYED AREAS

- Weld buildup shall not be used if the affected section of plate has wasted below 60% of the minimum required thickness per NBIC Part 2, Supplement 2 in an area exceeding 3 sq. inches (1,950 sq. mm.). (See NBIC Part 3, Figure S2.13.9.1).
- Wasted sections that have wasted below 60% of the minimum required thickness and have an area exceeding 3 sq. in. (1,950 sq. mm) shall be repaired by installing a flush patch using full penetration welds.
- Weld buildup of wasted areas shall not exceed 100 sq. in. (65,000 sq. mm).
- Weld buildup is to replace material that has been lost due to wastage and grooving, and is not to replace thickness on the opposite side of the sheet. Weld buildup must be applied to the side of the sheet that is wasted or grooved.
- Prior to welding, the rivets in the wasted area should be removed.
- Rivets holes should be reamed after welding.
- Welding shall not cover rivet heads.

FIGURE S2.13.9.1

WELD BUILDUP

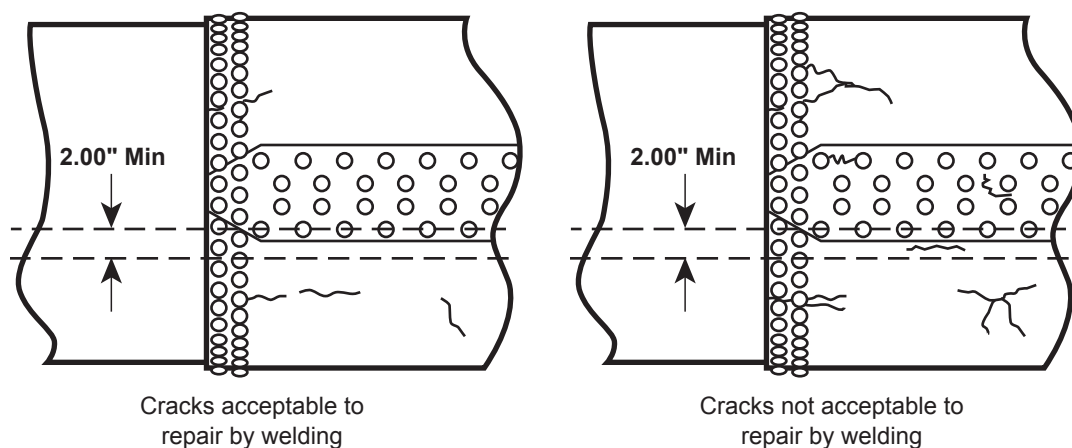


S2.13.9.2 WELDED REPAIR OF CRACKS IN UNSTAYED AREAS

- a) Prior to repairing cracks, the plate shall be NDE examined for other defects. All affected sections shall be repaired.
- b) Cracks in unstayed areas may be repaired by welding. Before cracks are repaired, however, the inner surface of the plate should be examined for possible excessive corrosion or grooving.
- c) Cracks in unstayed areas may be repaired by welding, providing the cracks do not extend between rivet holes in a longitudinal seam or parallel to a longitudinal seam within 2 in. (50 mm) from the center line of the outer most row of rivets. Minimum 175°F (79°C) preheat shall be used. The completed repair shall have volumetric NDE performed and stress relieved. Alternative methods in lieu of postweld heat treatment identified in NBIC Part 3, 2.5.3 may be used. (See NBIC Part 3, Figure S2.13.9.2)
- d) Cracks radiating from a common point (star cracking) shall not be repaired; installation of a flush patch is required. Cracks radiating from a rivet hole in a circumferential seam may be repaired if the plate is not seriously damaged. (See NBIC Part 3, Figure S2.13.9.2)
- e) Prior to welding, the rivets into which cracks extend and the rivets on each side of them shall be removed.
- f) In riveted joints, tack bolts should be placed in alternating holes to hold the plate laps firmly.
- g) Rivets holes should be reamed after welding.
- h) Welding shall not cover rivet heads.

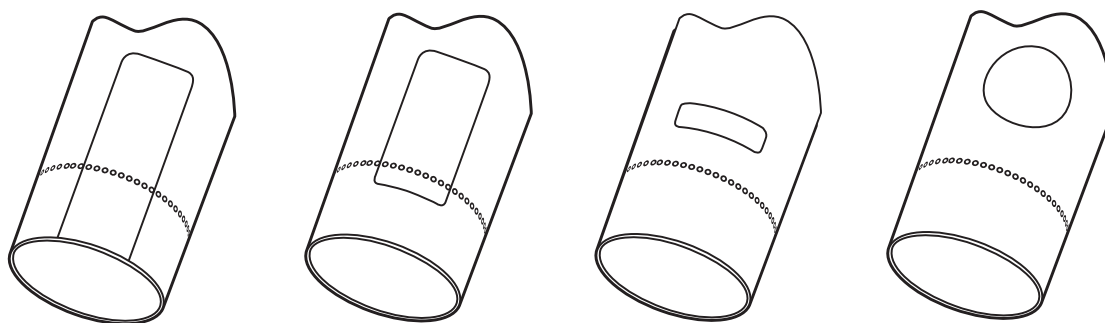
FIGURE S2.13.9.2

UNSTAYED AREA CRACK

**S2.13.9.3 WELDED FLUSH PATCHES IN UNSTAYED AREAS**

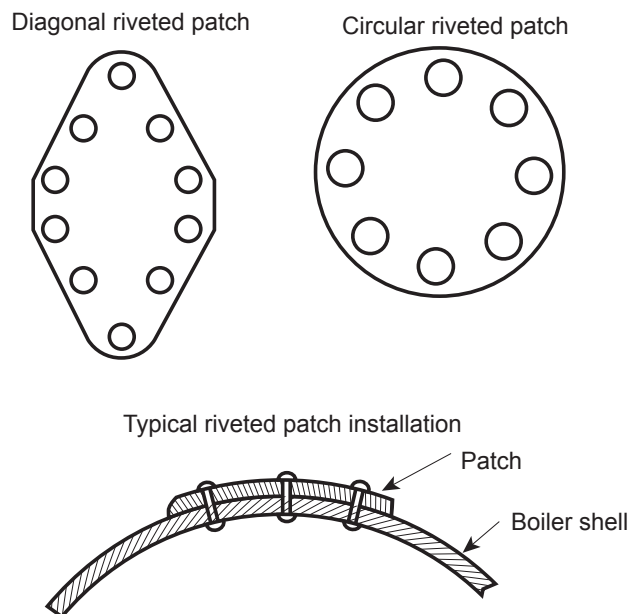
- a) Welded repairs to boiler unstayed areas shall have volumetric NDE performed in accordance with the approved code of construction or ASME Section I, when the size of the repaired area is greater than 3 in. (75 mm) in diameter. The completed repair must be stress relieved. Alternative Methods without Postweld Heat Treatment identified in NBIC Part 3, 2.5.3 may be used.
- b) The weld around a flush patch shall be a full penetration weld and the accessible surfaces shall be ground flush. Examples of flush welded patches are shown in Figure NBIC Part 3, S2.13.9.3.

- c) Before installing a flush patch, the defective material should be removed until sound material is reached.
- d) The patch should be rolled or pressed to the proper shape or curvature. The edges of the patch should align with original material without overlap. Patches shall fit flush on the waterside of the sheet. If the patch includes an existing riveted seam, the patch shall be riveted at that seam. Changing a riveted seam to a welded seam is considered an alteration. Patches may be of any shape or size. If the patch is square or rectangular, an adequate radius, of at least three times the material thickness should be provided at the corners. Square corners shall be avoided.
- e) Material thickness of patches shall be at least equal to, but not greater than, 1/8 in. (3 mm) thicker than original construction thickness.

FIGURE S2.13.9.3**UNSTAYED AREA FLUSH PATCH****S2.13.9.4 REPAIR OF CRACKS, GROOVING, AND WASTAGE USING A RIVETED PATCH IN UNSTAYED AREAS**

- a) If the cracked section of plate is retained and is to be repaired by installation of a riveted patch, the crack may be stopped by drilling stop holes at each end or removed by a method such as grinding, cutting, or machining. Results of stop drilling or crack removal shall be verified by NDE. (See NBIC Part 3, Figure S2.13.9.4)
- b) Riveted patches may be installed on the boiler shell interior or exterior.
- c) Installation of a riveted patch shall be considered an alteration.
- d) Riveted patches may be any shape or size provided the lowest patch efficiency is equal to or greater than the lowest equivalent seam efficiency of the boiler course to which it is applied.
- e) The design margin of all riveted patches shall not be less than four.

FIGURE S2.13.9.4
RIVETED BOILER SHELL PATCH



S2.13.9.5 BARREL REPLACEMENT

An entire course of a barrel may be replaced as a repair provided that:

- a) The replacement material is code-accepted material (see NBIC Part 3, S2.7.1) that has a nominal composition and strength that is equal to or greater than the original, and is suitable for the intended service;
- b) The minimum required thickness shall be at least equal to the original material thickness. The original thickness may be determined from the original Manufacturer's Data Report, original drawings, or by measuring the original material thickness in an area unaffected by corrosion;
- c) The longitudinal joint efficiency of the new barrel course meets or exceeds the original design/construction;
- d) All doubling/reinforcing plates, stays and openings in the original barrel are duplicated or retained on the new barrel and installed in a manner that meets or exceeds the original design/construction;
- e) All attachments and connections with other portions of the boiler are attached in the same manner as the original;
- f) The boiler will not be re-rated at a MAWP greater than the original design MAWP; and
- g) If all of the above requirements are not met, then the replacement will be considered an alteration and must follow the requirements of NBIC Part 3, 3.4 and S2.13.10 repairs and alterations to stayed areas.

S2.13.10 REPAIRS AND ALTERATIONS TO STAYED AREAS

S2.13.10.1 WELD BUILDUP OF WASTAGE AND GROOVING IN STAYED AREAS

Requirements specified in NBIC Part 3, S2.13.9.1 shall apply with the following additional requirements identified below:

- a) Prior to welding, the rivets and or staybolts in the wasted areas should be removed.
- b) Threaded staybolt holes shall be retapped after welding.
- c) Welding shall not cover rivet or staybolt heads.

S2.13.10.2 WELDED REPAIR OF CRACKS IN STAYED AREAS

Requirements specified in NBIC Part 3, S2.13.9.2 shall apply with the following additional requirements identified below:

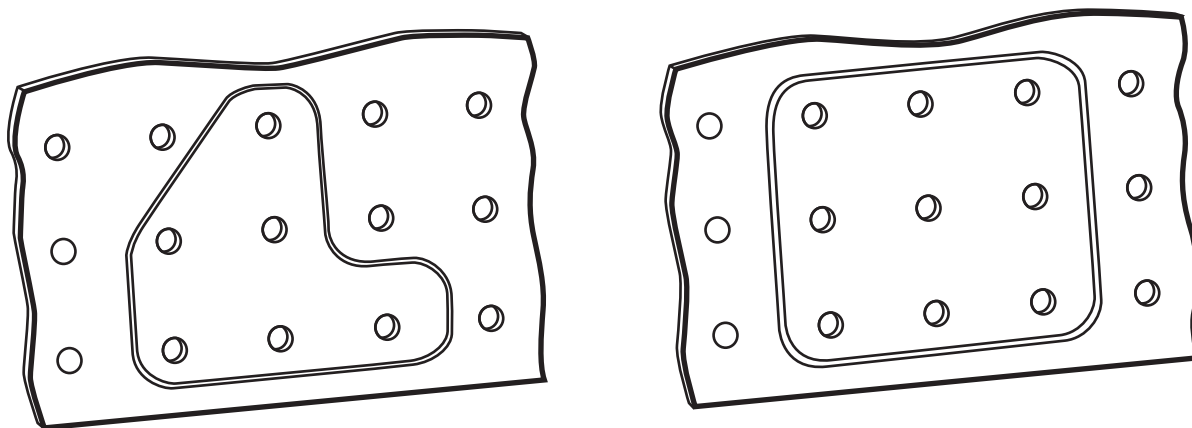
- a) If the crack extends into a staybolt hole, the staybolt shall be removed prior to making the repair.
- b) Threaded staybolts shall be retapped after welding.
- c) If the load on repair area is carried by other forms of construction, such as staybolts, rivets, or tubes, volumetric NDE of the welds is not required.

S2.13.10.3 WELDED FLUSH PATCHES IN STAYED AREAS

The requirements identified in NBIC Part 3, S2.13.9.3 shall apply with the additional requirements specified below:

- a) Patches may be any shape provided they are adequately supported by staybolts, rivets, tubes, or other forms of construction. Patches on stayed surfaces should be designed so weld seams pass between staybolt rows. (See NBIC Part 3, Figure S2.13.10.3-a);
- b) Patches are to be flush type, using full penetration welds. If the load on the patch is carried by other forms of construction, such as staybolts, rivets, or tubes, then volumetric NDE of the welds is not required;
- c) Staybolts and rivets should be installed after welding of patch is completed. Reuse of staybolts and rivets is prohibited; and
- d) For welded flush patches in stayed areas that include a knuckle area, see S2.13.11.3, *Welded Flush Patches in Firebox and Tubesheet Knuckles*.

FIGURE S2.13.10.3-a
STAYED AREA FLUSH PATCH



S2.13.10.4 REPAIR OF STAYED FIREBOX SHEETS GROOVED OR WASTED AT THE MUDRING

- a) Mudgings of the Ogee style (knuckle) shall be repaired in accordance with NBIC Part 3, S2.13.11.
- b) For mudgings of the locomotive style (See NBIC Part 3, Figure S2.13.10.4-a), weld buildup shall not be used if the affected section of plate has wasted below 60% of the minimum required thickness per Part 2, Supplement 2 in an area exceeding 3 sq. in. (1,950 sq. mm). (See NBIC Part 3, Figure S2.13.9.1) Repair by weld buildup cannot be used if the wastage extends below the waterside surface of the mudring or if the strength of the structure will be impaired. If extensive welding is required, the affected area shall be removed and replaced with a flush patch.
- c) Wasted sections that have wasted below 60% of the minimum required thickness, and have an area exceeding 3 sq. in (1950 sq.mm) shall be repaired by installing a flush patch using a full penetration weld.
- d) If wastage and grooving extends below the mudring waterside surface and if the plate thickness remaining has been reduced to less than the minimum required thickness, the affected section shall be removed and replaced with a flush patch. (See NBIC Part 3, Figure S2.13.10.4-a)
- e) Flush patches shall be arranged to include the mudring rivets and at least the first row of staybolts above the mudring. (See NBIC Part 3, Figure S2.13.10.4-b)
- f) For mudgings of the locomotive style, pitted and wasted sections of mudgings may be built up by welding provided the strength of the mudring will not be impaired. Where extensive weld buildup is employed, the Inspector may require an appropriate method of NDE for the repair.
- g) Cracked or broken mudgings may be repaired by welding or installing flush patches using full penetration welds. Patches shall be made from material that is at least equal in strength and thickness to the original material. Patches shall fit flush on waterside surfaces. Where necessary, firebox sheets on both sides of the defect may be removed to provide access for inspection and welding.

FIGURE S2.13.10.4-a
MUDRING WASTAGE REPAIR

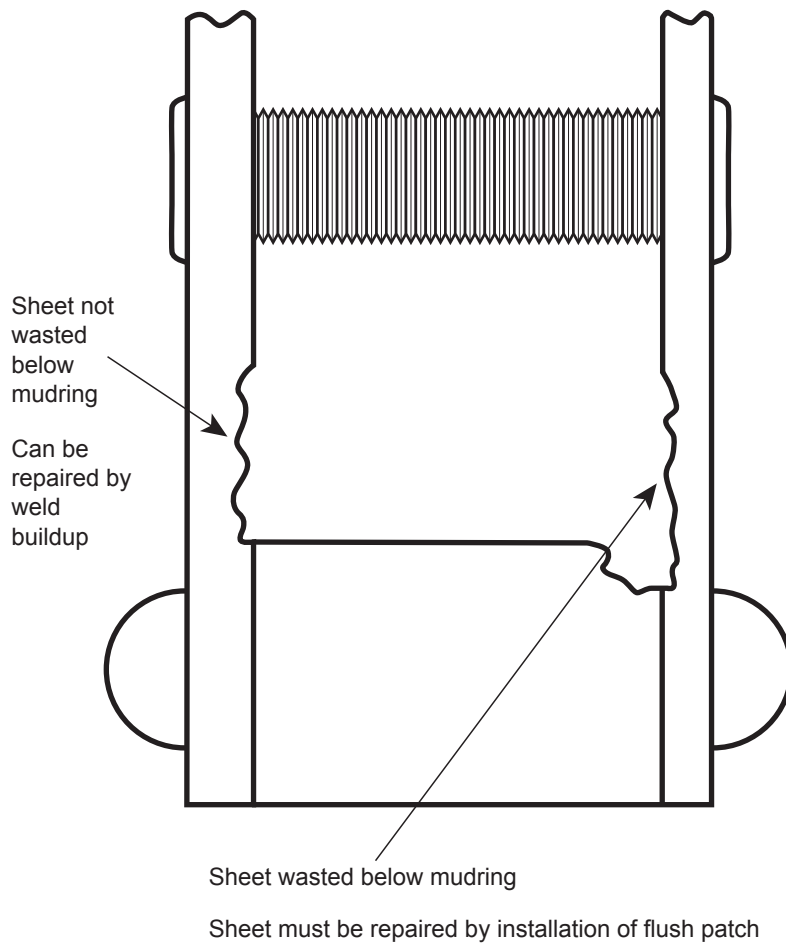
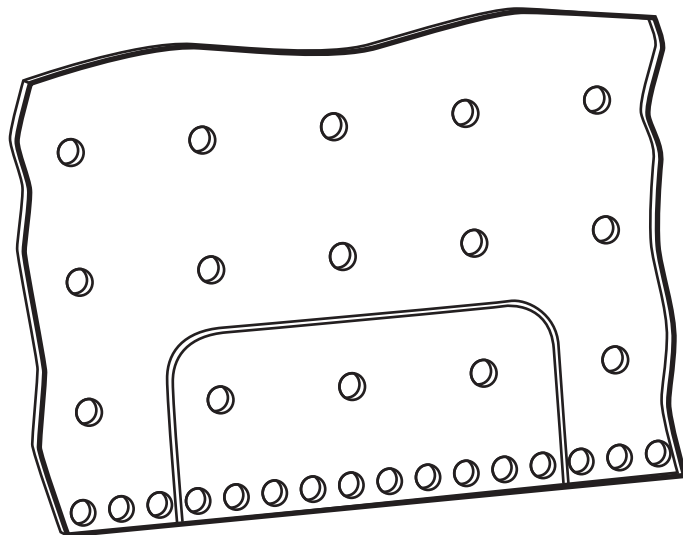


FIGURE S2.13.10.4-b
MUDRING FLUSH PATCH



S2.13.11 REPAIR OF FIREBOX AND TUBESHEET KNUCKLES

S2.13.11.1 WELD BUILDUP OF WASTAGE AND GROOVING IN FIREBOX AND TUBESHEET KNUCKLES

- a) Weld buildup shall not be used if the affected section of plate has wasted below 60% of the minimum required thickness per NBIC Part 2, Supplement 2. (See NBIC Part 3, Figure S2.13.9.1)
- b) Wasted sections that have wasted below 60% of the minimum required thickness shall be repaired by installing a flush patch using full penetration welds.
- c) Weld buildup of wasted areas shall not exceed 100 sq. in. (65,000 sq. mm).
- d) Weld buildup is to replace material that has been lost due to wastage and grooving, and is not to replace thickness on the opposite side of the sheet. Weld buildup must be applied to the side of the sheet that is wasted or grooved.

S2.13.11.2 WELDED REPAIR OF CRACKS IN FIREBOX AND TUBESHEET KNUCKLES

- a) Prior to repairing cracks, the plate shall be NDE examined for other defects. All affected sections shall be repaired.
- b) Welded repair of cracks within the points of tangency of a knuckle are permitted. All welds within the points of tangency of the knuckle shall have volumetric NDE performed.
- c) Cracks radiating from a common point (star cracking) shall not be repaired; installation of a flush patch is required.

S2.13.11.3 WELDED FLUSH PATCHES IN FIREBOX AND TUBESHEET KNUCKLES

- a) Any patch not supported by means other than the weld, such as rivets, staybolts, tubes, or other forms of construction, shall have volumetric NDE performed on the weld seams. (See NBIC Part 3, Figure S2.13.11.3-b)
- b) Weld seams parallel to a knuckle shall be located no closer to the knuckle than the knuckle point of tangency. (See NBIC Part 3, Figure S2.13.11.3-a)
- c) All other requirements specified in NBIC Part 3, S2.13.9.3, S2.13.10.3, and S2.13.12.3 shall be followed.

FIGURE S2.13.11.3-a

KNUCKLE FLUSH PATCH

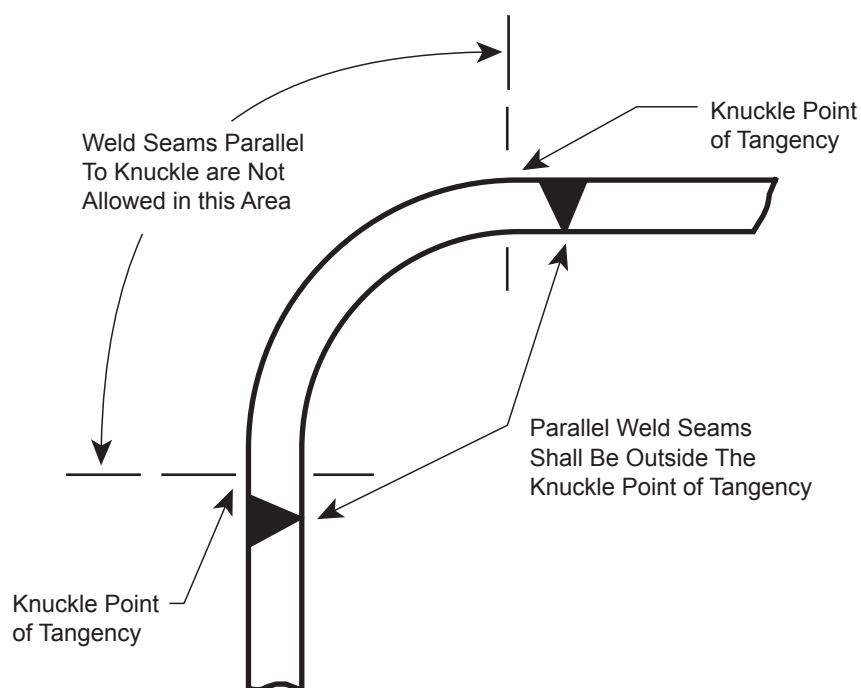
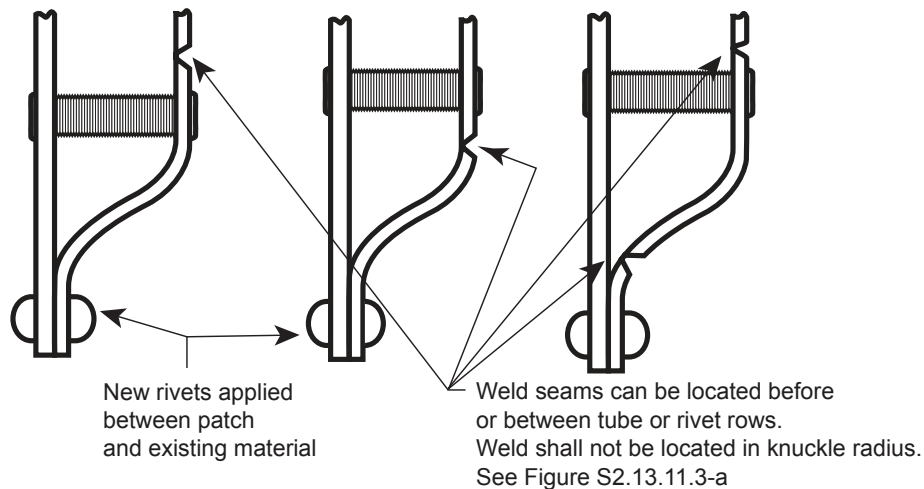
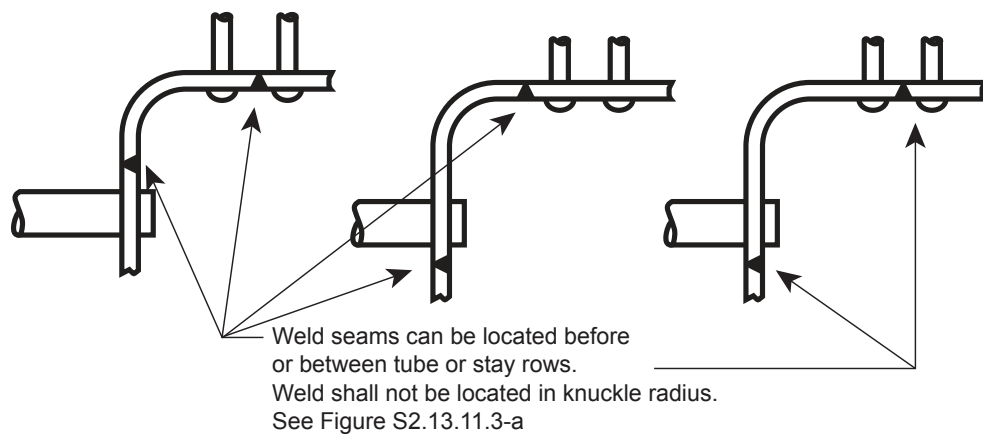


FIGURE S2.13.11.3-b
KNUCKLE FLUSH PATCH

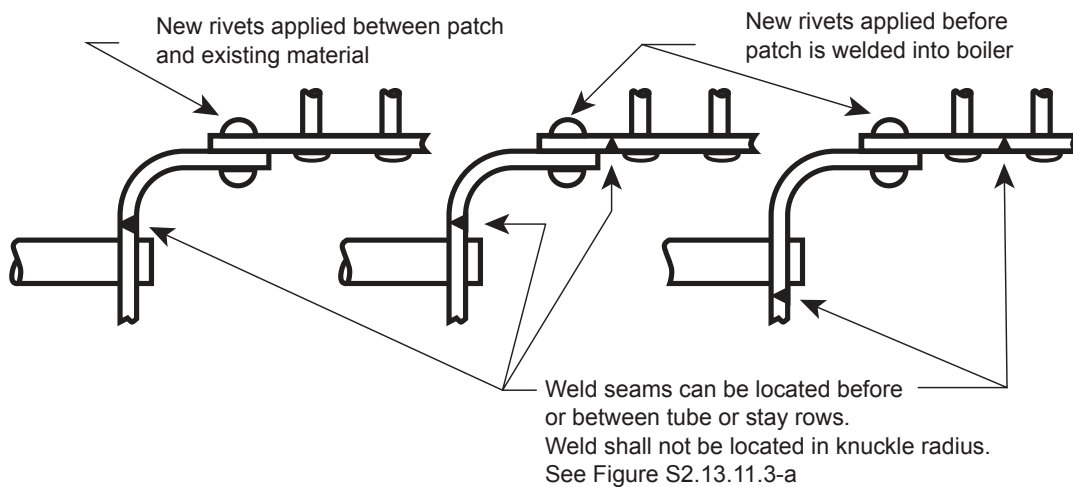
Stayed Patch Applied to Riveted Ogee Knuckle Seam



Stayed Patch Applied to Buttwelded Seam



Stayed Patch Applied to Riveted Seam



S2.13.12 REPAIR OF TUBESHEETS

S2.13.12.1 WELD BUILDUP OF WASTAGE AND GROOVING IN TUBESHEETS

All requirements of NBIC Part 3, S2.13.9.1 and S2.13.10 shall be followed with the additional requirements listed below:

- a) Damaged tubesheet holes may be repaired by welding;
- b) Prior to welding, tubes in the wasted area should be removed;
- c) Tube holes should be reamed after welding;
- d) Welding shall not cover tube ends.

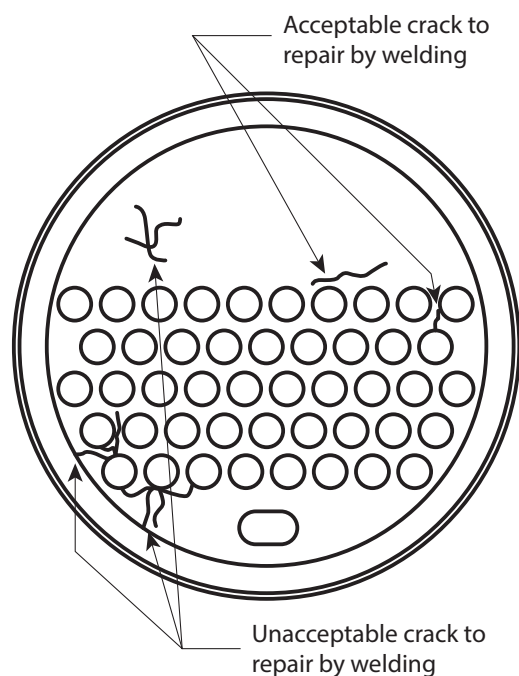
S2.13.12.2 WELDED REPAIR OF CRACKS IN TUBESHEETS

The same method of repairing cracks in stayed areas identified in NBIC Part 3, Figure S2.13.12.2 shall be followed with the additional requirements identified below:

- a) Cracks in a tubesheet and cracks between tubesheet ligaments may be repaired by welding using full penetration welds. Before cracks are repaired, however, the inner surface of the plate should be carefully examined for possible excessive corrosion or grooving;
- b) If the crack extends into a tube hole, the tube shall be removed prior to making the repair;
- c) Tube holes should be reamed after welding; and
- d) Welding shall not cover tube ends.

FIGURE S2.13.12.2

WELDED REPAIR OF CRACKS IN TUBESHEETS



S2.13.12.3 WELDED FLUSH PATCHES IN TUBESHEETS

The method of repair shall follow the same requirements identified in S2.13.10.3 with the following requirements as noted below:

- Tubes, staybolts, and rivets should be installed after welding of the patch is completed. (See NBIC Part 3, Figure S2.13.12.3-a)
- A flush patch repair can be welded through tube holes or around tube holes. (See NBIC Part 3, Figure S2.13.12.3-a)
- If the Flush Patch repair extends through the tube sheet radius either the sheet should be flanged to match the original tube sheet flange or a welded alternative may be used as shown in NBIC Part 3, Figure S2.13.12.3.a.

FIGURE S2.13.12.3-a
TUBESHEET FLUSH PATCH

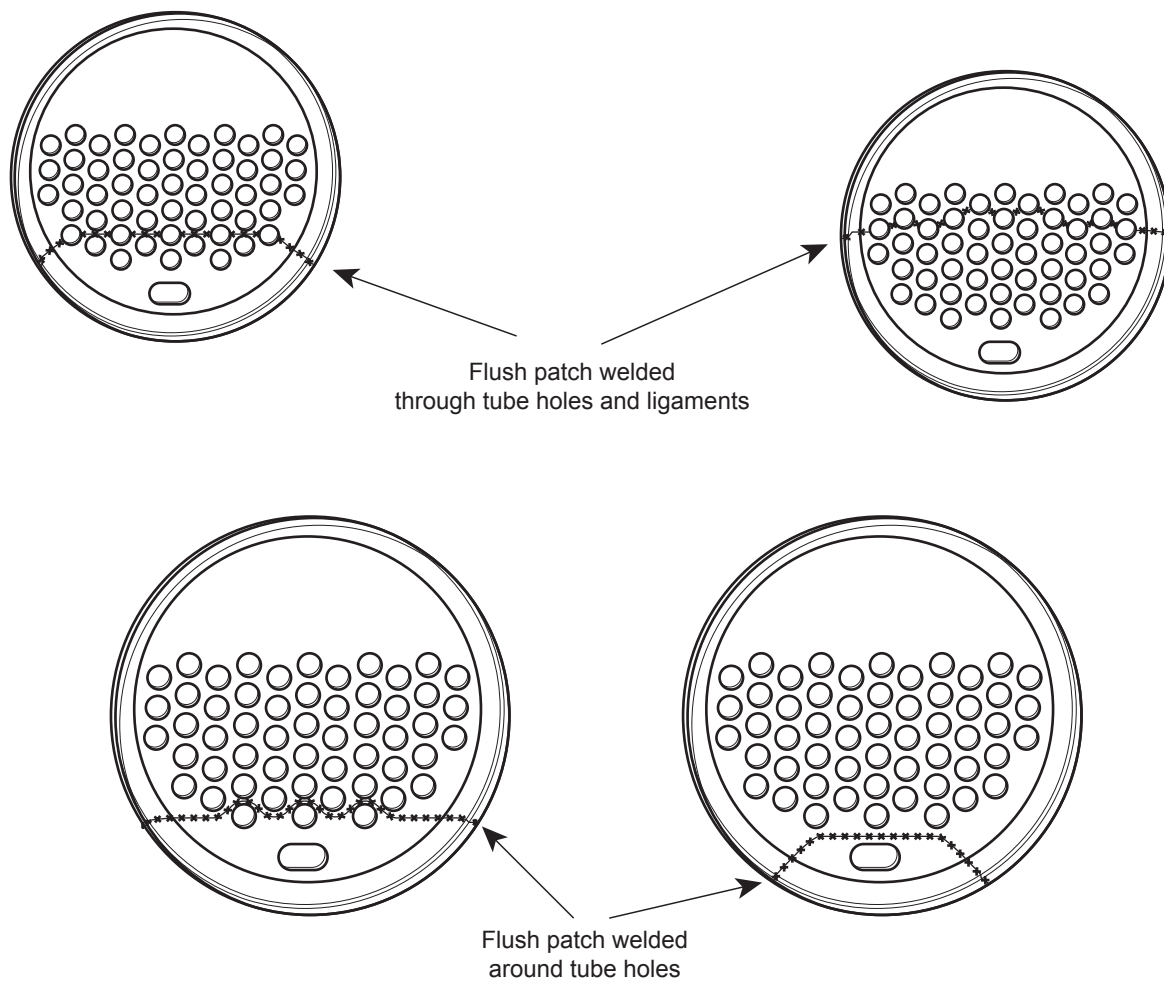
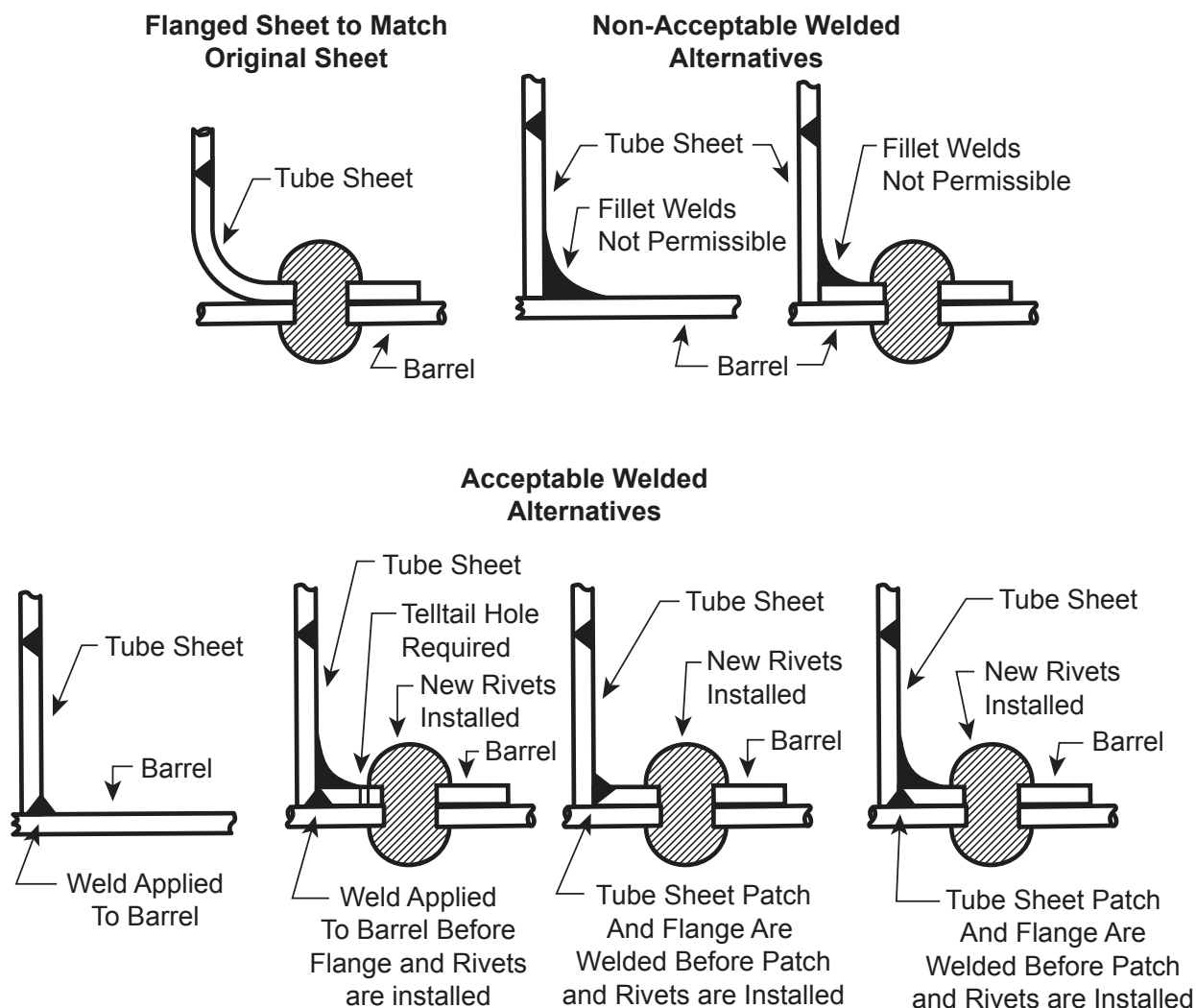


FIGURE S2.13.12.3-b
FRONT TUBESHEET REPAIR

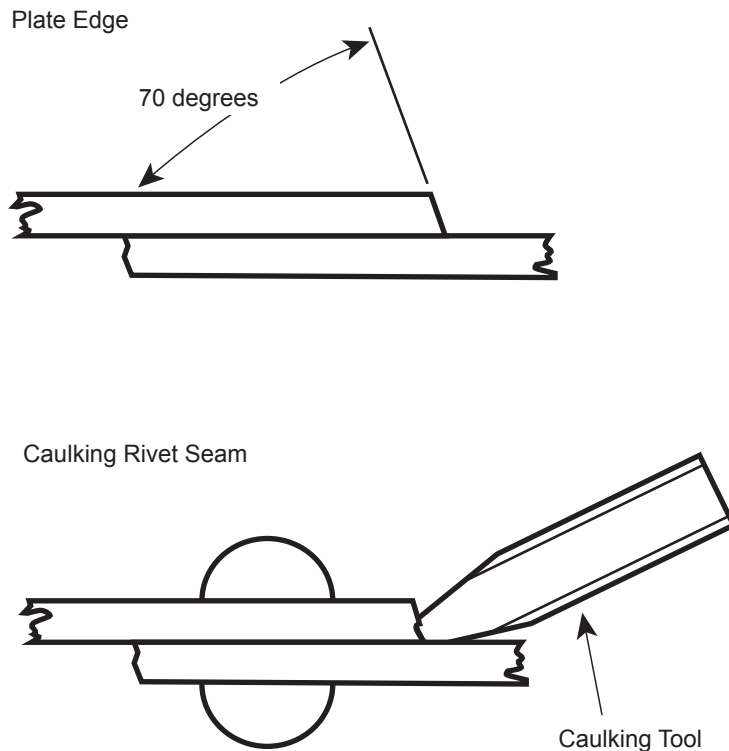


S2.13.13 SEAMS, JOINTS, AND RIVETS

S2.13.13.1 CAULKING RIVETED SEAMS AND RIVET HEADS

- Caulking refers to the sealing of plate seams and rivet heads by driving the edge of one surface onto the other by use of a caulking tool.
- The plate edges should be beveled to an angle not sharper than 70 degrees to the plane of the plate and as near thereto as practicable.
- Caulking shall be done with a tool of such form that there is no danger of scoring or damaging the plate underneath the caulking edge, or splitting the caulked sheet.
- Riveted seams and rivet heads may be re-caulked after repairs to tighten joint.

FIGURE S2.13.13.1
CAULKING RIVET SEAMS



S2.13.13.2 RIVET HOLES

- All holes for rivets in plates, buttstraps, heads, stays, and lugs shall be drilled; or they may be punched at least 1/8 in. (3.2 mm) less than full diameter for material not over 5/16 in. (7.9 mm) in thickness and at least 1/4 in. (6.3 mm) less than full diameter for material over 5/16 in. (7.9 mm).
- Such holes shall not be punched in material more than 5/8 in. (16 mm) in thickness.
- For final drilling or reaming the hole to full diameter, the parts shall be firmly bolted in position by tack bolts.
- The finished holes must be true, clean, and concentric.

S2.13.13.3 ASSEMBLY OF RIVETED JOINTS

After drilling or reaming rivet holes, the plates shall be separated, the burrs and chips removed, and the plates reassembled. Barrel pins fitting the holes and tack bolts to hold the plates firmly together shall be used.

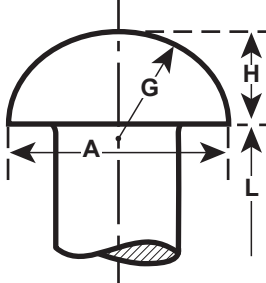
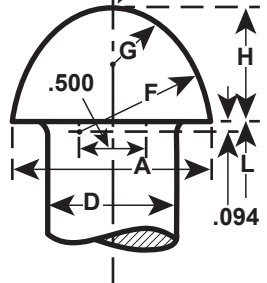
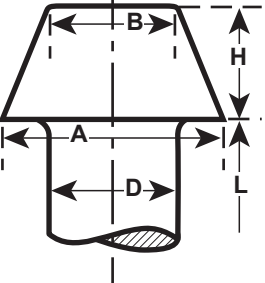
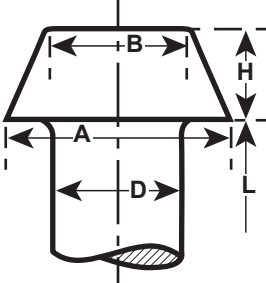
S2.13.13.4 RIVETING

- Rivets shall be so driven as to fill the holes preferably by a machine that maintains the pressure until no part of the head shows red in the daylight. Barrel pins fitting the holes and tack bolts to hold the plates firmly together shall be used. A rivet shall be driven on each side of each tack bolt before removing the tack bolt.

- b) Rivets shall be of sufficient length to completely fill the rivet holes and form heads at least equal in strength to the bodies of the rivets. Forms of finished rivet heads that will be acceptable are shown in NBIC Part 3, Figure S2.13.13.4-a and S2.13.13.4-b and S2.13.13.4-c.
- c) For rivet head designs not shown in Figure S2.13.13.4-a, S2.13.13.4-b and S2.13.13.4-c, the strength of the rivet head design may be calculated to demonstrate strength equivalent to the body of the rivet. Formulas for calculation are permitted at the discretion of the Inspector.

FIGURE S2.13.13.4-a

AMERICAN NATIONAL STANDARD LARGE RIVETS — I (ANSI B18.1.2-1972, R1989)

Button Head  High Button See Note 3  Cone Head  Pan Head 								
Nom. Body Diam. D†	Head Diam. A		Height H		Head Diam. A		Height H	
	Mfd. Note 1	Driven Note 2	Mfd. Note 1	Driven Note 2	Mfd. Note 1	Driven Note 2	Mfd. Note 1	Driven Note 2
Button Head					High Button Head (Acorn)			
1/2	0.875	0.922	0.375	0.344	0.781	0.875	0.500	0.375
5/8	1.094	1.141	0.469	0.438	0.969	1.062	0.594	0.453
3/4	1.312	1.375	0.562	0.516	1.156	1.250	0.688	0.531
7/8	1.531	1.594	0.656	0.609	1.344	1.438	0.781	0.609
1	1.750	1.828	0.750	0.688	1.531	1.625	0.875	0.688
1-1/8	1.969	2.062	0.844	0.781	1.719	1.812	0.969	0.766
1-1/4	2.188	2.281	0.938	0.859	1.906	2.000	1.062	0.844
1-3/8	2.406	2.516	1.031	0.953	2.094	2.188	1.156	0.938
1-1/2	2.625	2.734	1.125	1.031	2.281	2.375	1.250	1.000
1-5/8	2.844	2.969	1.219	1.125	2.469	2.562	1.344	1.094
1-3/4	3.062	3.203	1.312	1.203	2.656	2.750	1.438	1.172
Cone Head					Pan Head			
1/2	0.875	0.922	0.438	0.406	0.800	0.844	0.350	0.328
5/8	1.094	1.141	0.547	0.516	1.000	1.047	0.438	0.406
3/4	1.312	1.375	0.656	0.625	1.200	1.266	0.525	0.484
7/8	1.531	1.594	0.766	0.719	1.400	1.469	0.612	0.578
1	1.750	1.828	0.875	0.828	1.600	1.687	0.700	0.656
1-1/8	1.969	2.063	0.984	0.938	1.800	1.891	0.788	0.734
1-1/4	2.188	2.281	1.094	1.031	2.000	2.094	0.875	0.812
1-3/8	2.406	2.516	1.203	1.141	2.200	2.312	0.962	0.906
1-1/2	2.625	2.734	1.312	1.250	2.400	2.516	1.050	0.984
1-5/8	2.844	2.969	1.422	1.344	2.600	2.734	1.138	1.062
1-3/4	3.062	3.203	1.531	1.453	2.800	2.938	1.225	1.141

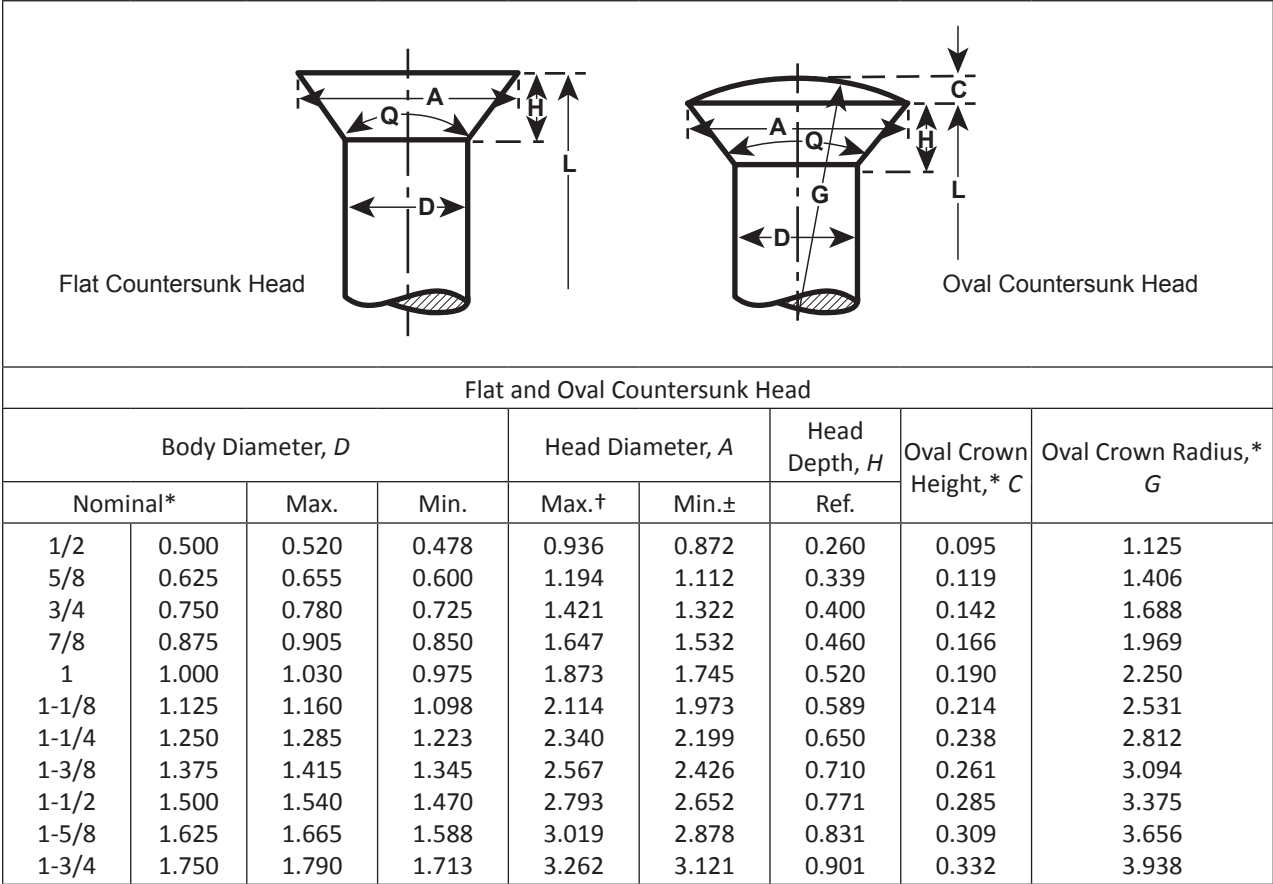
All dimensions are given in inches.

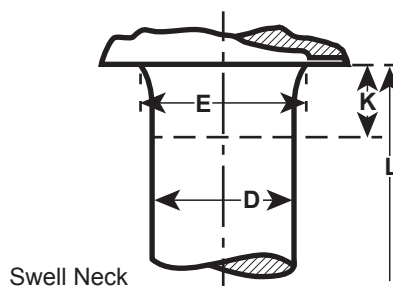
† Tolerance for diameter of body is plus and minus from nominal and for 1/2-inch size equals +0.020, -0.022; for size 5/8 to 1-inch, incl., equals +0.030, -0.025 for sizes 1-1/8 and 1-1/4-inch equals +0.035, -0.027; for sizes 1-3/8 and 1-1/2-inch equals +0.040, -0.060; for sizes 1-5/8 and 1-3/4-inch equals +0.040, -0.037.

The following formulas give the basic dimensions for manufactured shapes: Button Head, $A = 1.750D$; $H = 0.750D$; $G = 0.885D$. High Button Head, $A = 1.500D + 0.031$; $H = 0.750D + 0.125$; $F = 0.750D + 0.281$; $G = 0.750D - 0.281$. Cone Head, $A = 1.750D$; $B = 0.938D$; $H = 0.875D$. Pan Head, $A = 1.600D$; $B = 1.000D$; $H = 0.700D$. Length L is measured parallel to the rivet axis, from the extreme end to the bearing surface plane for flat bearing surface head-type rivets, or to the intersection of the head top surface with the head diameter for countersunk head-type rivets.

- Note 1:** Basic dimensions of head as manufactured.
- Note 2:** Dimensions of manufactured head after driving and also driven head.
- Note 3:** Slight flat permissible within the specified head-height tolerance.

FIGURE S2.13.13.4-b
AMERICAN NATIONAL STANDARD LARGE RIVETS — I (ANSI B18.1.2-1972, R1989)



Swell Neck[#]

Body Diameter, D				Diameter Under Head, E		Neck Length, K^*
Nominal*		Max.	Min.	Max. (Basic)	Min.	
1/2	0.500	0.520	0.478	0.563	0.543	0.250
5/8	0.625	0.655	0.600	0.688	0.658	0.312
3/4	0.750	0.780	0.725	0.813	0.783	0.375
7/8	0.875	0.905	0.850	0.938	0.908	0.438
1	1.000	1.030	0.975	1.063	1.033	0.500
1-1/8	1.125	1.160	1.098	1.188	1.153	0.562
1-1/4	1.250	1.285	1.223	1.313	1.278	0.625
1-3/8	1.375	1.415	1.345	1.438	1.398	0.688
1-1/2	1.500	1.540	1.470	1.563	1.523	0.750
1-5/8	1.625	1.665	1.588	1.688	1.648	0.812
1-3/4	1.750	1.790	1.713	1.813	1.773	0.875

All dimensions are given in inches. * Basic dimension as manufactured.

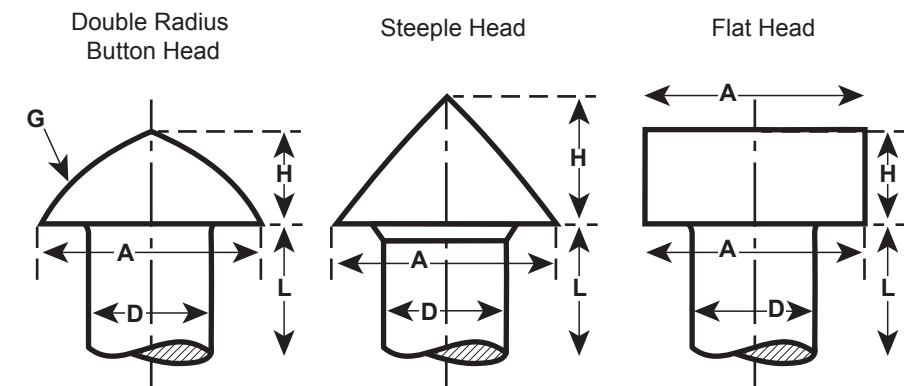
† Shard-edged head. ± Rounded or flat-edged irregularly shaped head (heads are not machined or trimmed.)

The swell neck is applicable to all standard forms of large rivets except the flat countersunk and oval countersunk-head types.

The following formulas give the basic dimensions for manufactured shapes: *Flat Countersunk Head*, $A = 1.810D$; $H = 1.192D$ (Max. $A - D$)/2; included angle Q of head = 78 degrees. *Oval Countersunk Head*, $A = 1.810D$; $H = 1.192$ (Max. $A - D$)/2; included angle of head = 78 degrees. *Swell Neck*, $E = D + 0.063$; $K = 0.500D$. Length L is measured parallel to the rivet axis, from the extreme end to the bearing surface plane for flat bearing surface head-type rivets, or to the intersection of the head top surface with the head diameter for countersunk head-type rivets.

Note: For more information see ANSI B18.1.2. A copy can be obtained in the machinist handbook.

FIGURE S2.13.13.4-c
HISTORIC LARGE RIVETS (C.I.S)



Nom. Body Diam. D†	Head Diam. A	Height H	Head Diam. A	Height H	Head Diam. A	Height H
	Double Radius Button Head		Steeple Head		Flat Head	
1/2	0.950	0.350	1.000	0.500	0.875	0.250
5/8	1.188	0.428	1.250	0.625	1.094	0.313
3/4	1.425	0.525	1.500	0.750	1.313	0.375
7/8	1.663	0.613	1.750	0.875	1.531	0.438
1	1.900	0.700	2.000	1.000	1.750	0.500
1-1/8	2.138	0.788	2.250	1.125	1.969	0.563
1-1/4	2.375	0.875	2.500	1.250	2.188	0.625
1-3/8	2.613	0.963	2.750	1.375	2.406	0.688
1-1/2	2.850	1.050	3.000	1.500	2.625	0.750
1-5/8	3.088	1.138	3.250	1.625	2.844	0.813
1-3/4	3.325	1.225	3.500	1.750	3.063	0.875

All Dimensions are given in inches.

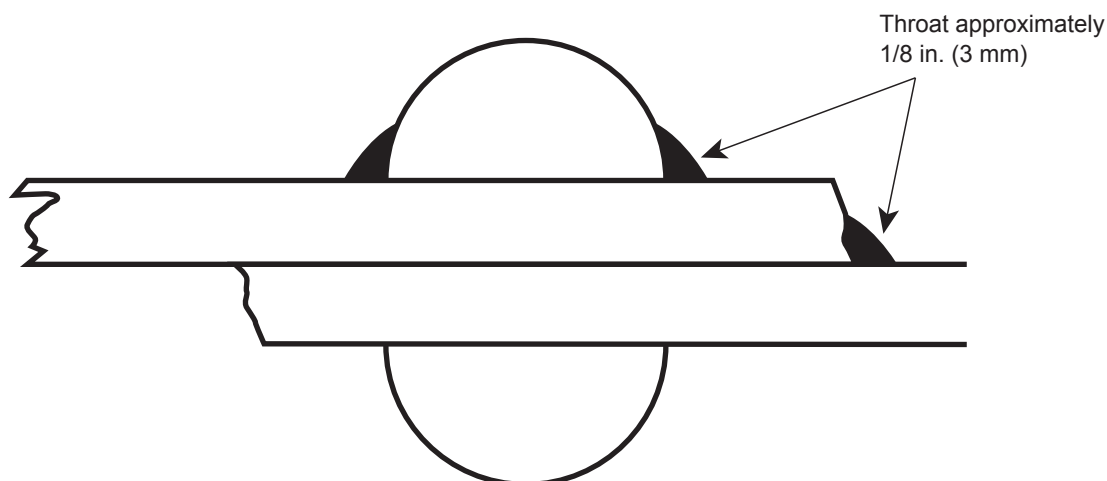
Tolerance for diameter of body is plus and minus 10% of nominal (shank diameter).

The following formulas give basic dimensions for manufactured shapes: *Double Radius Button Head*, $A=1.900D$; $H=0.700D$; $G=2.000D$. *Steeple Head*, $A=2.000D$; $H=1.000D$. *Flat Head*, $A=1.750D$; $H=0.500D$. Length L is measured parallel to the rivet axis, from the extreme end to the bearing surface-plane for flat bearing surface head-type rivets, or to the intersection of the head top surface with the head diameter for countersunk head-type rivets.

S2.13.13.5 SEAL WELDING SEAM, JOINTS, AND RIVET HEADS

- a) Prior to welding the area should be examined to assure that there are no cracks radiating from the rivet holes. (See NBIC Part 3, Figure S2.13.13.5)
- b) Seal welding should not be performed if cracks are present in riveted areas.
- c) Seal welding shall not be considered a strength weld.

FIGURE S2.13.13.5
SEAL WELDING SEAM AND RIVET HEAD



S2.13.14 REPAIR OF OPENINGS

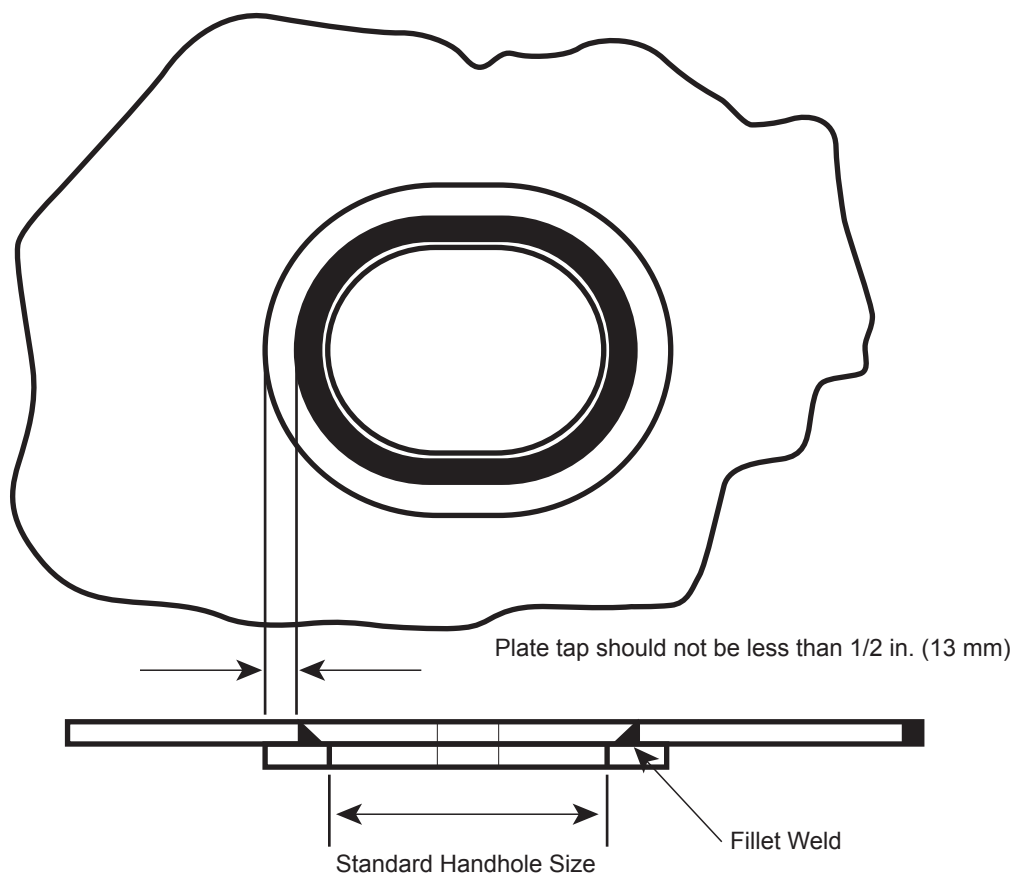
S2.13.14.1 REPAIR OF THREADED OPENINGS

- Threaded holes with damaged threads may be repaired by weld buildup and re-tapping. The threads shall be removed prior to welding.
- Threaded openings with damaged threads that cannot be repaired by re-tapping or re-threading should be repaired by welding a flush patch or a connection in the sheet.
- The connection shall be of such a size as to not interfere with proper operation, washout and inspection.
- Patches are to be flush type, using full penetration welds. If the load on the patch is carried by other forms of construction, such as staybolts, rivets, or tubes, radiographic examination of the welds is not required.
- Threaded bushings and piping found to be defective shall be replaced. Seal welding is not permitted.

S2.13.14.2 REPAIR OF HANDHOLE OPENINGS

- Weld buildup shall not be used if the affected section of plate has wasted below 60% of the original thickness per NBIC Part 3, Supplement 2 in an area exceeding 3 sq. in. (1950 sq. mm). (See NBIC Part 3, Figure S2.13.9.1)
- Weld buildup is to replace material that has been lost due to wastage and grooving, and is not to replace thickness on the opposite side of the sheet. Weld buildup must be applied to the side of the sheet that is wasted or grooved.
- Wasted sections that have wasted below 60% of the minimum required thickness and have an area exceeding 3 sq. in. (1950 sq. mm.) shall be repaired by installing a flush patch using full penetration welds.
- Weld buildup of wasted areas shall not exceed 100 sq. in. (65,000 sq. mm).

FIGURE S2.13.14.2
REPAIR OF HANDHOLE OPENING



S2.13.14.3 REPAIR OF FUSIBLE PLUG OPENING

- Threaded holes with damaged threads may be repaired by re-tapping or weld buildup and re-threading the threads shall be removed prior to welding.
- Threaded opening with damaged threads that can not be repaired by re-tapping or re-threading should be repaired by welding a flush patch or half coupling connection to the sheet.
- The half coupling connection shall be such a size as to not interfere with proper operation of the fusible plug. The half coupling shall be welded flush to the fire side using a full penetration weld. The half coupling must not project higher than 1/2 inch (13 mm) from the water side. (See Figure NBIC Part 3, S2.13.14.3-a)
- Flush patch type repairs are to be installed in accordance with S2.13.9.3 and S2.13.10.3. (See Figure S2.13.14.3-b)
- A fusible plug shall be of such length that when installed it shall project at least 3/4 inch (19 mm) on the water side of the plate, tube, or flue. It shall extend through the plate, tube, or flue on the fire side as little as possible but not more than 1 inch (25 mm).

FIGURE S2.13.14.3-a
FUSIBLE PLUG REPAIR USING HALF COUPLING

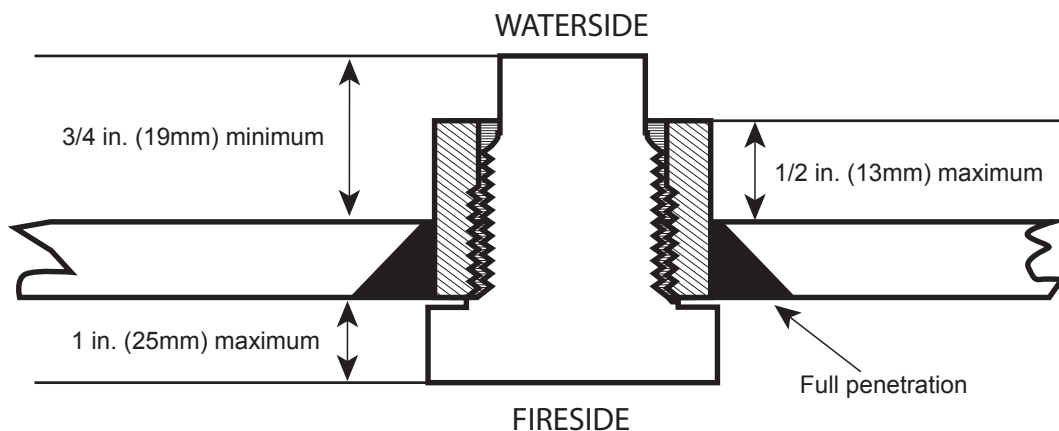
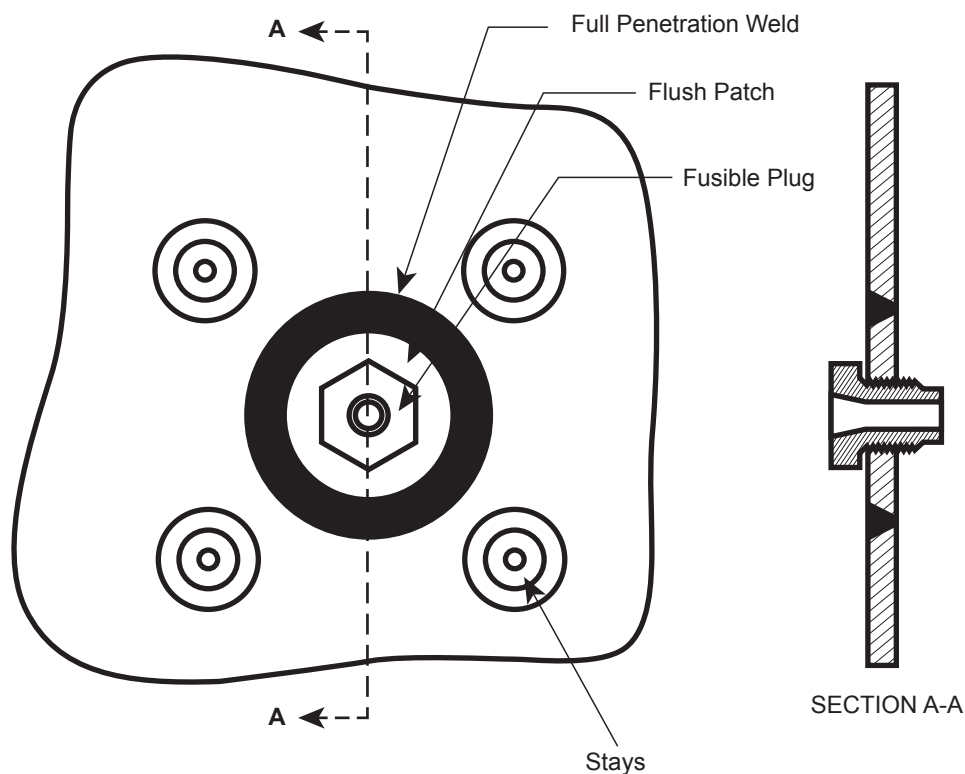


FIGURE S2.13.14.3-b
FUSIBLE PLUG REPAIR USING FLUSH PATCH



S2.13.14.4 REPAIR OF HANDHOLE DOORS

Handhole doors, studs, nuts, yokes, and clamps which are worn, cracked or otherwise damaged shall be replaced and not repaired. Replacements shall be of new manufacture, rated for the pressure and temperature of service.

SUPPLEMENT 3**REPAIR AND ALTERATION OF GRAPHITE PRESSURE EQUIPMENT****S3.1 SCOPE**

- a) This supplement provides requirements and guidelines for repairs to graphite pressure equipment requiring the use of certified impregnated graphite and cement. The determining factor in establishing the desired material properties is the resin impregnation cycle. If the resin impregnation cycle is not controlled, it is not possible to meet the minimum design values.
- b) The letter “G” shall be included on the “R” *Certificate of Authorization* for those organizations authorized to perform repairs/alterations of graphite pressure equipment except as permitted by NBIC Part 3, S3.5.4 f).

S3.2 REPAIRS

The requirements provided in this supplement shall apply, insofar as they are applicable to graphite pressure equipment. Graphite specific requirements include:

- a) When the original code of construction is other than ASME, replacement parts subject to internal or external pressure shall be manufactured by an organization certified as required by the original code of construction. The item shall be inspected and stamped as required by the original code of construction. Certification to the original code of construction as required by the original code of construction or equivalent shall be supplied with the item. When this is not possible or practicable, the organization fabricating the part shall have a National Board *Certificate of Authorization*; replacement parts shall be documented on Form R-3 and the “R” Symbol Stamp applied as described in NBIC Part 3, Section 5.
- b) When the standard governing the original construction is not the ASME Code, repairs or alterations shall conform to the edition of the original construction standard or specification most applicable to the work. Where the original code of construction is unknown, the edition and addenda of the ASME Code most appropriate for the work shall be used, provided the “R” Certificate Holder has the concurrence of the Inspector and the Jurisdiction where the pressure-retaining item is installed.
- c) The materials used in making repairs or alterations shall conform to the requirements of the original code of construction except as provided in NBIC Part 3, S3.2 j). The “R” Certificate Holder is responsible for verifying identification of existing materials from original data, drawings, or unit records and identification of the materials to be installed.
- d) When ASME is the original code of construction, replacement parts subject to internal or external pressure, which require shop inspection by an Authorized Inspector, shall be fabricated by an organization having an appropriate ASME *Certificate of Authorization*. The item shall be inspected and stamped as required by the applicable section of the ASME Code. A completed ASME *Manufacturer’s Partial Data Report* shall be supplied by the manufacturer. Further, all impregnated graphite material subject to internal or external pressure shall be fabricated by an organization having the appropriate ASME *Certificate of Authorization*. The impregnated graphite material shall be inspected and stamped as required by the applicable section of the ASME Code. A completed ASME *Manufacturer’s Partial Data Report* with supplementary U1B shall be supplied by the impregnated graphite material manufacturer.
- e) When the original code of construction is other than ASME, replacement parts subject to internal or external pressure shall be manufactured by an organization certified as required by the original code of construction. The item shall be inspected and stamped as required by the original code of construction. Certification to the original code of construction as required by the original code of construction or equivalent shall be supplied with the item. When this is not possible or practicable, the organization

fabricating the part may have a National Board *Certificate of Authorization*; replacement parts shall be documented on Form R-3 and the “R” Symbol Stamp applied as described in NBIC Part 3, Section 5.

- f) Organizations performing repairs under an “R” stamp program shall register such repairs with the National Board.
- g) Before signing the appropriate NBIC Form, the Inspector shall review the drawings, witness any required pressure test, ensure that the required nondestructive examinations have been performed satisfactorily, and that the other functions necessary to ensure compliance with the requirement of this code have been performed.
- h) Pressure-retaining items repaired in accordance with the NBIC shall be marked as required by NBIC Part 3, Section 5. The letter “G” shall be applied to the nameplate under the “R” stamp when graphite repairs are made. The alternate procedure defined in NBIC Part 3, 5.10 may be used in lieu of the stamping and nameplate attachment requirements of NBIC Part 3, Section 5.
- i) Legible copies of the completed Form R-1, together with attachments, shall be distributed to the owner or user, the Inspector, the Jurisdiction if required, and the Authorized Inspection Agency responsible for inservice inspection. Form R-1 shall be registered with the National Board. Distribution of Form R-1 and attachments shall be the responsibility of the organization performing the repair.
- j) Graphite parts that have previously been in service in one pressure vessel should not be used in a second vessel without prior approval of the owner. Consideration should be given to the service condition of the previous process and possible contamination of the subsequent process.
- k) Blind cracks and delaminations may not be repaired by cement injection only.
- l) Cracks and porosity in tubes may not be repaired. Cracked and porous sections may be removed so that the remainder of the tube may be used. Individual tube sections shall not be less than 24 in. (610 mm) in length, and the number of segments in a tube shall not exceed the quantity listed in NBIC Part 3, Table S3.2.

TABLE S3.2

PERMITTED QUANTITY OF TUBE SEGMENTS

Total Tube Length, ft. (m)	Number of Tube Segments	Number of Joints
6 (1.8)	1	0
9 (2.7)	2	1
12 (3.7)	3	2
14 (4.3)	3	2
16 (4.9)	4	3
18 (5.5)	4	3
20 (6.1)	4	3
22 (6.7)	4	3
24 (7.3)	5	4
27 (8.2)	5	4

- m) Cementing procedure specifications shall be qualified by the repair organization. The specifications shall be qualified as required by the code of construction. Cementing procedure qualification shall be verified by the Inspector.

- n) Cementing technicians shall be qualified by the repair organization. The technicians shall be qualified as required by the code of construction. A cementing technician is any individual who is responsible for proper joint preparation, cleaning parts to be joined, mixing cement, applying cement, securing the joint during the curing process, and controlling the curing process.
- o) All records shall be made available to the Inspector.
- p) Completed repairs shall be subjected to a pressure test. The test pressure shall not be less than operating pressure or more than maximum allowable working pressure. The test pressure shall be maintained for 30 minutes minimum.
- q) Reimpregnation may be used to reduce porosity in an existing graphite component, which will improve the existing graphite component's performance and expected life. Reimpregnation of graphite shall not be considered a means to restore original strength, nor shall it be considered a means to restore the original depth of impregnation.

(23) S3.3 ROUTINE REPAIRS

- a) The following repairs shall be considered routine, and shall comply with NBIC Part 3, 3.3.2 a), b), and c).
 - 1) Machining — routine repair shall not include the machining of pressure-retaining parts with the exception of minor machining for cleaning and joint preparation not to exceed 1/32 in. (0.8 mm) of material thickness.
 - 2) Repair of Gasket Surfaces — re-machining of gasket surfaces, re-serrating, or flattening is permitted if the design thickness is maintained.
 - 3) Replacing Individual Tubes — drilling out and replacing tubes with new tubes or repaired tubes. Only certified materials shall be used for this repair.
 - 4) Nozzle Replacement — complete or partial replacement of nozzles by removing all or a length of the existing nozzle and cementing a new piece in place. This is applicable for nozzles with inside diameters not exceeding 6 inches (152 mm).
 - 5) Plugging Tubes — plugging individual tubes using accepted procedures.
 - 6) Surface Repair — surface repair by installation of plugs or inlay material shall not exceed 1 in.³ (16 cm³) of total volume.
 - 7) Replacement or Addition of Non-Load Bearing Attachments to Pressure-Retaining Item — For attachment of non-load bearing attachments to pressure-retaining items, the cementing procedure specification need only be qualified for the pressure part and cement to be used.
- b) Complete records of these routine repairs shall be kept for review by the Inspector. The records shall include the number of tubes replaced or plugged and their location within the tube bundle.

(23) S3.4 ALTERATIONS

- a) The requirements provided in this section shall apply, insofar as they are applicable to the materials discussed herein. Completed alterations shall be subjected to a pressure test not less than that required by the code of construction. The test pressure shall be maintained for a minimum of 30 minutes. The pressure shall be reduced to MAWP and maintained for inspection.
- b) Alteration of the spring design (e.g., change in stiffness or the initial compression) of a graphite shell-and-tube heat exchanger shall be done only after revised calculations have been prepared in accordance with the "R" Certificate Holder's Quality Control System and accepted by the Inspector.

When the standard governing the original construction is any edition of the ASME Code, the calculations shall comply with Section VIII, Div. 1 2019 Edition or later.

- c) The nameplate shall be applied in accordance with Section 5 of this part. The letter “G” shall be applied to the nameplate under the “R” stamp when graphite alterations are made. The alternate procedure defined in 5.10 may be used in lieu of the stamping and nameplate attachment requirements of NBIC Part 3, Section 5.
- d) Organizations performing alterations under an “R” stamp program shall register such alterations with the National Board.

S3.5 REPAIR GUIDE FOR IMPERVIOUS GRAPHITE

S3.5.1 INTRODUCTION

- a) This section is intended to provide suggested process and technique details for repairs. This section should be used as a guide by the repair organization in developing specific repair procedures.
- b) Damage to domes (heads), tubesheets, or nozzles is invariably a sign of improper installation, operation, or maintenance. Because such damage is random in nature, each case must be analyzed separately to determine the appropriate repair procedure, and the economics of repair versus replacement.
- c) Impervious graphite is a machinable material. Parts can be modified or repaired in the field, or in a repair shop.
- d) Machining operations may be handled with high-speed steel tools. Extensive machining requires tungsten carbide or diamond tooling. No cooling or flushing fluid is required, nor should either be used.
- e) Cleanliness is important. Dusty, dirty, and chemically contaminated surfaces prevent proper cement adhesion. Poor cement adhesion will result in a low strength joint or a joint which leaks. All surfaces should be neutralized to a pH of 7. Graphite parts should be cleaned and washed with acetone to remove all moisture.
- f) All damage shall be examined and should be evaluated to determine the cause. Identification and elimination of the cause is essential in helping to prevent a recurrence.
- g) A hydrophilic solvent wash on the surface of the damaged part is useful in identifying the full extent of the cracks. The hydrophilic solvent will quickly evaporate from the surface, leaving the cracks damp and clearly visible.

FIGURE S3.5.1-a
TYPICAL TUBE-TUBESHEET JOINTS

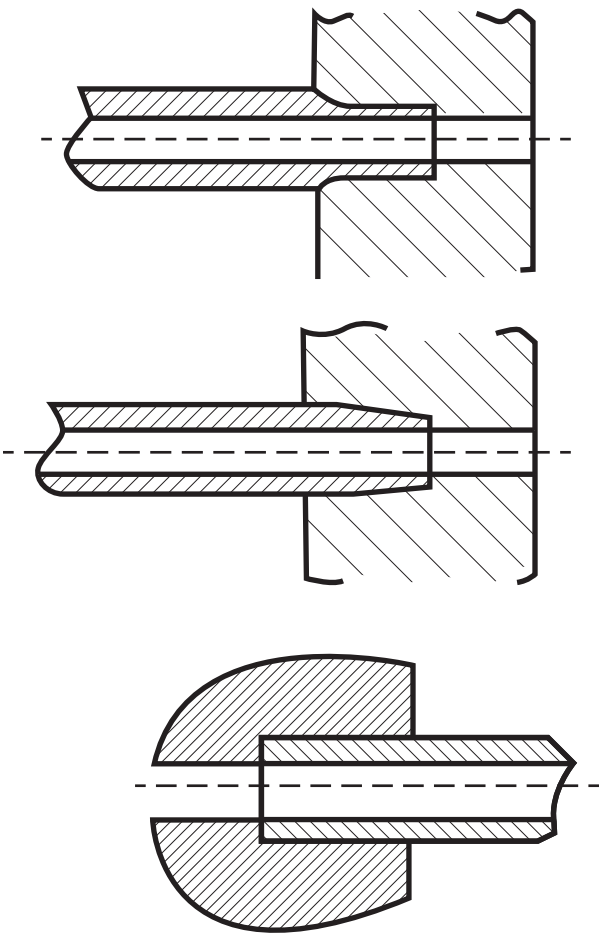


FIGURE S3.5.1-b
TYPICAL TUBE REPLACEMENT USING SLEEVE AND INSERT AT TUBESHEET JOINT

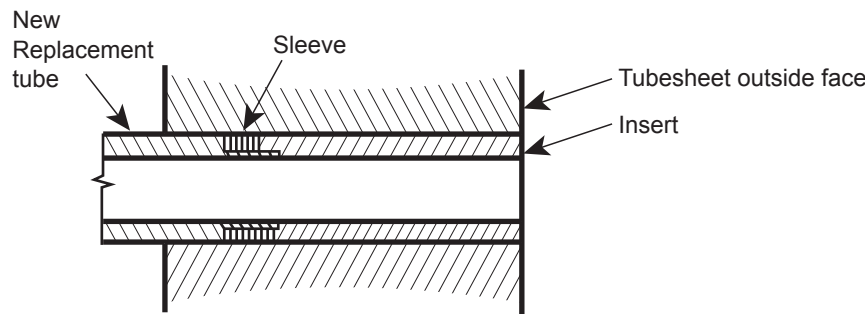


FIGURE S3.5.1-c

TYPICAL TUBE REPLACEMENT USING SLEEVE AT TUBESHEET JOINT

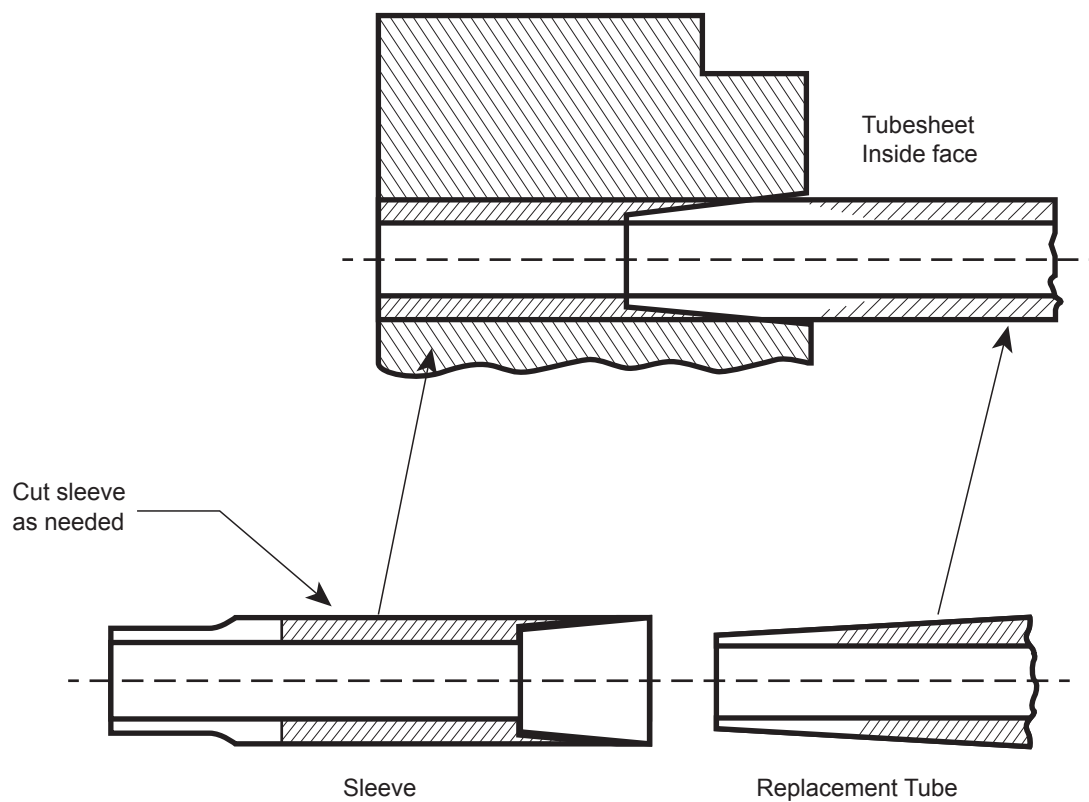


FIGURE S3.5.1-d
TYPICAL TUBE-TUBE JOINT

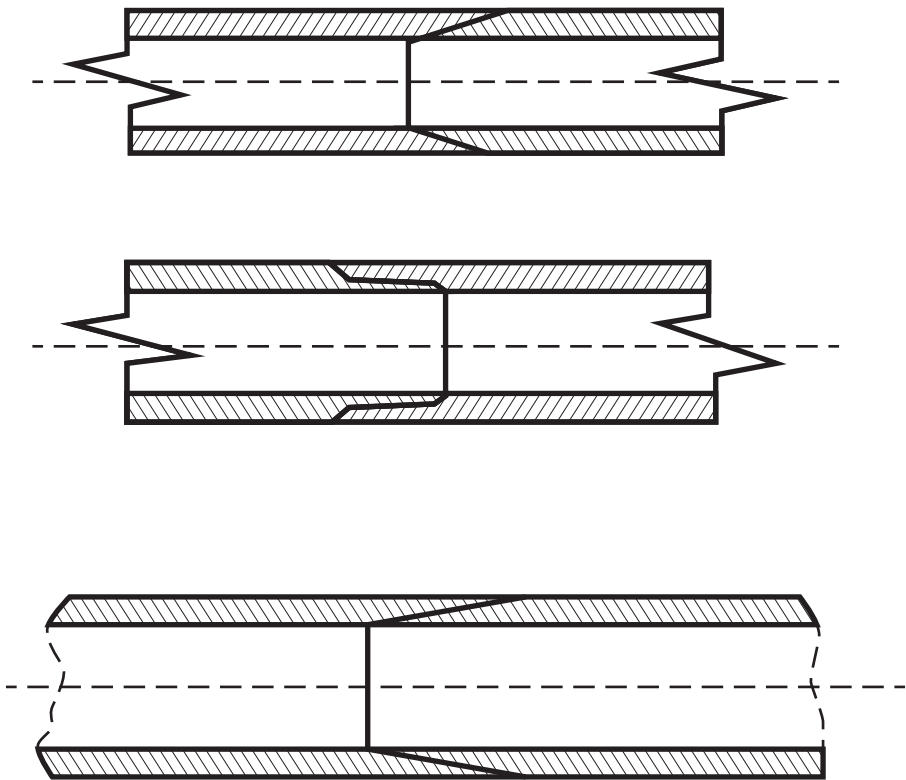


FIGURE S3.5.1-e
TYPICAL EDGE REPAIR MATERIAL INLAY

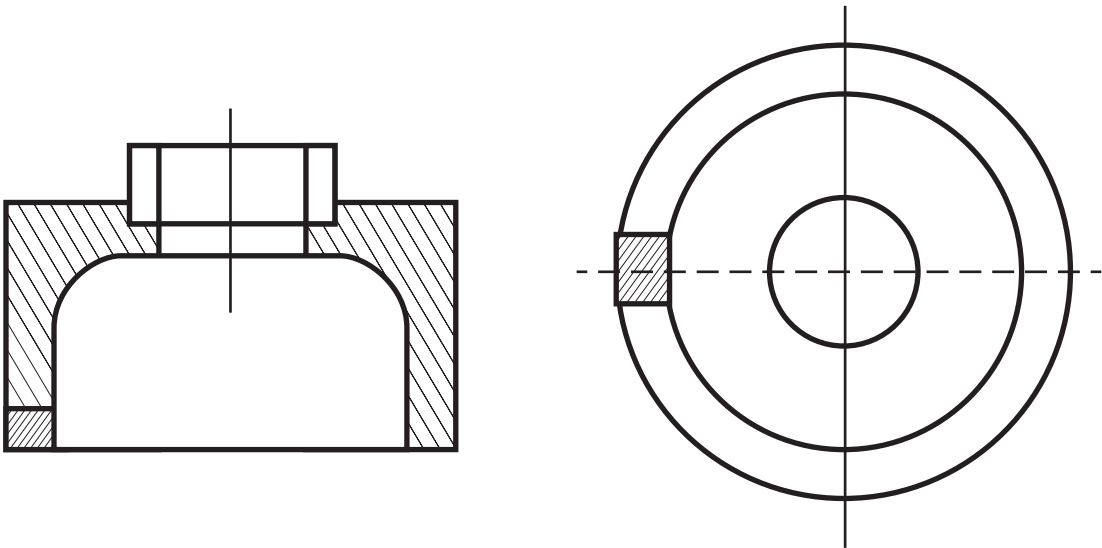
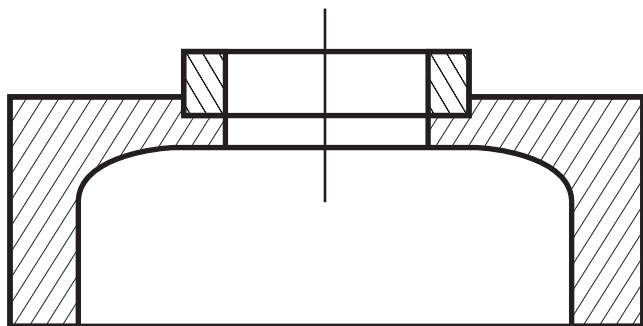


FIGURE S3.5.1-f
TYPICAL NOZZLE CONNECTION

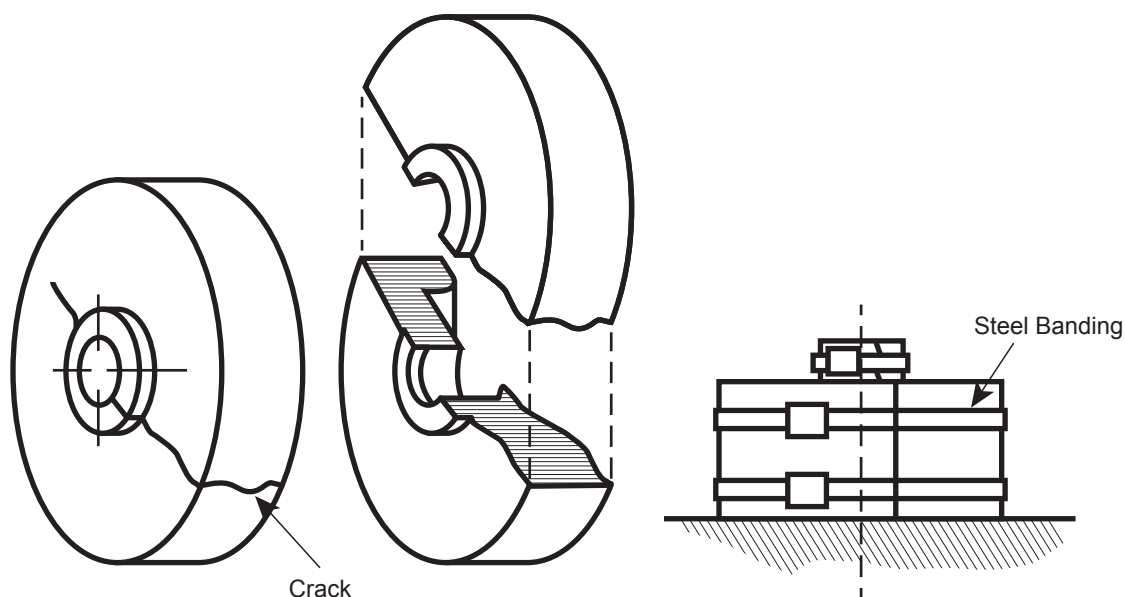


S3.5.2 TYPICAL GRAPHITE FRACTURES

S3.5.2.1 MAJOR FRACTURE

An extensive fracture, such as shown in NBIC Part 3, Figure S3.5.2.1, is best repaired by completing the break and re-cementing the two pieces. Temporary steel banding around the circumference is a method of clamping the repair until the cement is cured.

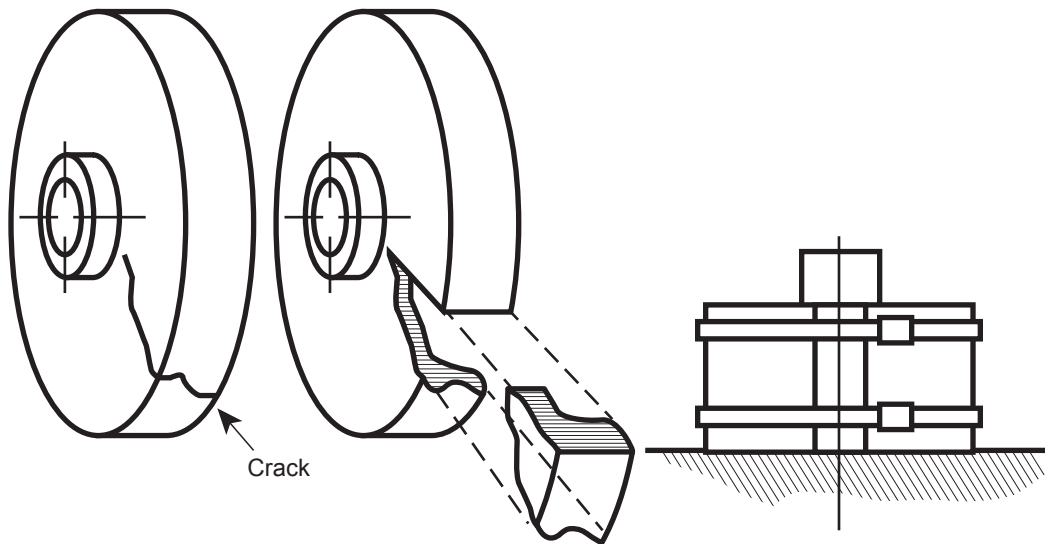
FIGURE S3.5.2.1
EXAMPLE OF EXTENSIVE FRACTURE REPAIR



S3.5.2.2 INTERMEDIATE FRACTURE

If the break is too minor to warrant completing the fracture, a pie-shaped cut may be made and the segment re-cemented in place. (See NBIC Part 3, Figure S3.5.2.2)

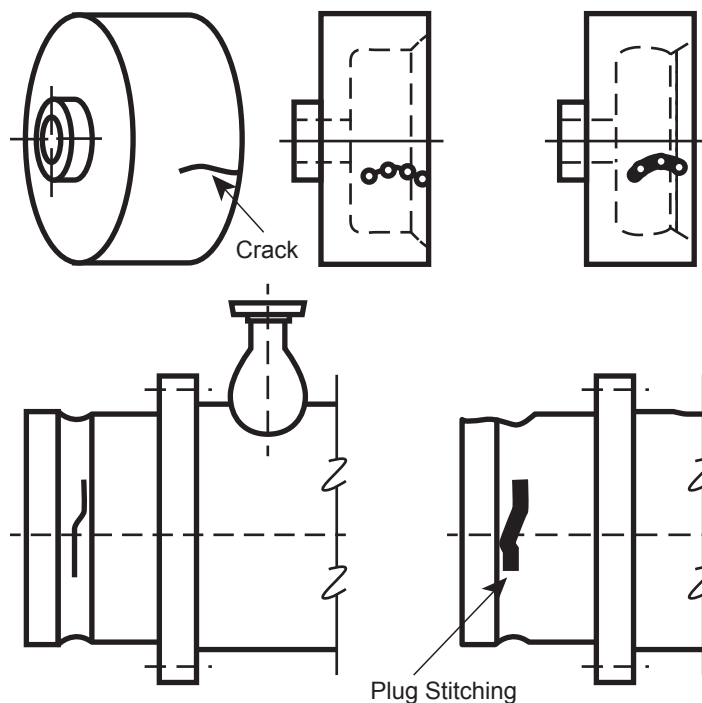
FIGURE S3.5.2.2
EXAMPLE OF INTERMEDIATE FRACTURE REPAIR



S3.5.2.3 MINOR FRACTURE

For minor fractures, such as those shown in NBIC Part 3, Figure S3.5.2.3, plug stitching can be used. The crack is removed by drilling and plugging a continuous chain of overlapping holes along the length and depth of fracture.

FIGURE S3.5.2.3
EXAMPLES OF MINOR FRACTURE REPAIR

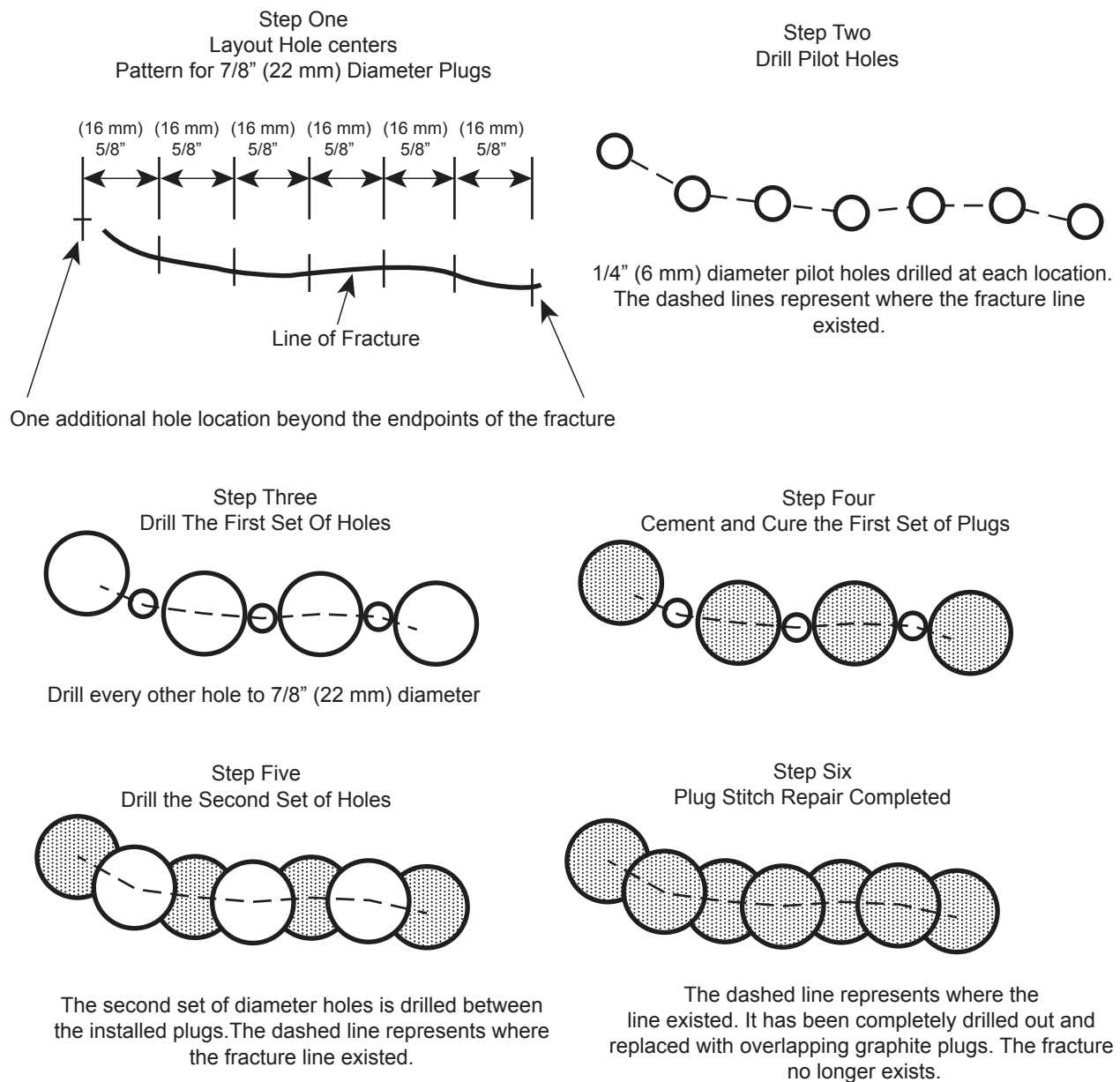


S3.5.2.4 FINISHING THE REPAIR

- a) The parts should be held in place to prevent movement while curing the cemented joint to achieve a proper repair. The repair firm shall take care to ensure that the cement joint thickness is within the range recommended by the cement manufacturer. Care spent in precisely aligning the parts while clamping will avoid many finishing and machining operations later. Particular attention should be given to gasket and other bearing surfaces.
- b) Gasket and bearing surfaces may have to be machined, filed, or sanded before the job is completed. Gasket serrations must be clean and continuous. Serrations can be easily re-cut into graphite and any repair plugs that cross the gasket surface.

S3.5.3 GRAPHITE REPAIR BY PLUG STITCHING

- a) Plug stitching is a form of repair by material inlaying. In this case, the inlays are small cylindrical impervious graphite plugs. The crack or fracture is removed by drilling and plugging a continuous series of overlapping holes along its length and depth.
- b) Most plug stitching is done with 7/8 in. (22 mm) diameter plugs. The plugs are laid out along the fracture line on a pitch of 5/8 in. (16 mm) centers. The overlap of plug material is 1/4 in. (6 mm) along the fracture line. A number of plug sizes are available and are used in repair, and the amount of overlapping is proportional to their diameters.

FIGURE S3.5.3**S3.5.3.1 PLUG STITCHING PROCEDURE (SEE NBIC PART 3, FIGURE S3.5.3)**

The following procedure is defined for 7/8 in. (22 mm) diameter plugs (an undersized plug will allow the use Reimpregnation of a graphite component may be used to reduce porosity in an existing graphite component, which in turn will improve the performance and expected life of the existing graphite components. A written re-impregnation procedure acceptable to the Inspector is required. The reimpregnation procedure shall include as a minimum:

- 1) Decontamination and drying of the graphite component
- 2) Subjecting the component to a vacuum
- 3) Introducing resin under pressure

- 4) Curing the resin at a specified temperature and time
- 5) Leak test

(23)

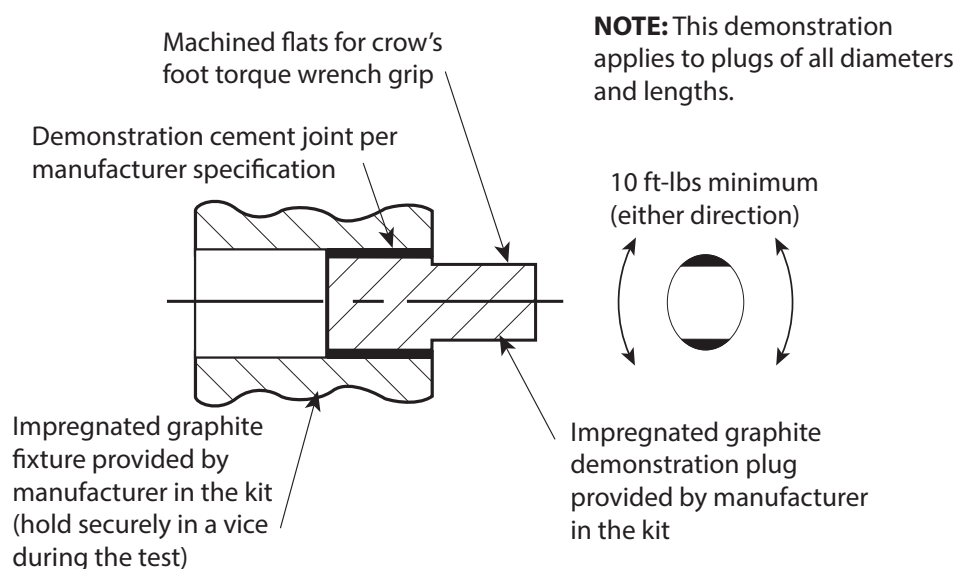
S3.5.4 PLUGGING OF LEAKING OR DAMAGED TUBES

- a) The material used for plugging tubes shall comply with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Part UIG.
- b) The point(s) of leakage shall be verified, and the corresponding leak site(s) shall be marked/labeled on the tubesheet, and recorded.
- c) A plug shall be used to plug each end of the tube(s) in question and each plug shall have a minimum length of 1 in. (25 mm). Multiple plugs may be used.
- d) The tube(s) shall be prepared for plugging by enlarging the inside of the tube(s) with a suitable drill bit or reamer.
 - 1) To ensure a sound cement joint between the tube sidewall and the plug, a slightly smaller diameter plug shall be selected. The maximum clearance between the tube inside diameter and the outside diameter of the plug shall not exceed 3/32 in. (2.4 mm).
 - 2) As an alternative to d)1) a mandrel with an abrasive, such as sandpaper, may be used, as long as the maximum tube I.D. to plug O.D. clearance of 3/32 in. (2.4 mm) is not exceeded.
 - 3) The minimum plug insertion depth of the prepared hole(s) shall meet the minimum combined plug length requirements of "c". When the minimum plug length of "c" is exceeded, the total insertion depth of the plugs may exceed the combined length of the plugs; however, the longer plugs shall not project outside the face of the tube(s) being plugged.
- e) Plugging of leaking or damaged tubes shall be performed by certified cementing technicians, using qualified cementing procedures, in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Part UIG.
- f) As an alternative to e) any "R" Certificate Holder, with or without the letter "G" included on the "R" *Certificate of Authorization*, may install graphite tube plugs provided the following conditions are met. The "R" Certificate Holder shall gain the concurrence of the Inspector, and shall utilize a tube plugging kit provided by an ASME Certificate Holder authorized to use the "G" designator. The kit shall include the following items:
 - 1) Certified graphite plugs and certified cement ingredients, both accompanied by the appropriate documentation (Partial Data Report).
 - 2) The qualified cementing procedure of the ASME Certificate Holder authorized to use the "G" designator, and a step-by-step procedural checklist that shall be followed explicitly. The procedure shall address the entire tube plugging process including plug configuration, tube hole cleaning and preparation, mixing and applying of the cement, application of the plugs, securing the plugs during the curing process, controlling the curing process, and leak testing, thereby meeting S3.3.
 - 3) Additional materials and procedure shall be provided and used to prepare a demonstration plug joint prior to performing the repair. This demonstration plug joint shall be tested by a twist (torsional) test designed to demonstrate acceptable application and curing of the cement (Fig. S3.5.4). The test procedure shall include acceptance criteria, which may be based on a principle of breakage of part of the test piece. A successful twist test, in conjunction with the completed procedural checklist, shall serve as a valid cement technician certification for a single repair operation. The twist test shall be witnessed by the Inspector.

The “R” Certificate Holder shall review the material certifications including verification that the shelf life of the cement has not been exceeded, and assure that the certified cement technician has completed the qualification demonstration, and has access to the procedure and checklist. The Inspector shall review and verify that the procedure and the other elements of the certified kit, as provided by the ASME Certificate Holder authorized to use the “G” designator, have been administered and completed prior to his acceptance. The “R” Certificate Holder shall note on Line 8 of the R-1 Form the installation of cemented graphite tube plugs in accordance with this section. The letter “G” shall not be applied to the vessel when performing this alternative repair. The “R” Certificate Holder shall identify and document the location of the plugged tubes on the “R” Form.

- g) The cement shall be prepared per the cement manufacturer’s instructions.
- h) When cementing the plug(s), all contact surfaces of each plug, as well as the inside diameter of the tube opening(s), shall be coated with cement. The plug(s) shall be inserted into each end of the tube(s) being plugged.
- i) Once the plugging is completed, and before the cement cures, the plug(s) may need to be held in place as newly cemented plugs may exhibit a tendency to dislodge from the tube(s) prior to final curing of the cement.
- j) Curing time is dependent upon the cement manufacturer’s instructions, and is considered complete when the cement is hardened to the point that it cannot be indented with pressure from a flat screwdriver or other similar instrument.
- k) After the cement is completely cured, the plugged, cemented area(s) on the tubesheet face may be dressed with sandpaper or other suitable abrasive.
- l) Repaired tubes shall be tested in accordance with this code, using a method acceptable to the Inspector, with a written procedure as approved by the manufacturer’s internal quality system, to ensure leaks have been repaired.
- m) The scope of the work completed shall be described and reported on a Form R-1.

FIGURE S3.5.4
DEMONSTRATION PLUG JOINT TWIST TEST



S3.5.5 TUBE REPLACEMENT

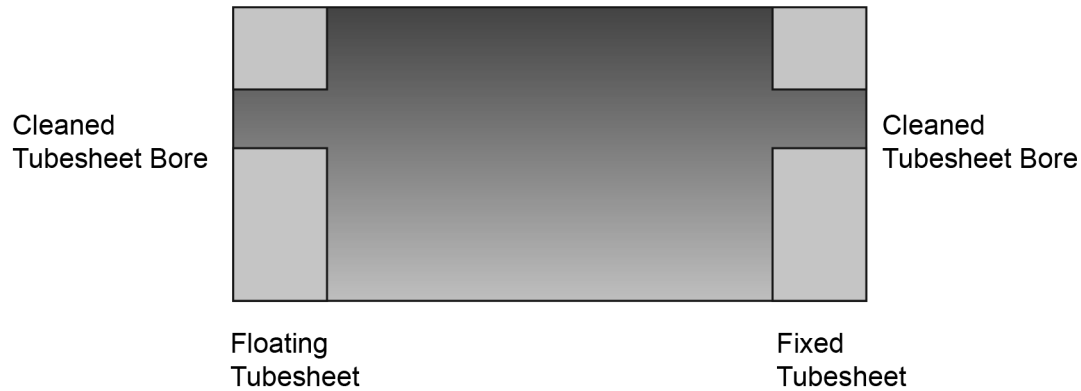
Tube replacement should be performed with the unit preferably in the horizontal position. Avoid replacing adjacent tubes simultaneously because the replacement areas may overlap or reduce the ligament between holes and possibly damage the tubesheet. The general steps used in horizontal tube replacement follow below.

- a) The material used for tube replacement shall comply with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Part UIG.
- b) Tube replacement shall be performed by qualified cementing technicians, using qualified cementing procedures, in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Part UIG-79 and UIG-80.
- c) Determine the thickness of each tubesheet and inside distance between the tubesheets to obtain tube and sleeve length.
- d) Access each tubesheet face, clearly identify and mark each tube hole on each tubesheet of the tubes to be replaced.
- e) Prepare/clean the existing tube hole in preparation for extracting the damaged tube. Some holes may contain plugs which require removal. A boring tool slightly larger than the outside diameter of the tube being replaced is required.
- f) Drill/bore out the tube hole in each tubesheet to release the tube from the tubesheet. Exercise caution when centering and align cutting to the common axis of the tube.
- g) The damaged tube should disengage and become loose. Using guides, remove the damaged tube. Ensure that no debris is trapped in the space where the tube was removed (Fig. S3.5.5-a).
- h) Replacement tube shall have sleeves at the ends cemented in the bored holes to replace the material in the tubesheet that was bored out to access the damaged tube (Fig. S3.5.5-b and S3.5.5-c).
 - 1) Dry-fit a new tube and sleeve.
 - 2) The sleeve length may vary.
 - 3) Prior to applying cement, prepare and clean all surfaces to be cemented.
- i) Cement the ID of the prepared bore in the floating tubesheet and the tube end OD at the fixed tubesheet. (Fig. S3.5.5-b).
- j) Insert the tube through the fixed tubesheet and through the floating tubesheet cemented bore so that it protrudes. Cement the ID of the fixed tubesheet bore as shown in (Fig. S3.5.5-c). The use of alignment dowels can assist/guide in tube handling.
- k) Cement the OD of the tube end protruding from the floating tubesheet. Cement the ID of the mating sleeve end, fit it to the cemented tube end and push the assembly part-way into the floating tubesheet. Cement the remainder of the OD of the floating tube end sleeve. Push this cemented assembly the rest of the way into the floating tubesheet (Fig S3.5.5-c).
- l) Cement the ID and OD of the sleeve for the fixed tubesheet and insert it until it mates with the tube end inside. Push together cemented tube/sleeve assemblies. (Fig S3.5.5-d). Clean/wipe away any excess cement.
- m) Apply slight pressure on the sleeves to seat the joints. Remove excess cement.
- n) Maintain pressure and cure both ends of the cemented assembly according to the cement manufacturer's instructions.

- o) Sleeves may be trimmed after curing.
- p) Replaced tubes shall be tested in accordance with this code per a written procedure acceptable to the Inspector.
- q) The scope of work completed shall be described and reported on a Form R-1.

FIGURE S3.5.5-a

CLEANED AND PREPARED TUBESHEETS

**FIGURE S3.5.5-b**

STARTING TUBE REPLACEMENT

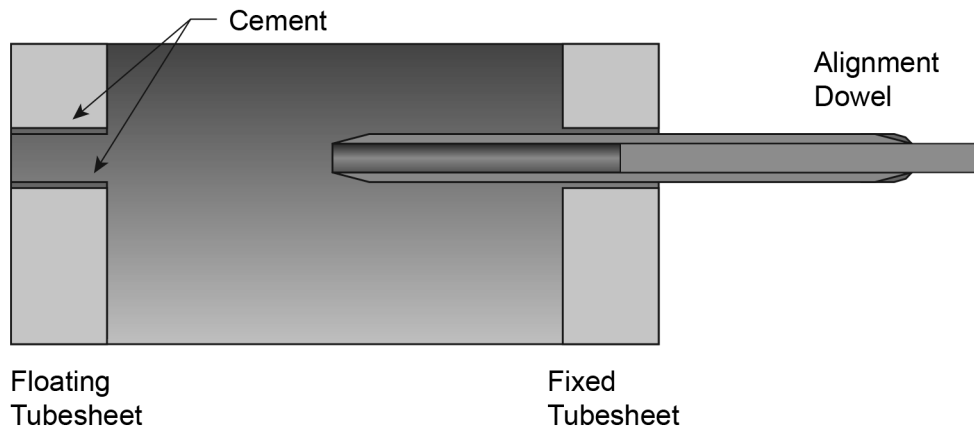


FIGURE S3.5.5-c
SLEEVE CEMENTING

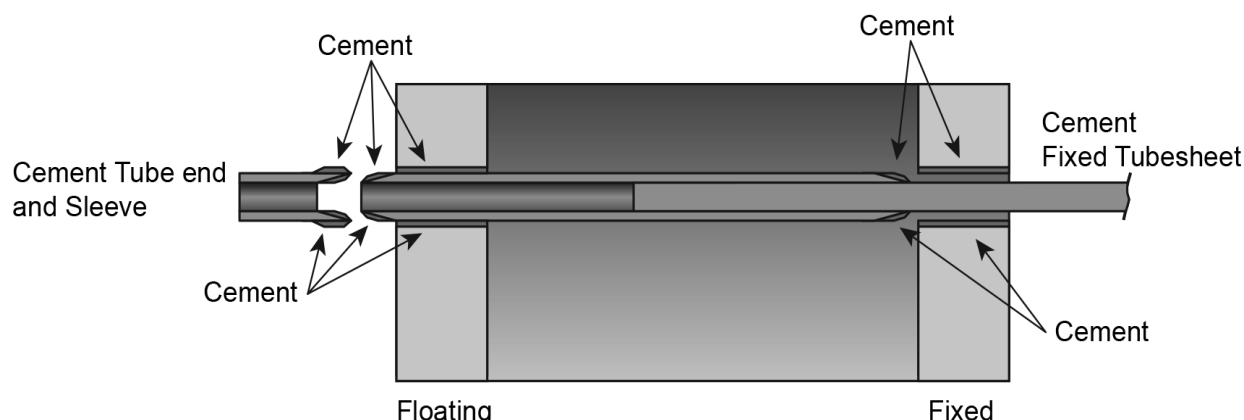
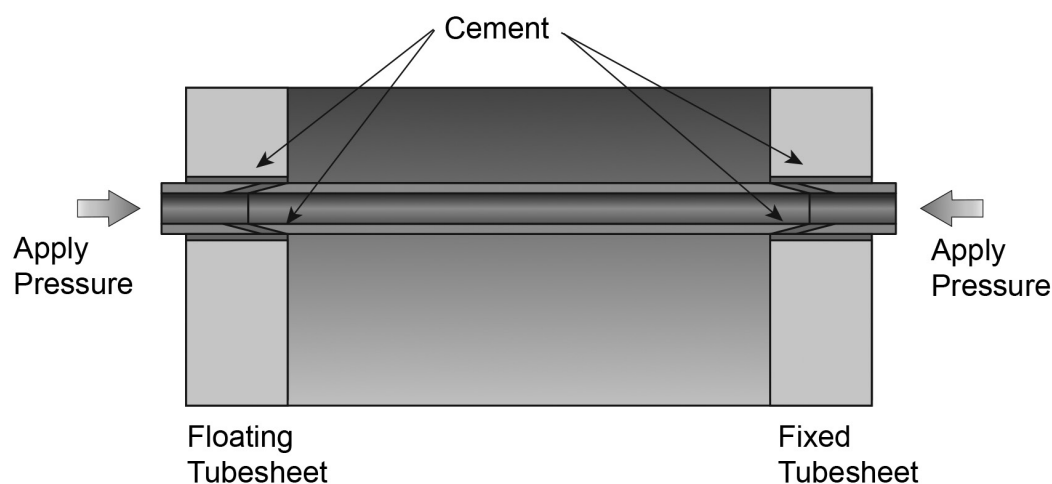


FIGURE S3.5.5-d
COMPLETED TUBE REPLACEMENT



S3.5.6 REIMPREGNATION OF GRAPHITE PARTS (TUBESHEETS, HEADS, AND BLOCKS)

- a) As a function of time, temperature, and chemical exposure, the resin used to impregnate graphite may shrink and/or degrade. As such, it is possible for voids to develop in impregnated graphite that has been in chemical service for a period of time. The resin loss can vary from slight to almost complete loss of impregnation. There is no practical way to determine the amount of resin remaining in the pores. However a pressure test will determine if the graphite has continuous porosity.
- b) Reimpregnation of a graphite component may be used to reduce porosity in an existing graphite component, which in turn will improve the performance and expected life of the existing graphite components. A written re-impregnation procedure acceptable to the Inspector is required. The reimpregnation procedure shall include as a minimum:

- 1) Decontamination and drying of the graphite component;
- 2) Subjecting the component to a vacuum;
- 3) Introducing resin under pressure;
- 4) Curing the resin at a specified temperature and time; and
- 5) Leak test.

S3.5.6.1 CONTROL OF IMPREGNATION MATERIAL

- a) Impregnation material shall be the same as that specified in the Reimpregnation Procedure. Each impregnation material shall be traceable by the name of its manufacturer and the trade name or number of that manufacturer.
- b) The impregnation material manufacturer shall supply the Certificate Holder with a Certificate of Analysis for each material. It shall include the following:
 - 1) Impregnation material identification;
 - 2) Batch number(s);
 - 3) Date of manufacture;
 - 4) Shelf life;
 - 5) Viscosity per ASTM D 2393; and
 - 6) Specific gravity.
- c) Prior to reimpregnation, and at subsequent intervals not to exceed 14 days, the Certificate Holder shall test each batch of impregnation material to assure that the characteristics of the material have not changed from values specified in the Reimpregnation Procedure. The values obtained for viscosity and specific gravity for the impregnation material shall be within the limits specified by the manufacturer and as listed in the Reimpregnation Procedure. The test values shall be made available to the Inspector.

SUPPLEMENT 4**REPAIR AND ALTERATION OF FIBER-REINFORCED THERMOSETTING PLASTIC PRESSURE EQUIPMENT****S4.1 SCOPE**

- a) This supplement provides requirements and guidelines that apply to repairs and alterations to fiber-reinforced pressure-retaining items.
- b) The letters “RP” shall be included on the “R” *Certificate of Authorization* for those organizations authorized to perform repairs/alterations of fiber-reinforced plastic pressure equipment.

S4.2 QUALIFICATIONS FOR “R” CERTIFICATE HOLDER DESIGNEE

The “R” Stamp Holder shall designate an employee who will have the responsibility of verifying the repair and/or alteration activity meets the requirements of the NBIC. The designee shall have the following qualifications:

- a) No fewer than five years of current verifiable documented experience in an occupational function that has a direct relationship to Reinforced Thermoplastic (RTP) fabrication and inspection, following customer or national standards, and be directly involved in the following activities:
 - 1) the development of plans, drawings, procedures, inspection requirements, acceptance criteria, and personnel qualification requirements;
 - 2) fabrication, construction, and supervision of personnel in the production of assemblies or subassemblies;
 - 3) detection and measurement of nonconformities by application of visual or other nondestructive evaluation processes to written procedures;
 - 4) supervision of personnel engaged in material and component examination;
 - 5) repairs of equipment or supervision of personnel performing repairs;
 - 6) preparation of written procedures for assembly, acceptance, nondestructive evaluation, or destructive tests;
 - 7) qualification of secondary bonders, laminators, and welders to applicable codes, standards, or specifications;
 - 8) operation techniques or activities used to fulfill quality control requirements for RTP fabrication or assembly; and
 - 9) train the occupational skills of fabrication or assembly of RTP equipment.
- b) The designee shall meet the following visual and educational requirements:
 - 1) be able to read a Jaeger Type No. 1 standard chart at a distance of not less than 12 in. (305 mm);
 - 2) be capable of distinguishing and differentiating contrast between colors;
 - 3) have visual acuity checked annually to assure natural or corrected near distance vision; and
 - 4) be a high school graduate or hold a state or military approved high school equivalency diploma.
- c) The “R” Certificate Holder shall certify that the designee complies with the above qualification requirements.

S4.3 TOOLS

The following tools may be required by the “R” Certificate Holder’s designee:

- a) adequate lighting including overall lighting and a portable lamp for close inspections;
- b) handheld magnifying glass;
- c) Barcol hardness tester;
- d) small pick or pen knife;
- e) small quantity of acetone and cotton swabs;
- f) camera with flash capability;
- g) liquid penetrant testing kit.
- h) depth and length gages; and
- i) metallic tap tester (e.g. quarter dollar)

S4.4 LIMITATIONS

All field work shall be limited to secondary bonding.

S4.5 REPAIR LIMITATIONS FOR FILAMENT WOUND VESSELS

When the MAWP is greater than 200 psig (1.38 MPa) and less than 1500 psi (10.34 MPa), field repair of filament wound ASME Code Section X, Class I vessels shall be limited to corrosion barrier or liner repairs only, provided there is access to the vessel interior. Structural repairs are allowed for filament wound ASME Code Section X, Class 1 vessels that have an MAWP equal to or greater than 1500 psi (10.34 MPa) and Class III vessels in accordance with the requirements of S4.19.

S4.6 VESSELS FABRICATED USING ELEVATED TEMPERATURE CURED RESIN SYSTEMS

Repair of vessels fabricated using elevated temperature cured resin systems shall be limited to the corrosion barrier or liners only, providing there is adequate access to the vessel surface that requires the repair. No structural repairs, re-rating or alterations are permitted with the following exceptions:

- a) Repair of vessels fabricated using elevated temperature-cured material is permitted only if the following provisions are met:
 - 1) Calculations must be submitted by an Engineer meeting the ASME Section X criteria for an Engineer certifying ASME Section X or RTP-1 compliance of the appropriate calculations contained in the Fabricator’s Design Report.

Note: The engineer qualification criteria of the Jurisdiction where the pressure vessel is installed should be verified before selecting the certifying engineer.

- 2) The original fabricator must provide its approval showing that the damage does not compromise the pressure rating of the vessel and that the safety factor required by the ASME Code or the original code of construction is maintained.
- b) Repairs that result in a revision to the pressure rating of a vessel covered as a part of this section is permitted, provided the new rating is less than the original rating, and as long as the safety factor

required by the ASME Code or the safety factor used as a design basis from the original code of construction is met in its entirety, and all the requirements under NBIC Part 3, S4.17, *Additional Requirements for Alterations*, are met.

S4.7 CODE OF CONSTRUCTION

- a) When the standard governing the original construction is the ASME Code Section X or ASME RTP-1, repairs and alterations shall conform, insofar as possible, to the section and edition of ASME Code Section X or ASME RTP-1 most applicable to the work planned.
- b) When the standard governing the original construction is not the ASME Code Section X or ASME RTP-1, repairs and alterations shall conform to the original code of construction or standard. Where this is not possible, it is permissible to use other codes, standards, or specifications, including the ASME Code (Section X or RTP-1), provided the “RP” designated “R” Certificate Holder (hereafter called the certificate holder) has the concurrence of the Inspector and the Jurisdiction where the pressure-retaining item is installed.

S4.8 MATERIALS

The materials used in making repairs or alterations shall conform to the requirements of the original code of construction. All resins and reinforcements must be properly stored and prevented from being contaminated by water, soil, or other impurities. The certificate holder is responsible for verifying identification of existing materials from original data, drawings, or units records, and identification of the materials to be installed. Consideration shall be given to the condition of the existing laminate, especially in the secondary bond preparation area.

S4.9 REPLACEMENT PARTS

- a) Replacement parts that will be subject to internal or external pressure including liquid head that are preassembled with or without secondary bonds shall have the fabrication performed in accordance with the original code of construction. The fabricator shall certify that the material and fabrication are in accordance with the original code of construction. This certification shall be supplied in the form of bills of material and drawings with statements of certification. Examples include shell and head sections, or flanged nozzles.
- b) When ASME is the original code of construction, replacement parts subject to internal or external pressure that require shop inspection by an Authorized Inspector or by a Certified Individual as defined by ASME RTP shall be fabricated by an organization having an appropriate ASME *Certificate of Authorization*. The item shall be inspected and stamped or marked as required by the original code of construction. A completed ASME *Fabricator’s Partial Data Report* shall be supplied by the fabricator.
- c) When the original code of construction is other than ASME, replacement parts subject to internal or external pressure shall be manufactured by an organization certified as required by the original code of construction. The item shall be inspected and stamped as required by the original code of construction. Certification to the original code of construction as required by the original code of construction or equivalent shall be supplied with the item. When this is not possible or practicable, the organization fabricating the part may have a National Board *Certificate of Authorization*. Replacement parts shall be documented on Form R-3 and the “R” Symbol Stamp applied as described in NBIC Part 3, 5.7.

S4.10 SECONDARY BONDING

Secondary bonding shall be performed in accordance with the requirements of the original code of construction used for the pressure-retaining item.

S4.10.1 SECONDARY BONDING PROCEDURE SPECIFICATIONS

Secondary bonding shall be performed in accordance with the lamination procedure qualified in accordance with the original code of construction.

S4.10.2 PERFORMANCE QUALIFICATIONS

Secondary bonders shall be qualified for the lamination process that is used. Such qualifications shall be in accordance with the requirements of the original code of construction.

S4.10.3 RECORDS

The Certificate Holder shall maintain a record of the results obtained in secondary bonder procedure qualifications. These records shall be certified by the Certificate Holder and shall be available to the Inspector.

S4.10.4 SECONDARY BONDER'S IDENTIFICATION

The Certificate Holder shall establish a system for the assignment of a unique identification mark for each secondary bonder qualified in accordance with the requirements of the NBIC. The Certificate Holder shall also establish a written procedure whereby all secondary bonds can be identified as to the secondary bonder who made them. The procedure shall be acceptable to the Inspector. The Certificate Holder shall keep a record of all secondary bonded joints and the secondary bonders who made the joints.

S4.10.5 SECONDARY BONDER'S CONTINUITY

The performance qualification of a secondary bonder shall be affected when one of the following conditions occur:

- a) When the secondary bonder has not made joints using a specific qualified lamination procedure during a period of 18 months or more, the bonder's qualifications for that procedure shall expire.
- b) When there is specific reason to question the bonder's ability to make secondary bonds that meet the specification, the qualification which supports the secondary bonding that is being performed shall be revoked. All other qualifications not questioned remain in effect.

S4.11 CURING

Curing techniques shall be performed as required by the original code of construction or by the resin manufacturer's recommendations in accordance with a written procedure. The procedure shall contain the parameters for curing.

S4.12 NONDESTRUCTIVE EXAMINATION

Except as required by this supplement, the nondestructive examination (NDE) requirements, including technique, extent of coverage, procedures, personnel qualifications, and acceptance criteria, shall be in accordance with the original code of construction used for the construction of the pressure-retaining item. Secondary bonded repairs and alterations shall be subjected to the same nondestructive examination requirements as the original secondary bonds. As a minimum, all secondary bonded joints made for repairs and alterations shall be subjected to a Barcol hardness test in accordance with ASTM D-2583 and an acetone wipe test for all polyester and vinyl ester resins. A visual inspection in accordance with NBIC Part 3, Table S4.12 is always required. The criteria for visual acceptance shall be the same as the original code of construction.

TABLE S4.12
VISUAL INSPECTION ACCEPTANCE CRITERIA

Definition of Visual Inspection Levels (to be Specified User or User's Agent): Level 1 = Critically Corrosion Resistant Level 2 = Standard Corrosion Resistant		Maximum Size and Cumulative Sum of Imperfections Allowed After Repair: (See General Notes (a) and (b). Imperfections Subject to Cumulative Sum Limitations are indicated with an asterisk).					
		Inner Surface Veil(s), Surfacing Mat		Interior Layers Thick Mat or Chopped Strand Spray Layers		Structural Layers Balance of Laminate (Including Outer Surface)	
Imperfection Name	Definition of Imperfection	Level 1	Level 2	Level 1	Level 2	Level 1	Level 2
Burned Areas	Showing evidence of thermal decomposition through discoloration or heavy distortion	NONE	NONE	NONE	NONE	NONE	Never in more than one ply and not to exceed 16 sq. in. (10,500 mm ²) in any vessel
Chips (surface)	Small pieces broken off an edge or surface	*1/8 in. (3 mm) dia. max. by 30% of veil(s) thickness max.	*1/8 in. (3 mm) dia. max. by 50% of veil(s) thickness max.			*1/4 in. (6 mm) dia. or 1/2 in. (13 mm) length max. by 1/16 in. (1.5 mm) deep	Discoloration only, never delamination or decomposition
Cracks	Actual ruptures or debond of portions of the structure	NONE	NONE	NONE	NONE	NONE	Not to include areas to be covered by joints
Crazing (surface)	Fine cracks at the surface of a laminate	NONE	NONE			Max. 1 in. (25 mm) long by 1/64 in. (0.4 mm) deep, max. density 3 in. (75 mm) any sq. ft.	Max. 2 in. (50 mm) long by 1/64 in. (0.4 mm) deep, max. density 5 in. (125 mm) any sq. ft.
Delamination (internal)	Separation of the layers in a laminate	NONE	NONE	NONE	NONE	NONE	*None in three plies adjacent to interior layer, none larger than 1 sq. in. (650 mm ²) in total area

TABLE S4.12 (CONTINUED)
VISUAL INSPECTION ACCEPTANCE CRITERIA

Definition of Visual Inspection Levels (to be Specified User or User's Agent): Level 1 = Critically Corrosion Resistant Level 2 = Standard Corrosion Resistant		Maximum Size and Cumulative Sum of Imperfections Allowed After Repair. (See General Notes (a) and (b). Imperfections Subject to Cumulative Sum Limitations are indicated with an asterisk).						Notes
		Inner Surface Veil(s), Surfacing Mat		Interior Layers (-0.125 in. [3 mm] Thick) Mat or Chopped Strand Spray Layers		Structural Layers Balance of Laminates (Including Outer Surface)		
		Level 1	Level 2	Level 1	Level 2	Level 1	Level 2	
Imperfection Name	Definition of Imperfection							
Dry Spot (surface)	Areas of surface where the reinforcements have not been wetted with resin	NONE	NONE			NONE	NONE	
Edge Exposure	Exposure of multiple layers of the reinforcing matrix to the vessel contents, usually as a result of shaping or cutting a section to be secondary bonded (interior of vessel only)	NONE	NONE			NONE	NONE	Edges exposed to contents must be covered with same number of veils as inner surface
Foreign Inclusion	Particles included in a laminate which are foreign to its composition (not a minute speck of dust)	*3/16 in. (5 mm) long max. by dia. or thickness not more than 30% of veil(s) thickness	*1/4 in. (6 mm) long max. by dia. or thickness not more than 50% of veil(s) thickness	*1/2 in. (13 mm) long max. by dia. or thickness not more than 30% of veil(s) thickness	*1/2 in. (13 mm) long max. by dia. or thickness not more than 50% of veil(s) thickness	*Dime size, never to penetrate lamination to lamination	*Nickel size, never to penetrate lamination to lamination	Must be fully resin wetted and encapsulated
Gaseous Bubbles or Blisters Air Entrapment within, on, or between Plies of Reinforcements, 0.015 in. (0.4 mm) Diameter and Larger		Max. dia. 1/6 in. (1.5 mm) by 30% of veil(s) thickness deep	Max. dia. 1/6 in. (1.5 mm) by 50% of veil(s) thickness deep	Max. dia. 1/8 in. (3 mm)	Max. dia. 1/8 in. (3 mm)	Max. dia. 3/16 in. (5 mm)	Max. dia. 1/4 in. (6 mm)	Must not be breakable with a sharp point
Refer to User's Specification for Quantity Limitations								

TABLE S4.12 (CONTINUED)
VISUAL INSPECTION ACCEPTANCE CRITERIA

Definition of Visual Inspection Levels (to be Specified User or User's Agent): Level 1 = Critically Corrosion Resistant Level 2 = Standard Corrosion Resistant	Maximum Size and Cumulative Sum of Imperfections Allowed After Repair. (See General Notes (a) and (b). Imperfections Subject to Cumulative Sum Limitations are indicated with an asterisk).					
	Inner Surface Veil(s), Surfacing Mat	Interior Layers (-0.125 in. [3 mm] Thick) Mat or Chopped Strand Spray Layers		Structural Layers Balance of Laminate (Including Outer Surface)		Notes
Imperfection Name	Level 1	Level 2	Level 1	Level 2	Level 1	
Pimples (surface)	*Max. height of diameter 1/64 in. (0.4 mm)	*Max. height of diameter 1/64 in. (0.4 mm)			No Limit	Must be fully resin filled and wetted; generally captured sanding dust
Pit (surface)	*1/8 in. (3 mm) max. by 30% of veil(s) thickness max.	*1/8 in. (3 mm) max. by 30% of veil(s) thickness max.			*1/4 in. (6 mm) max. by 1/16 in. (1.5 mm) deep max.	No fibers should be exposed
Porosity (surface)	None more than 30% of veil(s) thickness	None more than 50% of veil(s) thickness			None to fully penetrate the exterior get coat or get coated exterior veil. No quantity limit.	No fibers should be exposed
Scratches (surface)	NONE	NONE			*None more than 6 in. long (150 mm)	No fibers should be exposed
Wet Blisters (surface)	*None over 3/16 in. (5 mm) dia. by 1/16 in. (1.5 mm) in height	*None over 3/16 in. (5 mm) dia. by 1/16 in. (1.5 mm) in height			No Limit	Must be fully resin filled; not drips loosely glues to surface, which are to be removed
Wet Out Inadequate	NONE	NONE	NONE	NONE	Dry mat or prominent and dry woven roving pattern not acceptable; discernible but fully saturated woven pattern acceptable	Split tests on cutouts may be used to discern degree of saturation on reinforcing layers

TABLE S4.12 (CONTINUED)
VISUAL INSPECTION ACCEPTANCE CRITERIA

Definition of Visual Inspection Levels (to be Specified User or User's Agent): Level 1 = Critically Corrosion Resistant Level 2 = Standard Corrosion Resistant		Maximum Size and Cumulative Sum of Imperfections Allowed After Repair. (See General Notes (a) and (b). Imperfections Subject to Cumulative Sum Limitations are indicated with an asterisk).					
		Inner Surface Veil(s), Surfacing Mat	Interior Layers (-0.125 in. [3 mm] Thick) Mat or Chopped Strand Spray Layers	Structural Layers Balance of Laminate (Including Outer Surface)			Notes
Imperfection Name	Definition of Imperfection	Level 1	Level 2	Level 1	Level 2	Level 1	Level 2
Wrinkles and Creases	Generally linear, abrupt changes in surface plane caused by laps of reinforcing layers, irregular mold shape, or Mylar® overlap	Max. deviation 20% of wall or 1/16 in. (1.5 mm), which is least	Max. deviation 20% of wall or 1/8 in. (3 mm), which is least			Maximum deviation 20% of wall or 1/8 in. (3 mm), whichever is least	Not to cause a cumulative linear defect (outside defect adding to inside defect)
Allowable Cumulative Sum of Highlighted Imperfections	Maximum allowable in any square foot (0.9 sq. m)	3	5	3	5	5	5
	Maximum allowable in any square yard (0.8 sq. m)	16	20	20	30	30	40

Note 1:

Above acceptable criteria apply to condition of laminate after repair and hydro test.

Note 2:

Non-catalyzed resin is not permissible to any extent in any area of the laminate.

S4.13 PRESSURE AND ACOUSTIC EMISSION TESTS

All vessels subject to repairs other than those defined in NBIC Part 3, S4.16.4 shall be tested in accordance with the requirements of the original code of construction. In addition, all structural repairs and alterations shall be pressure tested. All vessels acoustic emission tested as required by the original code of construction shall be retested during the pressure test concentrating on the repaired or altered part of the vessel.

S4.13.1 PRESSURE GAGES, MEASUREMENT, AND EXAMINATION AND TEST EQUIPMENT

The calibration of pressure gages, measurement, examination and test equipment, and documentation of calibration shall be performed as required by the applicable standard used for construction.

S4.14 ACCEPTANCE INSPECTION

Before signing the appropriate NBIC report form, the Inspector shall:

- a) review the drawings;
- b) ensure the secondary bonding was performed in accordance with the original code of construction;
- c) witness any pressure or acoustic emission test;
- d) ensure that the required nondestructive examinations have been performed satisfactorily; and
- e) that the other functions necessary to assure compliance with the requirements of this code have been performed.

S4.14.1 STAMPING

Stamping requirements for FRP vessels are identified in NBIC Part 3, Section 5.

S4.14.2 DOCUMENTATION

Documentation requirements for FRP vessels are identified in NBIC Part 3, Section 5.

S4.14.3 REGISTRATION OF DOCUMENTATION

Organizations performing repairs or alterations under an "R" stamp program shall register such repairs or alterations with the National Board.

S4.14.4 DISTRIBUTION OF DOCUMENTATION

Distribution of documentation requirements for FRP vessels are identified in NBIC Part 3, Section 5.

S4.15 PRESSURE TESTING FOR REPAIRS

Except as permitted in e) below, the following requirements apply to all repairs to pressure-retaining items:

- a) Repairs shall be pressure tested to 110% of the maximum allowable working pressure stamped on the pressure-retaining item using water or other liquid medium. The Certificate Holder is responsible for all activities relating to pressure testing of repairs.

- b) Replacement parts used in repairs shall be pressure tested at the maximum allowable working pressure indicated on the pressure-retaining item being repaired.
- c) During a pressure test, where the test pressure will exceed the set pressure of the pressure relief device, the device shall be prepared as recommended by the device manufacturer.
- d) Hold time for the examination by the Inspector shall be the time necessary for the Inspector to conduct the examination.
- e) When pressure testing using liquids is not practical, other methods shall be used as follows:
 - 1) The pressure test may be a pneumatic test provided the Certificate Holder has the concurrence of the Inspector, the jurisdictional authority where required, and the owner. Precautionary requirements of the applicable section of the original code of construction shall be followed. In addition, a pneumatic test shall always be monitored by acoustic emission examination.
 - 2) For vessels designed for vacuum, a vacuum test shall be carried out to the original test vacuum level of the vessel. During the vacuum test, the vacuum source may be left connected to the vessel to compensate for leakage at fittings. All vessels acoustic emission tested, as required by the original code of construction, shall be retested during the vacuum test concentrating on the repaired or altered part of the vessel.

S4.16 ADDITIONAL REQUIREMENTS FOR REPAIRS

S4.16.1 SCOPE

This section provides additional requirements for repairs to pressure-retaining items and shall be used in conjunction with NBIC Part 3, S4.1 through S4.14 and S4.18.

S4.16.2 DRAWINGS

Drawings shall be prepared or modified to describe the repair. Drawings shall include sufficient information to satisfactorily perform the repair.

S4.16.3 REPAIR PLAN

When repairs other than those defined in NBIC Part 3, S4.16.4 are being made to ASME Section X or RTP-1 stamped equipment, the user shall prepare or cause to have prepared a detailed plan covering the scope of the repair.

a) Engineer Review and Certification

The repair plan shall be reviewed and certified by an engineer meeting the ASME Section X or RTP-1 criteria for an engineer certifying ASME Section X or RTP-1 compliance of the appropriate calculations contained in the Fabricator's Design Report. The review and certification shall be such to ensure that the work involved in the repair is compatible with the User's Design Specification or User's Basic Requirements Specification and the Fabricator's Design Report. The certification shall also include any drawings and calculations prepared as part of the repair plan.

Note: The engineer qualification criteria of the Jurisdiction, where the pressure vessel is installed should be verified before selecting the Certifying Engineer. The certification shall also include any drawings and calculations prepared as part of the repair plan.

b) Authorized Acceptance

Following review and certification, the repair plan shall be submitted to the Inspector for his review and acceptance. Repairs to pressure-retaining items shall not be initiated without the authorization of the Inspector. Subject to acceptance of the Jurisdiction, the Inspector may give prior approval for routine repairs, provided the Inspector assures that the Certificate Holder has acceptable procedures covering the repairs.

S4.16.4 ROUTINE REPAIRS

Prior to performing routine repairs, the Certificate Holder should determine that routine repairs are acceptable to the Jurisdiction where the work is to be performed.

a) Acceptable routine repairs are listed below:

- 1) The addition or repair of non-load bearing attachments to pressure-retaining items where post curing is not required.
 - 2) Replacement and repair of damaged corrosion liner areas in shells and heads shall not exceed 100 sq. in. (65 sq. cm) and not exceed the original corrosion liner thickness.
- b) Routine repairs may be performed under the Certificate Holder's quality system program; however, the requirement for in-process involvement of the Inspector and stamping are waived. (See NBIC Part 3, Section 5).
- c) The process of controlling and implementing routine repairs shall be documented in the Certificate Holder's quality system program.
- d) Routine repairs shall be documented on a Form R-1 with a statement on line 10, Remarks: "Routine Repair."

S4.16.5 REPAIR METHODS

The repair methods shall be acceptable to the Inspector. Some methods of repair are contained in NBIC Part 3, S4.18.

S4.17 ADDITIONAL REQUIREMENTS FOR ALTERATIONS**S4.17.1 SCOPE**

This Section provides additional requirements for alterations to pressure-retaining items, and shall be used in conjunction with NBIC Part 3, S4.1 through S4.14 and S4.18.

S4.17.2 DESIGN

The Certificate Holder performing alterations shall establish controls to ensure that all required design information, applicable drawings, design calculations, specifications and instructions are prepared, obtained, controlled, and interpreted to provide the basis for an alteration in accordance with the original code of construction. When a *Fabricator's Data Report* is required by the original code of construction, a copy of the original data report shall be obtained for use in the design of the alteration. When the original *Fabricator's Data Report* cannot be obtained, agreements on the method of establishing design basis for the alteration shall be obtained from the Inspector and the Jurisdiction.

S4.17.3 ALTERATION PLAN

The user shall prepare, or cause to have prepared, a detailed plan covering the scope of the alteration.

a) Engineer Review and Certification

The alteration plan shall be reviewed and certified by an engineer meeting the ASME Section X or RTP-1 criteria for an engineer certifying ASME Section X or RTP-1 compliance of the appropriate calculations contained in the Fabricator's Design Report. The review and certification shall be such as to ensure that the work involved in the alteration is compatible with the user's design specification and the *Fabricator's Data Report*.

Note: The engineer qualification criteria of the jurisdiction where the pressure vessel is installed should be verified before selecting the certifying engineer.

b) Authorized Acceptance

Following review and certification, the alteration plan shall be submitted to the Inspector for his review and acceptance. Alterations to pressure-retaining items shall not be initiated without the authorization of the Inspector.

S4.17.4 CALCULATIONS

A set of calculations shall be completed prior to the start of any physical work. All design work shall be completed by an organization experienced in the design portion of the standard used for the construction of the item. All calculations for ASME Code Section X and RTP-1 alterations shall be certified by an engineer meeting the ASME Section X criteria for an engineer certifying ASME Section X compliance of the calculations contained in the Fabricator's Design Report. All calculations shall be made available for review by the Inspector.

Note: The engineer qualification criteria of the jurisdiction where the pressure vessel is installed should be verified before selecting the certifying engineer.

(23) S4.17.5 RE-RATING

- a) Re-rating of a pressure-retaining item by increasing the maximum allowable working pressure (internal or external) or temperature, or decreasing the minimum temperature shall be done only after the following requirements have been met to the satisfaction of the Jurisdiction at the location of the installation:
 - 1) Revised calculations verifying the new service conditions shall be prepared in accordance with the Certificate Holder's Quality Control System. Re-rating calculations for ASME Code Section X and RTP-1 vessels shall be performed by a Professional Engineer experienced in the design of reinforced plastic pressure vessels;
 - 2) All re-rating shall be established in accordance with the requirements of the construction standard to which the pressure-retaining item was built;
 - 3) Current inspection records shall verify that the pressure-retaining item is satisfactory for the proposed service conditions;
 - 4) The pressure-retaining item shall be pressure tested, as required, for the new service conditions.
- b) This code does not provide rules for de-rating pressure-retaining items; however, when the MAWP and/or allowable temperature of a pressure-retaining item is reduced, the Jurisdiction, if applicable, where the object is installed shall be contacted to determine if specific procedures should be followed.

S4.17.6 PRESSURE TESTING

Except as permitted in g) below, the following requirements apply for pressure testing of alterations to pressure-retaining items:

- a) When the alteration activity involves the installation of a replacement part and/or the alteration will impact the design pressure, the design temperature, or the design rated capacity, a pressure test, as required by the original code of construction, shall be conducted. An acoustic emission test is also required if the original vessel was so tested, unless a nozzle whose diameter is one-tenth the vessel diameter or less is being added.

The Certificate Holder is responsible for all activities related to pressure testing of replacement parts. The pressure test may be performed at the point of manufacture or point of installation.

- b) The pressure test of replacement parts and connecting secondary bonds shall be tested at 1.1 times the maximum allowable working pressure or the original test pressure, whichever is greatest.
- c) During the pressure test, where the test pressure will exceed the set pressure of the pressure relief device, the device shall be prepared as recommended by the device manufacturer.
- d) The liquid temperature used for pressure testing shall not be less than 40°F (4°C) nor more than 120°F (49°C) unless the original pressure test was conducted at a higher temperature. If an acoustic emission examination is being conducted, the temperature of the test liquid shall not vary by more than plus 5°F (-15°C) or minus 10°F (-12°C).
- e) Hold time for the pressure test shall be a minimum of 30 minutes with an acoustic emission examination or a minimum of four hours without an acoustic emission examination. The following procedure shall be used to retest a vessel that has been tested under the provisions of Article 6 of ASME Section X and has subsequently been repaired.
 - 1) Load the vessel as specified in Article 6 of ASME Section X without monitoring for acoustic emission.
 - 2) Hold the maximum load for at least 30 minutes.
 - 3) Condition the vessel by holding at reduced load as required by Section V, Article 11, T-1121.
 - 4) Retest the vessel as required by this supplement.
 - 5) The vessel shall be judged against the evaluation criteria for subsequent loadings.
- f) Hold time for the examination by the Inspector shall be the time necessary for the Inspector to conduct the inspection.
- g) When pressure testing using liquids is not practical, other methods shall be used as follows:
 - 1) The pressure test may be a pneumatic test provided the Certificate Holder has the concurrence of the Inspector, the jurisdictional authority where required, and the owner. Precautionary requirements of the applicable section of the original code of construction shall be followed.
 - 2) For vessels designed for vacuum, a vacuum test shall be carried out to as close as practical to the design vacuum level of the vessel. During the vacuum test the vacuum source may be left connected to the vessel to compensate for leakage at fittings. All vessels originally acoustic emission tested shall be retested during the vacuum test concentrating on the repaired or altered part of the vessel.

S4.18 REPAIR AND ALTERATION METHODS

S4.18.1 GENERAL REQUIREMENTS

- a) In general, when a defective or damaged vessel wall is to be repaired, the total structural laminate sequence of laminate construction removed as part of the repair shall be replaced. The replacement laminate shall provide structural properties meeting or exceeding the requirement of the original construction standard. Moreover, when damage includes the corrosion barrier, a corrosion barrier of the same type, which shall meet or exceed the barrier properties of the original construction, shall replace the corrosion barrier removed as part of the repair.
- b) The repair or alteration shall meet the requirements of the original construction standard.

S4.18.2 CLASSIFICATION OF REPAIRS

- a) Vessel repairs shall be classified into the following types:
 - 1) Type 1a — Corrosion barrier repairs;
 - 2) Type 1b — Corrosion barriers with precision bores;
 - 3) Type 2 — Corrosion barrier and interior structural layer repairs;
 - 4) Type 3 — External structural layer repairs;
 - 5) Type 4 — Alterations;
 - 6) Type 5 — Miscellaneous general external repairs or alterations;
 - 7) Type 6 — Thermoplastic repairs; and
 - 8) Type 7 — Gel coat repairs.
- b) Each type of repair shall have its own corresponding general repair procedure as given in the following paragraphs.

S4.18.2.1 TYPE 1A — REPAIR OF THE CORROSION BARRIER

- a) A corrosion barrier that has been exposed to a process may be permeated to the point that in some cases the entire corrosion barrier laminate may need to be removed.
- b) After the Inspector has verified that the repair procedure is acceptable, the repair shall be performed by the Certificate Holder as follows:
 - 1) Surface Preparation
 - a. The surface area that is damaged must be removed by abrasive blasting or grinding, to remove contaminated laminate and expose sound laminate. The edge of the repaired area must have a bevel of 2 in. (50 mm) minimum.
 - b. Note that any cracks, delaminations, or permeated surface must be removed. An adequate size abrasive, or proper sanding disc must be used to obtain a 0.002 to 0.003 in. (0.05 to 0.08 mm) anchor pattern.
 - c. Preparation of any surface requires that basic rules, common to all substrates, be followed. These rules are as outlined below:

1. Surface must be free of contaminants;
2. Surface must be structurally sound;
3. Surface must have adequate anchor pattern;
4. Surface must be dry;
5. Surface must be primed with recommended primer.

Note: After the surface has been properly prepared, it must be kept clean and dry until laminating can be started. Dust, moisture, or traces of oil that come in contact with the surface may act as a mold release or inhibit the cure and prevent a good secondary bond.

2) Applying Test Patches to Verify Adequate Surface Preparation

- a. Test patches should be applied to any substrate that will require a secondary bond to determine the integrity of the primer bond prior to the application of the laminate.
- b. The subsequent steps shall be followed:
 1. Apply the primer [0.003 -0.005 in. (0.08 to 0.13 mm)] to the prepared surface, and allow primer to cure.
 2. Coat the primed surface with the same resin to be used in the laminate repair. Apply 4 in. (100 mm) x 14 in. (360 mm) piece of polyester, such as Mylar®, strip to one edge of primed area. Allow the polyester film to protrude from beneath the patch.
 3. Apply two layers of 1-1/2 oz/sq. ft (0.46 kg/sq. m) chopped strand mat saturated with the same resin that will be used for the repair. Mat shall be 12 in. (305 mm) x 12 in. (305 mm) square.
 4. Allow the mat layers to cure completely, this may be verified by checking the hardness of the laminate.
 5. Pry patch from surface using a screwdriver, chisel, or pry bar.
 6. A clean separation indicates a poor bond.
 7. Torn patch laminate or pulled substrate indicates that the bond is acceptable.
- c. If the bond is not adequate, go back to step a) and repeat the procedure.

Note: If the repair area is smaller than the test patch dimensions, decrease the test patch size accordingly.

- d. As a last resort, if the previous procedure does not provide an adequate bond, the permeated laminate must be handled differently using the following procedure:
 1. Hot water wash the equipment.
 2. Abrasive blast to achieve 0.003 to 0.005 in (0.08 to 0.12 mm) anchor pattern, and allow to completely dry.
 3. Prime with the recommended primer, an area 12 in. (305 mm) x 12 in. (305 mm) and apply a test patch.
 4. Prime a second spot 12 in. (305 mm) x 12 in. (305 mm) and prime with a recommended alternate primer.
 5. Allow this primer to cure.

6. Water wash, dry, and lightly abrasive blast the epoxy primer.
7. Apply the test patches to both areas.
- e. Pull both test patches after they are fully cured.
- f. If both test patches are good, prime the vessel with the preferred primer. If only one test patch is good, prime the vessel with the successful primer.

Note: If the repair area is smaller than the test patch dimensions, decrease the test patch size accordingly.

- g. If neither patch bonds, the vessel is probably not capable of bonding a patch and shall not be repaired.

3) Laminate Repair

- a. Repairs can be accomplished by adding back the correct corrosion barrier surface material as specified on the Fabricator's design drawings.
- b. All repairs shall be made with the same type of resin and reinforcement materials used to fabricate the original vessel corrosion barrier. Laminate quality shall be in accordance with Table S4.12. The acceptance criteria shall be as agreed by the Certificate Holder and owner or as required by the code of construction.
 1. Apply the selected primer (0.003 -0.005 in. (0.08 to 0.13 mm)) and allow to dry to the touch.
 2. Continue with the specified laminate using the proper resin and cure. The first layer of chopped strand mat used in the repair shall extend a minimum of 1 in. (25 mm) past the damaged area. The following chopped strand mat layer shall extend a minimum of 1 in. (25 mm) past the first layer, (in this manner, the entire area that was removed will now be filled with the mat layers. If additional layers are required to fill the removed surface, they must be applied), followed by the specified layer(s) of veil. The veil(s) shall extend a minimum of 1 in. (25 mm) past the last chopped strand mat layer.
 3. Apply a final coat of resin over entire surfacing veil. This final coat should contain a small amount of wax to prevent air contact, which might inhibit the cure. Allow laminate to achieve the manufacturer's recommended Barcol hardness before finalizing the repair.

Note: Apply heat to finalize the cure if hardness is not achieved.

S4.18.2.2 TYPE 1B — REPAIR OF THE CORROSION BARRIER FOR VESSELS WITH PRECISION BORES

Vessels with precision bores are commonly used when a device is installed inside the vessel and a seal between the device and the inside diameter is required. A corrosion barrier of a precision bore vessel is susceptible to scratching and damage that may affect performance and service life of the vessel or the device placed inside the vessel. Many times this damage may extend into areas of the vessel that cannot be reached. Before starting, ensure that the damaged area can be reached. After the Inspector has verified that the repair procedure is acceptable, the repair shall be performed by the Certificate Holder as follows:

- a) Surface Preparation
 - 1) The surface area that is damaged must be removed by abrasive blasting or grinding, to expose sound laminate. No more than 0.020 in. (0.51 mm) may be removed from the wall of the vessel. The repaired area shall be beveled into the good areas surrounding the damage.

- 2) Note that any cracks, delaminations, or permeated surfaces must be removed. If the damage is deeper than the corrosion barrier and the material removed reaches the structural laminate, the vessel is not repairable. An adequate size abrasive, or proper sanding disc must be used to obtain a 0.002 to 0.003 in. (0.05 to 0.08 mm) anchor pattern to the area that requires the repair.
- 3) Preparation of any surface requires that basic rules, common to all substrates, be followed. These rules are as outlined below:
 - a. Surface must be free of contaminants;
 - b. Surface must be structurally sound;
 - c. Surface must have adequate anchor pattern;
 - d. Surface must be dry; and
 - e. Surface must be primed with recommended primer.

Note: After the surface has been properly prepared, it must be kept clean and dry until laminating can be started. Dust, moisture, or traces of oil that come in contact with the surface may act as a mold release or act to inhibit the cure and prevent a good secondary bond. Laminating should be done within two hours of the surface preparation.

b) Applying Test Patches to Verify Adequate Surface Preparation

- 1) Test patches may be applied to any substrate that will require a secondary bond to determine the integrity of the bond prior to the application of the laminate.
- 2) The subsequent steps shall be followed:
 - a. Apply the primer ((0.003 to 0.005 in. [0.08 to 0.13 mm]) to the prepared surface, and allow primer to cure;
 - b. Coat the surface with the same resin to be used in the laminate repair. Apply a small strip of polyester film, such as Mylar®, strip to one edge of primed area. Allow the polyester film to protrude from beneath the patch;
 - c. Apply two layers of 1-1/2 oz. per sq. ft. (0.46 kg per sq. m) chopped strand mat saturated with the same resin that will be used for the repair;
 - d. Allow the mat layers to cure completely; this may be verified by checking the hardness of the laminate. If required, heat may be used to cure the material providing it is compatible with the initial resin used in the fabrication of the vessel;
 - e. Pry patch from surface using a screwdriver, chisel, or pry bar;
 - f. A clean separation indicates a poor bond;
 - g. Torn patch laminate or pulled substrate indicates that the bond is acceptable; and
 - h. If the bond is not adequate, go back to step a) and repeat the procedure again.

Note: If the repair area is smaller than the test patch dimensions, decrease the test patch size accordingly.

- 3) If neither patch bonds, the vessel is probably not capable of bonding a patch and shall not be repaired.

c) Laminate repair

- 1) Repairs can be accomplished by adding back the correct corrosion barrier surface material as specified on the Fabricator's design drawings.
- 2) When possible, repairs shall be made with the same type of resin and reinforcement materials used to fabricate the original vessel corrosion barrier. Laminate quality shall be in accordance with Table S4.12, or the original code of construction. However, when the original material of construction was gelled and post cured at elevated temperatures, using the same resin may not be possible. In this case an alternate resin system may be used.
 - a. Apply the selected primer (0.003 to 0.005 in. [0.08 to 0.13 mm]) (as required for polyester and vinyl ester resins) and allow to dry to the touch.
 - b. Continue with the specified laminate using the proper resin and cure. The first layer of non-woven polyester veil used in the repair shall extend to the exact edge of the damaged area. If additional layers are required to fill the removed surface, they must be applied, followed by the specified layer(s) of veil.
 - c. Apply a final coat of resin over entire surfacing veil. If this final coat is a vinyl ester or polyester material, it should contain a small amount of wax to prevent air contact, which might inhibit the cure. Allow laminate to achieve the manufacturer's recommended Barcol hardness before finalizing the repair.

Note: Apply heat to finalize the cure if hardness is not achieved.

- d. After the repair has been properly cured, remove any excess material with the appropriate sanding tools to obtain a smooth surface that blends into the surrounding area. Care should be taken to ensure that the final inside diameter of the repaired area matches that of the surrounding area and also conforms to the original supplier's specifications.

S4.18.2.3 TYPE 2 — CORROSION BARRIER AND INTERNAL STRUCTURAL LAYER REPAIRS

- a) The procedure for the Type 1a repair must be followed with the exception of additional layers (structural layers) that must be removed if the structure is also damaged. The repair area must be tapered similar to the Type 1a, and all of the structural layers must be replaced making sure that the mat layers increase in length and width by at least 1 in. (25 mm). The structural laminate sequence and thickness must be approved by the Inspector, and proper calculations and the repair plan must be reviewed and approved by a Professional Engineer familiar with the work involved prior to the job.
- b) Surface preparation, priming, and laminate repair must be done per Type 1a procedure.

S4.18.2.4 TYPE 3 — EXTERNAL STRUCTURAL LAYER REPAIRS

a) Surface Preparation

- 1) The surface area that is damaged is to be repaired by removing the damaged area either by abrasive blasting or grinding to expose sound laminate. The repair area must have a bevel of 2 in. (50 mm) minimum. The ground or blasted surface must extend a minimum of 4 in. (100 mm) past the damaged area into the sound solid structural laminate (making sure that no layers are removed in these 4 in. (100 mm), or as calculated accordingly).
- 2) Note that any cracks or delaminations must be removed. An adequate size abrasive or proper sanding disc must be used to obtain a (0.003 to 0.005 in. [0.05 to 0.08 mm]) anchor pattern.

- 3) Preparation of any surface requires that basic rules, common to all substrates, be followed. These rules are as outlined below:

- a. Surface must be free of contaminants;
- b. Surface must be structurally sound;
- c. Surface must have adequate anchor pattern;
- d. Surface must be dry; and
- e. Surface must be primed with recommended primer.

Note: After the surface has been properly prepared, it must be kept clean and dry until laminating can be started. Dust, moisture, or traces of oil that come in contact with the surface may act as a mold release or inhibit the cure and prevent a good secondary bond. Laminating should be done within two hours of the surface preparation.

b) Applying Test Patches to Verify Adequate Surface Preparation

- 1) Test patches may be applied to any substrate that will require a secondary bond to determine the integrity of the primer bond prior to the application of the laminate.
- 2) The subsequent steps shall be followed:
 - a. Apply the primer (0.003 to 0.005 in. [0.08 to 0.13 mm]) to the prepared surface, and allow primer to cure;
 - b. Coat the primed surface with resin to be used in the repair. Apply a 4 in. (100 mm) x 14 in. (350 mm) Mylar® strip to one edge of primed area. Allow polyester film to protrude from beneath the patch;
 - c. Apply two layers of 1-1/2 oz. per sq. ft. (458 g/m²) chopped strand mat saturated with the specified resin that will be used for the repair. Mat shall be 12 in. (305 mm) x 12 in. (305 mm) square;
 - d. Allow to cure completely; this may be verified by checking the hardness of the laminate;
 - e. Pry patch from surface using a screwdriver, chisel, or pry bar;
 - f. A clean separation indicates a poor bond;
 - g. Torn patch laminate or pulled substrate indicates that the bond is acceptable; and
 - h. If the bond is not adequate, go back to step one and prepare the surface again.

Note: If the repair area is smaller than the test patch dimensions, decrease the test patch size accordingly.

c) Laminate Repair

- 1) Repairs can be accomplished by adding back the correct equivalent contact molded laminate material as specified on the Fabricator's design drawings, or in the Repair Plan.
- 2) All repairs shall be made with the same type of resin and reinforcement materials used to fabricate the original vessel. Laminate quality shall be in accordance with the original construction code as specified in the vessel drawings and specifications.
 - a. Apply the selected primer (0.003 to 0.005 in. [0.08 to 0.13 mm]) and allow to dry to the touch.

- b. Continue with the specified laminate using the proper resin and cure.
- c. Fill the removed layers with the same sequence as the original structural thickness, making sure that the layers are increasingly larger as the laminate is applied (in the case of filament wound structure, an equivalent contact molded thickness must be used for the repair calculations). The first bond of the repair shall cover one degree times the width in the axial direction and shall be centered. The repair shall extend completely around the circumference using contact molded procedures as set forth in the code of construction.
- d. After the area is completely filled with the proper laminate, a reinforcing laminate shall be applied over the entire surface with a minimum overlap of 4 in. (100 mm) over the original shell, or as shown in the calculations, whichever is greater. This overlay thickness shall be calculated in the same way as the reinforcing pad of a nozzle with the diameter equal to the damaged area. The design shall be in accordance with the original construction code. Allow the laminate to achieve the manufacturer's recommended Barcol hardness before finalizing the repair.

Note: Apply heat to finalize the cure if hardness is not achieved.

- e. A pressure test shall be performed per NBIC Part 3, 4.4.1.

S4.18.2.5 TYPE 4 — ALTERATIONS

- a) Alterations, such as the addition of a nozzle or supports, must be designed according to the original construction standard. In the case of nozzles, the internal overlay is required according to ASME RTP-1 Figure 4-8 or 4-9 (overlay "ti"). The procedure for preparing the inside surface is the same as the Type 1 repair. The external reinforcing pad shall be designed and installed according to the original construction standard. Surface preparation for the external overlay shall be according to the Type 3 repair procedure.
- b) After the alteration is completed, a pressure test shall be performed in accordance with NBIC Part 3, 4.4.1. As an option, an Acoustic Emission test can be performed to monitor the repaired area during the pressure test.

S4.18.2.6 TYPE 5 — MISCELLANEOUS GENERAL EXTERNAL REPAIRS OR ALTERATIONS

External repairs or alterations that are performed on nonpressure retaining parts, shall be calculated according to the original construction standard. The Inspector and the Professional Engineer must review and approve such modifications. All repairs and alterations shall be done according to the Type 3 repair procedure, with the exception of removing damaged layers from the structure. Surface preparation shall be restricted to the external layer of the vessel.

S4.18.2.7 TYPE 6 — THERMOPLASTIC REPAIRS

- a) The surface area that is damaged must be reconditioned so that the thermoplastic liner geometry matches that of its contacting laminate. Surfaces that are cut or torn, or missing sections, shall be repaired by plastic welding. Welding practice, including choice of welding equipment, weld surface preparation, and weld temperature shall conform to Appendix M-14 of ASME RTP-1. For materials not specified in these documents, the best practice as recommended by the material supplier shall be used. Welding rod, pellets, powder, or plates shall be made with plastic of an identical type with properties such as melt index and specific gravity as close as possible to the original corrosion barrier plastic.
- b) Thickness of the repaired barrier between the wetted surface and the original surface shall be equal to or greater than the original corrosion barrier surface specification.

- c) The repaired surface shall be capable of supporting the full pressure rating of the vessel at the temperature rating of the vessel with no fluid leakage.

S4.18.2.8 TYPE 7 — GEL COAT REPAIRS

Following restoration of the structural laminate layers, a gel coat shall be applied to replace the gel coat lost in the repair. The procedure for the Type 1 repair item a) surface preparation shall be followed. Gel coat of the same type is then to be applied to the surface. Gel coat thickness is to be checked with a wet thickness gage at each 36 sq. in. (23,200 sq. mm) area element. Thickness shall be equal to or greater than the original gel coat specification in the “as manufactured” state of the vessel. The entire repair surface, including all seams, shall be coated. There shall be at least a 3 in. (75 mm) overlap of gel coat at the union of repaired surface and nonrepaired surface.

S4.19 REPAIR OF HIGH PRESSURE FILAMENT WOUND VESSELS

S4.19.1 SCOPE

Types of damage that are addressed in this section include abrasion, cuts and scratches, impact, chemical, fire and heat, and weathering.

S4.19.2 LEVEL OF DAMAGE

- Level 1 damage, up to 0.010 inches (0.254 mm), is repairable any time
- Level 2 damage, defined by the manufacturer (or up to 0.050 inches (1.27 mm) if not defined), is repairable with the manufacturer’s concurrence
- Level 3 damage, defined by the manufacturer (or 0.050 inches (1.27 mm) or greater if not defined), is not repairable

Softening of the resin due to chemical attack, or charring due to exposure to fire, shall be defined as Level 3 damage.

The manufacturer’s guidance for assessing damage depth and levels shall be followed if it conflicts with general guidelines in this document.

TABLE S4.19.2-1

DAMAGE LEVELS AND ASSESSMENT

Type of damage	Definition	Level 1 – accept	Level 2	Level 3 – reject
Cuts/scratches	A sharp impression where material has been removed or redistributed.	When depth is less than 0.010 in.	Depth from 0.010 in to the limit defined by the manufacturer, or 0.050 if not defined.	Greater than the limit defined by the manufacturer, or greater than 0.050 if not defined.
Abrasion	An area that is scuffed or worn thinner by rubbing or scraping.	When depth is less than 0.010 in.	Depth from 0.010 in to the limit defined by the manufacturer, or 0.050 if not defined.	Greater than the limit defined by the manufacturer, or greater than 0.050 if not defined.
Charring/soot	Blackening or browning of an area, burning of an area.	Soot only, which washes off.	Minor discoloration; recommendation.	Charring

Chemical attack, including stress corrosion cracking	Vessel is subjected to a chemical that softens or dissolves the composite.	Residue may be cleaned off, no evidence of softening or dissolving.	Permanent discoloration.	Softening or dissolving of the material, cracking of the composite due to stress and chemical exposure.
Impact	Composite material was struck or hit; the resin has a frosted or smashed appearance.	Damaged area is less than 0.20 in ² and no other damage is apparent.	Damage is uncertain, requiring the manufacturer's advice.	Permanent deformation of cylinder or liner, evidence of underlying delamination.
Weathering	Composite affected by UV exposure and general weather.	Minor gloss loss or chalking, only non-structural materials affected.	Structural laminate affected to a level less than defined by the manufacturer, or 0.050 inch.	Structural laminate affected to a level greater than defined by the manufacturer, or 0.050 inch.

S4.19.3 THICKNESS CONSIDERATIONS

Damage to a depth greater than 5% of the structural laminate thickness is not repairable, and the vessel shall be removed from service. Depth of damage does not include paint thickness, or material designated by the manufacturer as protective (non-structural) rather than structural.

S4.19.4 IMPACT DAMAGE CONSIDERATIONS

Impact damage may result in rejection, without possibility of repair, regardless of the measurable depth due to risk of internal fracture or delamination. Impact damage may be characterized by noting permanent deformation, softness or deflection of the surface, or localized surface crazing.

S4.19.5 ASSESSMENT OF DAMAGE DEPTH

All loose fibers and affected resin shall be removed. This includes material that is softened by actions of chemicals or heat. Confirmation that the material remaining is sound shall be determined by a tap test, Barcol hardness measurement, and/or visual inspection.

S4.19.6 REPAIR PROCEDURE

- a) Non-structural material, including paint, shall be removed from any area involved in the repair.
- b) Resin used in structural repairs shall be compatible with the resin used to fabricate the vessel.
- c) Cloth patches made of glass or carbon fiber may be used in the repair and to cover the repaired area.
 - 1) Cloth patches shall extend at least 0.5 inches beyond the edge of the repair area, and subsequent layers shall extend at least 0.25 inch beyond the edge of the previous patch.
 - 2) Total patch thickness shall not be more than 5% of the structural thickness of the original laminate.
- d) A layer of fiber wound continuously in the hoop direction may be applied over the repair.
- e) Non-structural material may be applied to the repaired area for protection if originally used in the vessel design.
- f) The repaired area may be covered with epoxy, polyurethane, or other compatible paint.

- g) The repaired area shall be cured at a temperature that will not degrade the resin in the vessel. It may be cured prior to applying any non-structural material or paint.
- h) The repair shall be confirmed by either:
 - 1) A tap test or Barcol hardness measurement conducted on the structural material after cure and prior to applying any non-structural material or paint, or
 - 2) A Modal Acoustic Emission (MAE) test, in accordance with Part 2 S10.10, conducted after cure of the structural material
- i) A hydrostatic proof test shall be conducted following confirmation of the repair.

S4.19.7 ACCEPTANCE OF THE VESSEL FOR RETURN TO SERVICE

The repair shall meet the repair confirmation requirement (i.e. confirmation of soundness using the tap test or Barcol hardness measurement, or confirmation using MAE). There shall be no delamination of the repaired area resulting from a hydrostatic proof test in accordance with the Design Specification. A vessel that does not meet the requirements of the repair confirmation or hydrostatic proof test shall not be returned to service.

SUPPLEMENT 5**GENERAL REQUIREMENTS FOR REPAIRS AND ALTERATIONS TO YANKEE DRYERS****S5.1 SCOPE**

This supplement provides requirements and guidelines for repairs and alterations to yankee dryer pressure-retaining components and shall be used in conjunction with inspection requirements identified in NBIC Part 2, *Inspection* Supplement 5.

(23) S5.2 EXAMINATIONS AND TEST METHODS

The following supplemental examination and test methods may be used in addition to the requirements of NBIC Part 3, 4.4.1. and 4.4.2:

- a) Acoustic emission testing; and
- b) Metallographic examination when thermal damage is suspected due to operational or repair activities.

S5.3 YANKEE DRYER REPAIR METHODS

This supplement provides additional requirements for repair methods to yankee dryer pressure-retaining components and shall be used in conjunction with NBIC Part 3, Section 2 through 5 of this part, as appropriate.

S5.3.1 REPLACEMENT PARTS FOR YANKEE DRYERS

- a) Yankee dryer replacement pressure-retaining parts shall be fabricated in accordance with the manufacturer's design and the original code of construction. Yankee dryer pressure-retaining parts may include:
 - 1) shell;
 - 2) heads;
 - 3) center shaft, stay, or trunnion;
 - 4) stay bars;
 - 5) structural bolting; and
 - 6) journals.
- b) Replacement of nonpressure-retaining parts, when different from the manufacturer's design, shall be evaluated for any possible effect on the pressure-retaining parts.

(23) S5.4 REPAIR GUIDE FOR YANKEE DRYERS

- a) Welding or brazing shall not be used on any yankee dryer pressure-retaining component manufactured from cast iron. The *Manufacturer's Data Report* shall be carefully reviewed to determine the material of construction of each yankee dryer component such as shell, heads, and journals.
- b) Weld repairs performed in accordance with NBIC Part 3 are permitted on yankee dryer pressure-retaining components that are manufactured from steel, except that head bolts may not be welded.

- c) Structural deterioration or damage caused by corrosion, thinning, or cracking shall not be repaired until its extent has been determined by suitable nondestructive examination.
- d) The user shall have a plan covering the scope of the repair. The plan shall ensure that the work involved is compatible with the original design specification and good engineering practices.
- e) All repair work shall be documented.

S5.5 REPAIRS THAT DO NOT REQUIRE STAMPING OR NAMEPLATE ATTACHMENT (23)

The following examples of repairs do not require stamping or nameplate attachment provided the repair procedure has been accepted by the Inspector and the owner or user has verified there will be no effect on the pressure-retaining capability of the yankee dryer.

- a) Grinding and machining:
 - 1) removing bolt-stop ring for test specimens;
 - 2) head/shell joint corrosion removal;
 - 3) journal grinding;
 - 4) shell surface grinding (crowning);
 - 5) crack removal;
 - 6) head flange OD reduction during shell grinding; and
 - 7) back spot facing of flange surfaces (head, shell, journal).
- b) Metallizing (full face, spot, edge):
 - 1) applying a metallized coating; and
 - 2) grinding of a metallized coating.
- c) Epoxy (sealant) repair of steam leaks at bolted joints (using fittings and pumping bolts) and epoxy filling of surface imperfection;
- d) Installation of spoiler bars;
- e) Maintain/repair/replace internal condensate removal system;
- f) Driven plug repair when completed as described in NBIC Part 3, S5.6.3;
- g) Threaded plug repair when completed as described in NBIC Part 3, S5.6.4; and
- h) Installation of head insulation.

S5.6 DAMAGE REPAIR

S5.6.1 REPAIR OF LOCAL THINNING (23)

- a) A Local Thin Area (LTA) may develop in a pressure-retaining part or may result from the original manufacturing process. Inservice thin areas may result from mechanical wear, erosion-corrosion caused by steam and condensate flow, corrosion, impact damage, or grinding for the removal of material flaws.

- b) Evaluation of thinning for repair shall consider the unique design and loading characteristics of the yankee dryer. Local thin areas are often analyzed as specific cases by the finite element method.
 - 1) When an LTA is evaluated by finite element method, analysis should consider the location of the thin area and account for strength provided by the vessel center shaft and heads in addition to the strength provided by the shell alone. Such structural analysis should consider all relevant loads to ensure safe operation of the pressure vessel.
 - 2) Following evaluation and determination of maximum allowable operating parameters, an LTA can be coated or filled to prevent further wear or deterioration. Grooves and gouges should always be lightly ground to remove sharp notches and edges. Welding or brazing repairs are NOT permitted on cast-iron pressure-retaining components.
 - 3) Where the LTA is of sufficient size to cause a reduction in maximum allowable operating parameters, an R-2 form shall be submitted.
 - 4) Depending upon the cause of the LTA, further monitoring may be necessary to ensure deterioration has been arrested.
 - 5) Inspection data, including all thickness readings and corresponding locations used to determine the minimum and average thicknesses, and the accompanying stress analysis, should be included in the documentation and retained for the life of the vessel.

(23) S5.6.2 ASSESSMENT OF CRACK-LIKE FLAWS

- a) Crack-like flaws are planar flaws that are predominantly characterized by a length and depth with a sharp root radius. They may either be embedded or surface breaking. In some cases, it may be advisable to treat volumetric flaws, such as aligned porosity, inclusions, and laps, as planar flaws, particularly when such volumetric flaws may contain microcracks at the root.
 - 1) Knowledge of local stress level and classification, and of flaw origin, type, size, location, and angle relative to the principal stress direction is essential in making determinations regarding remediation. It is also important to know whether the crack is active. Acoustic Emissions testing can be used to determine if the crack is active. Various other methods of nondestructive examination should be employed to determine crack length and depth. Ultrasonics is the recommended sizing technique for depth and inclination of crack-like flaws. Magnetic particle, specifically the wet fluorescent technique, and liquid penetrant methods are applicable in determining the length of a surface flaw. Radiographic and metallographic methods may also be useful.
 - 2) Crack-like flaws are most often removed via grinding or machining. Weld repairs are permitted in steel, but not in cast iron. Metal-stitching is permitted as a repair. However, this method of repair requires evaluation as to whether a reduction in allowable operating conditions is required. This evaluation shall be performed by the manufacturer or by another qualified source acceptable to the Inspector.
 - 3) Crack-like flaws that have been identified as cracks, but which developed from normal service exposure or excessive operating conditions, shall be remediated by appropriate means regardless of location.
 - 4) Crack-like flaws that have been identified as cracks that developed through non-standard load events, such as by water hoses from operation or firefighting or mechanical damage, shall be evaluated and remediated as necessary.
 - 5) Crack-like flaws that are not identified as cracks, but which existed in the original material, i.e., material flaws, shall be analyzed, documented, and monitored to ensure their presence will not be, or have not been, affected by current operating conditions.

- b) All documents pertaining to crack-like flaw assessment shall be retained for the life of the vessel. Documentation should address the engineering principles employed, including stress analysis methods and flaw sizing, the source of all material data used, identification of any potential material property degradation mechanisms and the associated influence on the propagation of flaw, and the criteria applied to the assessment procedures.

(23)

S5.6.3 DRIVEN PLUG REPAIR

Cast iron shell surface imperfections may be repaired with smooth, driven plugs as described in ASME Section VIII, Div. 1, UCI-78, with the following additional requirements:

- a) Maximum plug length (depth) shall be limited to 20% of shell effective thickness, and plug diameter shall not exceed the plug length (depth);
- b) Total surface area of plugs shall not exceed 4 sq. in. in an 8 in. diameter circle (2580 sq. mm in a 200 mm diameter circle);
- c) Average number of shell plugs shall not exceed 1 plug per 1 sq. ft. (1 plug per 0.1 sq. m) of the surface;
- d) The land distance between edges of plugs shall be at least equal to the diameter of the larger plug;
- e) The plug material shall conform in all respects to the material specification of the base material;
- f) The installed plug shall have an interference fit. The average hole diameter is determined after the plug hole is drilled or reamed. The maximum plug diameter shall not exceed 1.012 times the average hole diameter. This provides an interference fit while minimizing the residual stresses; and
- g) All plug repair work shall be documented in the form of a plug repair map or other suitable method of recording and retained in the dryer's permanent file.

(23)

S5.6.4 THREADED PLUG REPAIR

Casting defects, leaks and local thin areas may be repaired with threaded plugs as described in ASME Section VIII, Division 1, UCI-78, with the additional requirement that a threaded plug shall not be used in an area subject to thermal/mechanical fatigue stresses (e.g., yankee dryer shell) as determined by the manufacturer or another qualified source acceptable to the Inspector.

S5.7 ALTERATIONS TO YANKEE DRYERS

S5.7.1 SCOPE

This supplement provides additional requirements for alterations to yankee dryer pressure-retaining components and shall be used in conjunction with NBIC Part 3, Sections 2 through 5, as appropriate.

S5.7.2 ALTERATION TYPES

(23)

- a) Any change in the yankee dryer (shell, heads, center shaft, journals, manway covers, fasteners), as described on the original *Manufacturer's Data Report*, which affects the pressure-retaining capability, shall be considered an alteration. Examples of alterations are:
 - 1) Drilling/enlarging of bolt holes for larger diameter bolts;
 - 2) Replacement of structural bolts differing in size, material, or design, from those described on the *Manufacturer's Data Report*;

- 3) Removal of shell overhung flange;
 - 4) Journal outside diameter reduction to install a sleeve;
 - 5) Head flange outside diameter reduction;
 - 6) Machining of head flange or shell flange mating surfaces to remove corrosion; and
 - 7) Changes to the nameplate temperature.
- b) Alteration plans to yankee dryers shall be accepted by the Inspector, and when required, by the Jurisdiction, prior to the start of work.

(23) **S5.7.3 PRESSURE TESTING OF ALTERATIONS**

Pressure testing of alterations shall be performed in accordance with NBIC Part 3, 4.4.2, and Part 2, S5.6. When enlarging bolt holes referenced in Part 3, S5.7.2 a) 1), the item shall be visually examined and tested in accordance with the rules for repairs (see NBIC Part 3, 4.4.1).

SUPPLEMENT 6

REPAIR, ALTERATION, AND MODIFICATION OF DOT TRANSPORT TANKS

S6.1 SCOPE

This supplement provides requirements and guidelines for repairs, alterations, or modifications to DOT Transport Tanks used for the transportation of dangerous goods via highway, rail, air, or water.

S6.2 DEFINITIONS

The definitions specified in NBIC Part 3, Section 9, *Glossary*, shall be used in conjunction with those specified in NBIC Part 2, S6.17. Where conflicts between definitions exist, those identified in NBIC Part 2, S6.17 shall take precedence.

S6.3 CONSTRUCTION STANDARDS

When the standard governing the original construction is the ASME Code or other regulations of the Competent Authority, repairs, alterations, or modifications shall conform, insofar as possible, to the edition of the construction standard or specification most applicable to the work. Where this is not possible or practical, it is permissible to use other codes, standards or specifications, including the ASME Code provided the “R” Certificate Holder has the concurrence of the Inspector and, if required, the Competent Authority.

S6.4 ACCREDITATION AND REGISTRATION

Organizations performing repairs, alterations, or modifications shall be accredited in accordance with the National Board “R” Accreditation Program. In addition repair organizations performing repairs, alterations, or modifications to transport tanks shall be registered with DOT as required by 49 CFR Part 180.

S6.5 MATERIALS

The materials used in making repairs, alterations, or modifications shall conform to the original code of construction including the material specification requirements. Carbon or alloy steel having a carbon content of more than 0.35% (0.30% for ton tanks) shall not be welded unless permitted by the original code of construction. The “R” Certificate Holder is responsible for verifying identification of existing materials from original data, drawings, or unit records and identification of the material to be installed. Additional material requirements are provided in NBIC Part 3, Section 3.

S6.6 REPLACEMENT PARTS

- a) Replacement parts that will be subject to internal or external pressure that consist of new material which may be formed to the required shape by spinning, forging, die forming, and on which no fabrication welding is performed shall be supplied as material. Such parts shall be marked with the material and part identification and the name or trademark of the parts manufacturer. In lieu of full identification marking on the material or part, the part manufacturer may use a coded marking system traceable to the original marking. Such markings shall be considered as the part manufacturer’s certification that the part complies with the original code of construction. Examples include seamless or welded tube or pipe, forged nozzles, heads or subassemblies attached mechanically.
- b) Replacement parts that will be subject to internal or external pressure, that are preassembled by attachment welds, shall have the welding performed in accordance with the original code of construction. This certificate shall be supplied in the form of a bill of material or drawings with statement of certification.

- c) Replacement parts subject to internal or external pressure fabricated by welding that require shop inspection by an Authorized Inspector shall be fabricated by an organization having an appropriate ASME *Certificate of Authorization*. The item shall be inspected and stamped as required by the applicable section of the ASME Code and DOT specification requirements. A completed ASME *Manufacturer's Partial Data Report* shall be supplied by the manufacturer.
- d) When the original code of construction is other than ASME, replacement parts subject to internal or external pressure fabricated by welding shall be manufactured by an organization certified as required by the original code of construction. The item shall be inspected and stamped as required by the original code of construction. Certification as required by the original code of construction shall be supplied with the item. When this is not possible or practicable the organization fabricating the part may have a National Board *Certificate of Authorization*. Replacement parts fabricated by an "R" stamp holder shall be documented on Form R-3 and the "R" Stamp applied as described in NBIC Part 3, S6.15.

S6.7 AUTHORIZATION

The Inspector's written authorization to perform a repair, alteration, or modification shall be obtained prior to initiation of the work to be performed on a transport tank. Additional requirements are specified in NBIC Part 3, 1.3.1 and 1.3.2.

S6.8 INSPECTION

Inspection and certification shall be made by an Inspector holding an appropriate National Board Commission as required by NBIC Part 3, 1.3 and shall be a Registered Inspector meeting the requirements of the Competent Authority.

S6.8.1 INSPECTOR DUTIES FOR REPAIRS, ALTERATIONS, AND MODIFICATIONS

- a) Inspectors performing repair, alteration, or modification inspections under the requirements of this supplement shall satisfy the requirements of S6.8.1 to be authorized to sign the Form R-1, *Repairs* and Form R-2, *Alterations*.
- b) For repairs, alterations, and modifications of transport tanks, the duties of the Registered Inspector performing inspections are detailed in Part 2, S6.10 through S6.15, as required by the Competent Authority.
- c) The Registered Inspector shall meet the rules of NB-263, RCI-1, *Rules for Commissioned Inspectors*. Additional duties are summarized below:
 - 1) Verify the organization performing the repair, alteration or modification activity is properly accredited and in possession of a current valid *Certificate of Authorization* to apply the "R" Stamp issued by the National Board and is working to an accepted Quality Control System;
 - 2) Verify that the design, if required, for the modification of the vessel is approved by a Design Certifying Engineer, or Designated Approval Agency or other applicable individual;
 - 3) Verify the materials to be used to make the repair, alteration, or modification are approved for use and comply with applicable code requirements;
 - 4) Verify the welding procedures and welders or welding operators are properly qualified;
 - 5) Verify that all heat treatments, if required, including PWHT have been performed in accordance with the applicable standards and that the results are acceptable;
 - 6) Verify that all NDE, impact tests, and other tests have been performed when required, and that the results are acceptable;

- 7) Make a visual inspection of the work performed to confirm there are no visible defects or deviations from code requirements;
- 8) Perform external and internal visual inspections, if the vessel is equipped with a manway, and witness the hydrostatic or pneumatic pressure test and/or leak tightness test when they are required;
- 9) Verify the correct nameplate is properly attached to the vessel and that the current test and inspection markings are properly attached and displayed on the proper vessel; and
- 10) Sign the Form R-1 and, as appropriate, form R-2 when work is completed.

S6.9 WELDING

- a) Welding shall be performed in accordance with the requirements of the original code of construction used for the fabrication of the pressure vessel. For hydrogen control when low alloy steel filler metals are used, the filler metal classification shall include an H4 supplemental diffusible hydrogen designator (maximum 4 ml [H₂]/100 g deposited metal) for each of the following welding processes:
 - 1) electrodes for shielded metal arc welding (SMAW) conforming to SFA-5.5;
 - 2) electrodes and fluxes for submerged arc welding (SAW) conforming to SFA-5.26;
 - 3) electrodes and rods for gas shielded metal arc welding (GMAW) conforming to SFA-5.28; and
 - 4) electrodes for flux-cored arc welding (FCAW) conforming to SFA 5.29.
- b) Practices used for controlling storage and exposure of filler metals shall be those developed by the "R" Certificate Holder or those recommended by the filler metal manufacturer.

S6.9.1 WELDING PROCEDURE SPECIFICATION

Welding shall be performed in accordance with a Welding Procedure Specification (WPS) qualified in accordance with the original code of construction. When this is not possible or practicable, the WPS may be qualified in accordance with ASME Section IX.

S6.9.2 STANDARD WELDING PROCEDURE SPECIFICATIONS

An "R" Certificate Holder may use one or more applicable *Standard Welding Procedure Specifications* shown in NBIC Part 3, 2.3 without supporting *Procedure Qualification Records* (PQRs) since SWPS are pre-qualified and the PQR will not be supplied.

S6.9.3 PERFORMANCE QUALIFICATION

Welders or welding operators shall be qualified for the welding processes that are used. Such qualification shall be in accordance with the requirements of the original code of construction or ASME Section IX. Use of Standard Welding Procedures Specification shown in NBIC Part 3, 2.3 is permitted for performance qualification testing.

S6.9.4 WELDING RECORDS

The "R" Certificate Holder shall maintain a record of the results obtained in welding procedure qualification, except for those qualifications for which the provisions of NBIC Part 3, S6.8.2 are used and of the results obtained in welding performance qualifications. These records shall be certified by the "R" Certificate Holder and shall be available to the inspector.

S6.9.5 WELDERS' IDENTIFICATION

The "R" Certificate Holder shall establish a system for the assignment of a unique identification mark to each welder/welding operator qualified in accordance with the requirements of the NBIC. The "R" Certificate Holder shall also establish a written procedure whereby all welded joints can be identified as to the welder or welding operator who made them. This procedure shall use one or more of the following methods and be acceptable to the Inspector. The welder's or welding operator's identification mark may be stamped (low stress stamp) adjacent to all welded joints made by the individual or, in lieu of stamping, the "R" Certificate Holder may keep a record of the welded joints and the welders or welding operators used in making the joint.

S6.9.6 WELDERS' CONTINUITY

The performance qualification of a welder or welding operator shall be affected when one of the following conditions occurs:

- a) When the welder or welding operator has not welded using a specific process during a period of six months or more, their qualifications for that process shall expire; and
- b) When there is specific reason to question their ability to make welds that meet the specification, the qualification which supports the welding that is being performed shall be revoked. All other qualifications not questioned remain in effect.

S6.10 HEAT TREATMENT

S6.10.1 PREHEATING

Preheating may be employed during welding to assist in completion of the welded joint (see NBIC Part 3, 2.5.1). The need for and the temperature of preheat are dependent on a number of factors such as chemical analysis, degree of restraint of the items being joined, material thickness, and mechanical properties of the base metals being joined. The Welding Procedure Specification for the material being welded shall specify the preheat temperature requirements.

S6.10.2 POSTWELD HEAT TREATMENT

Postweld heat treatment may be performed as required by the original code of construction in accordance with a written procedure. The procedure shall contain the parameters for postweld heat treatment. Local PWHT that is not specified by the original code of construction may be performed in accordance with an Alternative Postweld Heat Treatment Method described in NBIC Part 3, 2.5.2 with acceptance by the Inspector and required by the Competent Authority.

S6.10.3 ALTERNATIVES TO POSTWELD HEAT TREATMENT

- a) Under certain conditions, postweld heat treatment in accordance with the original code of construction may be inadvisable or impractical. In such instances, alternative methods of postweld heat treatment or special welding methods in accordance with NBIC Part 3, 2.5.3, and acceptable to the Inspector and Competent Authority may be used.
- b) When the standard governing the original construction is the Code of Federal regulation for DOT/MC 331 cargo tanks for propane, butane, anhydrous ammonia, and other DOT permitted commodities, and the tanks are made to the ASME Code, Section VIII, Division 1, Part UHT, repairs, alterations, or modifications shall conform insofar as possible, to the edition of the construction standard or specification most applicable to the work. Where this is not possible or practicable, it is permissible to use other codes, standards, or specifications provided the "R" Certificate Holder has the concurrence of

the DOT. Shells and heads of MC 331 cargo tanks were made from quenched and tempered alloy steel plate, SA517, Grade E (originally Code Case 1298) and Grade F (originally Code Case 1204) prior to 1994.

- c) The 1994 ASME Code Addenda revised UHT-5(b) to permit the joining of UHT materials to UCS or UHA materials in head and shell sections. Propane, butane, and anhydrous ammonia are the most common transported commodities and the shipper is required by DOT to comply with certain composition limitations. Propane and butane transported must have sufficiently low hydrogen sulfide content so as not to exceed the limitations for Classification One of the ASTM D1838-74 copper strip test, and the anhydrous ammonia transported must be inhibited with a minimum water content of 0.2% by weight. In addition, such cargo tanks made for propane, butane, and anhydrous ammonia service must be postweld heat treated, unless specifically exempted by a DOT special permit that exempts PWHT.

S6.11 NONDESTRUCTIVE EXAMINATION

- a) The nondestructive examination (NDE) requirements, including technique, extent of coverage, procedures, personnel qualification, and acceptance criteria, shall be in accordance with the original code of construction used for the pressure vessel, and repairs, alterations, and modifications shall be subjected to the same nondestructive examination requirements as the original welds. Where this is not possible or practicable, alternative NDE methods acceptable to the Inspector and the Competent Authority may be used on a case-by-case basis.
- b) NDE personnel shall be qualified and certified in accordance with the requirements of the original code of construction. When this is not possible or practicable, NDE personnel may be qualified and certified in accordance with their employer's written practice. ASNT SNT-TC-1A, *Recommended Practice for Nondestructive Testing Personnel Qualification and Certification (2006 Edition)*, or ANSI/ASNT CP-189, *Standard for Qualification and Certification of Nondestructive Testing Personnel (2006 Edition)*, shall be used as a guideline for employers to establish their written practice. The ASNT Central Certification Program (ACCP) may be used to fulfill the examination and demonstration requirements of the employer's written practice. Provisions for training, experience, qualification and certification of NDE personnel shall be described in the "R" Certificate Holder's written quality system.

S6.12 COATINGS AND LININGS

When coatings or linings are to be inspected, such inspections shall be done in accordance with the Structural Steel Painting Council, SSPC publication, No. 91-12, *Coating and Lining Inspection Manual*.

S6.13 MEASUREMENT, EXAMINATION, AND TEST EQUIPMENT

The calibration of pressure gages, measurement, examination, and test equipment, and documentation of calibration shall be performed, as required, by the applicable standard used for construction. This system shall be documented.

S6.14 ACCEPTANCE INSPECTION

The Inspector making the acceptance inspection shall be the same Inspector who authorized the repairs, alterations, or modifications. Where this is not possible or practical, another Inspector may perform the acceptance inspection; however, in all cases, the Inspector who performs the acceptance inspection shall be an employee of the same organization as the Inspector who authorized the repairs, alterations, or modifications.

S6.15 GENERAL STAMPING REQUIREMENTS

The stamping of or attaching of a nameplate to a pressure-retaining item shall indicate that the work was performed in accordance with the requirements of this code and any requirements of the Competent Authority.

Such stamping or attaching of a nameplate shall be done only with the knowledge and authorization of the Inspector and Competent Authority. The “R” Certificate Holder responsible for the repair or the construction portion of the modification/alteration shall apply the stamping. For a re-rating where no physical changes are made to the pressure-retaining item, the “R” Certificate Holder responsible for the design shall apply the stamping. Requirements for stamping and nameplate information are shown in NBIC Part 3, Section 5.

S6.15.1 REMOVAL OF ORIGINAL STAMPING OR NAMEPLATE

If it becomes necessary to remove the original stamping, the Inspector shall, subject to the approval of the Competent Authority, witness the making of a facsimile of the stamping, the obliteration of the old stamping, and the transfer of the stamping. When the stamping is on a nameplate, the Inspector shall witness the transfer of the nameplate to the new location. Any relocation shall be described on the applicable NBIC “R” Form. The restamping or replacement of a code symbol stamp shall be performed only as permitted by the governing code of construction.

S6.16 “R” FORMS

S6.16.1 DOCUMENTATION

Repairs, alterations, or modifications that have been performed in accordance with the NBIC shall be documented on Form R-1, *Report of Repair* or Form R-2, *Report of Alteration* as shown in NBIC Part 3, Section 5. Form R-4, *Report Supplementary Sheet*, shall be used to record additional data when space is insufficient on Form R-1 or R-2.

S6.16.2 PREPARATION OF “R” FORMS

Preparation of “R” Forms shall be the responsibility of the “R” Certificate Holder performing the repairs, alterations, or modifications. An Inspector shall indicate acceptance by signing the appropriate “R” form.

S6.16.3 DISTRIBUTION

- a) Legible copies of the completed “R” forms together with attachments shall be distributed to the owner or user, the Inspector, the Competent Authority as required, the Authorized Inspection Agency responsible for the inspection, and the National Board for registration.
- b) Distribution of the “R” forms and attachments shall be the responsibility of the “R” Certificate Holder performing the work.

S6.16.4 REGISTRATION OF FORM R-1 AND FORM R-2

- a) Organizations performing repairs, alterations, or modifications required by this supplement shall register such repairs, alterations, or modifications with the National Board.
- b) The repair organization shall maintain a sequential Form “R” Log that shall identify the following:
 - 1) Form number assigned to the “R” Form;
 - 2) Identify if the activity was a repair, alteration, or modification;
 - 3) When the repair, alteration, or modification was completed, and
 - 4) Date sent to the National Board.

S6.17 ADDITIONAL REQUIREMENTS FOR REPAIRS, ALTERATIONS, OR MODIFICATIONS

S6.17.1 SCOPE

This section provides additional requirements for repairs, alterations, or modifications to DOT Transport Tank pressure-retaining items and shall be used in conjunction with NBIC Part 3.

S6.17.2 REPAIRS OF DEFECTS

Before a repair is made to a defect in a welded joint or base metal, care should be taken to investigate its cause and to determine its extent and likelihood of recurrence. This information shall be made available to the Inspector.

S6.17.3 MODIFICATIONS

All modifications to the pressure-retaining item shall meet the requirements of NBIC Part 3 for alterations.

S6.17.4 DRAWINGS

Drawings or instructions shall be prepared to describe the repair, alterations, or modification. Drawings shall include sufficient information to satisfactorily perform the activity.

S6.17.5 AUTHORIZATION

Repairs, alterations, or modifications to a pressure-retaining item shall not be initiated without the authorization of the Inspector, who shall determine that the methods are acceptable.

S6.18 EXAMINATION AND TEST

The following requirements shall apply to all repairs, alterations, or modifications to DOT Transport Tank pressure-retaining items:

- a) The integrity of repairs and replacement parts used in repairs, alterations, or modifications shall be verified by examination and test;
- b) The “R” Certificate Holder is responsible for all activities relating to examination and test of repair, alterations, or modifications; and
- c) Examination and tests to be used shall be subject to acceptance of the Inspector and the Competent Authority when required.

S6.18.1 METHODS

One, or a combination of the following examination methods, shall be applied to DOT Transport Tank pressure-retaining items with the concurrence of the Inspector and the Competent Authority when required.

a) Liquid Pressure Test

Pressure testing of repairs shall meet the following requirements:

- 1) Pressure tests shall be conducted using water or other suitable liquid. The test pressure shall be the minimum required to verify the leak tightness integrity of the repair, but not more than 150%

of the maximum allowable working pressure (MAWP) stamped on the pressure-retaining item, as adjusted for temperature. When original test pressure included consideration of corrosion allowance, the test pressure may be further adjusted based on the remaining corrosion allowance;

- 2) During a pressure test where the test pressure will exceed 90% of the set pressure of the pressure relief device, the device shall be removed whenever possible. If not possible, a test gag should be used using the valve manufacturer's instructions and recommendations; and
- 3) Hold time for the pressure test shall be a minimum of 10 minutes prior to examination by the Inspector. Where the test pressure exceeds the MAWP of the item, the test pressure shall be reduced to the MAWP for close examination by the Inspector. Hold time for close examination shall be as necessary for the Inspector to conduct the examination.

b) Pneumatic Test

A pneumatic test may be conducted. Concurrence of the owner shall be obtained in addition to that of the Inspector and the Competent Authority where required. The test pressure shall be the minimum required to verify leak tightness integrity of the repair, but shall not exceed the maximum pneumatic test pressure of the original code of construction. Precautionary requirements of the original code of construction shall be followed.

c) Nondestructive Examination

Nondestructive examination (NDE) may be conducted. NDE methods shall be suitable for providing meaningful results to verify the integrity of the repair.

S6.19 REPAIRS, ALTERATIONS, OR MODIFICATION REPORTS

- a) When repairs, alterations, or modifications are performed on a transport tank, i.e., cargo tank, portable tank, or ton tank, the owner or User shall have the activity performed by a Repair Organization that has a valid "R" *Certificate of Authorization* issued by the National Board. "R" forms shall be completed and certified by the "R" Certificate Holder and received and certified by the Inspector.
- b) For the purposes of documentation and stamping, modification shall be considered an alteration.

SUPPLEMENT 7**REPAIR AND ALTERATIONS OF PRESSURE VESSELS IN LIQUEFIED PETROLEUM GAS SERVICE****S7.1 SCOPE**

This supplement provides requirements and guidelines that apply to the repairs or alterations to pressure vessels designed for storing Liquid Petroleum Gas (LPG) and fabricated in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, or the API-ASME Code for Unfired Pressure Vessels for Petroleum Liquid and Gases. When the standard governing the original construction is not the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 or the API-ASME Code for Unfired Pressure Vessels for Petroleum Liquid and Gases, the requirements of NBIC Part 3, 1.2 b, shall apply. In addition to this supplement, the applicable paragraphs of Part 3 of the NBIC shall be met. Vessels used for anhydrous ammonia service shall not be considered for repair or alteration in accordance with this supplement.

S7.2 GENERAL AND ADMINISTRATIVE REQUIREMENTS

- a) Refer to NBIC Part 3, Section 1 for all applicable post construction activities pertaining to general and administrative requirements.
- b) Repairs or alterations shall conform to the edition of the ASME Code or standard most applicable to the work.

S7.3 WELDING

Refer to NBIC Part 3, Section 2 for all applicable post construction activities pertaining to welding requirements.

S7.4 REQUIREMENTS FOR REPAIRS AND ALTERATIONS

- a) Refer to NBIC Part 3, Section 3 for all applicable post construction activities pertaining to requirements for repairs and alterations.

Excluded is NBIC Part 3, 3.3.4.8 *Repair of Pressure-Retaining Items Without Complete Removal of Defects*.

- b) Radiographic or ultrasonic examinations are considered to be suitable alternative nondestructive examination methods to ensure complete removal of the defect, as described in NBIC Part 3, 3.3.4.1.

S7.5 REQUIREMENTS FOR CHANGE OF SERVICE FROM ABOVE GROUND TO UNDERGROUND SERVICE

ASME LPG storage vessels may be altered from above ground (AG) service to underground (UG) service subject to the conditions of NBIC Part 2, S7.10.

S7.6 EXAMINATION AND TESTING

Refer to NBIC Part 3, Section 4 for all applicable post construction activities pertaining to examination and testing.

S7.7 CERTIFICATION/DOCUMENTATION AND STAMPING

- a) Section 5 of this part is applicable for all post construction activities pertaining to certification/documentation and stamping.
- b) The “R” Certificate Holder shall assure all repairs or alterations involving a change to the following are recorded on the proper NBIC form and marked on the NBIC nameplate or stamping without changing the required format of the NBIC markings.
 - 1) Service for which the container is designed (for example, underground, aboveground, or both).
 - 2) Dip tube length.
 - 3) Maximum filling limit with liquid temperature reference.

S7.8 INSPECTION

Refer to NBIC Part 2, Supplement 7 for all applicable post construction activities pertaining to inspection.

S7.9 COATINGS

When coatings are reapplied, the user should verify the coating is compatible with any coating that remains intact and is suited for the intended service application.

SUPPLEMENT 8**WELD AND POST REPAIR INSPECTION OF CREEP STRENGTH ENHANCED FERRITIC STEEL PRESSURE EQUIPMENT****S8.1 SCOPE**

(23)

- a) The technical information provided in this supplement pertains to weld repair and post repair inspection of creep strength enhanced ferritic steel (CSEF) pressure retaining items. The present guidance covers P-No. 15E, Group 1, Grade 91 and dissimilar welds made to this material (e.g. P-No. 4, P-No. 5A or P-No. 8, P-No. 42, P-No. 43 or P-No. 45). This Supplement provides guidance for full penetration and partial penetration weld repairs not covered under Welding Method 6 (NBIC Part 3, 2.5.3.6) or Welding Method 7 (NBIC Part 3, 2.5.3.7).
- b) Creep Strength Enhanced Ferritic alloys (CSEFs) are a collection of ferritic steels whose creep strength is enhanced by the creation of a precise condition of micro-structure, specifically martensite or bainite, which is stabilized during tempering by controlled precipitation of temper-resistant carbides, carbo-nitrides, or other stable and/or meta-stable phases. Careful consideration shall be given to pressure-retaining items that are fabricated from CSEF steels. The behavior of these materials in low temperature (i.e. fracture toughness and/or fatigue) and in high temperature (i.e. creep and/or creep-fatigue) components can be degraded by not adhering to the welding procedures and/or improper application of post-weld heat treatment (PWHT). Experienced inspection personnel should oversee weld repairs of this nature for strict compliance with all welding procedure and repair requirements.
- c) Post construction access and in-service operation may not allow the practicable application of PWHT following original construction fabrication requirements and repair weld joint design. This supplement provides guidelines for weld repair options and post repair inspection using a well-engineered approach for CSEF steels. The user is cautioned to seek technical guidance for welding and selection of heat treating requirements.
- d) Prior to using this guideline an engineering evaluation shall be performed to determine the scope of the repair and impact to safety prior to returning the pressure-retaining item to service for a specified period of time, based on acceptance by the Inspector, and when required the Jurisdiction. The organization performing the engineering evaluation shall have demonstrated experience with Grade 91 CSEF steels.

S8.2 WELD REPAIR OF GRADE 91 STEEL**S8.2.1 WELD REPAIR OPTIONS**

(23)

- a) 9Cr-1Mo-VNbN Filler Metal (i.e. matching to Grade 91) + Controlled Fill + Low PWHT (Minimum temperature is 1250°F, 675°C). Acceptable filler materials are referenced in Table S8.2.1. The minimum time and maximum heat treatment temperature shall be in accordance with the original code of construction. For reference, where the Ni+Mn content of the filler metal is not known, the maximum PWHT temperature shall be 1425°F (775°C). This maximum shall be enforced to avoid over-tempering or exceeding the absolute maximum PWHT temperature. PWHT hold times at temperature shall be as follows:
 - 1) Minimum holding time at PWHT temperature is specified as 1 hour per 1.0 inch (25 mm) of thickness, 30 minute minimum provided the component < 0.5 inches (12.5 mm) in thickness; and
 - 2) Minimum holding time at PWHT temperature is specified as 5 hours plus 15 minutes for each additional 1.0 inch (25 mm) over 5.0 inches (125 mm).
- b) 9Cr-1Mo Filler Metal + Controlled Fill and No PWHT. Acceptable filler materials are detailed in Table S8.2.1.

- c) Ni-base Filler Metal + Controlled Fill and No PWHT. Acceptable nickel base consumables include selected ASME F No. 43 filler metals as detailed in Table S8.2.1.

TABLE S8.2.1

ALTERNATIVE WELD REPAIR METHODS, FILLER METALS AND WELDING PROCESSES FOR GRADE 91 STEEL.

Acceptable Weld Repair Method		Welding Process and Filler Metal AWS Classification
Filler Metal	Welding Procedure	
Matching (9Cr-1Mo-VNbN)	Controlled Fill + Low PWHT	- SMAW – E9015-B9, E9016-B9, E9018-B9 or E9015-B9¹_A, E9016-B9¹_A or E9018-B9¹_A - FCAW – E91T1-B9 or E91T1-B9¹_A - GTAW – ER90S-B9 or ER90S-B9¹_A
9Cr-1Mo	Controlled Fill	- SMAW – E8015-B8, E8016-B8 or E8018-B8 - FCAW – E81T1-B8 - GTAW – ER80S-B8
Ni-base	Controlled Fill	- SMAW – EPRI P87^B, ENiCrFe-2, ENiCrFe-3 - FCAW – None available - GTAW – EPRI P87^C, ERNiCr-3

^A–B91 AWS classification is pending for the various Grade 91 filler metal product forms (currently –B9)

^BIncorporated by ASME B&PV Code as Code Case 2734 for classification as an F No. 43 filler material

^CIncorporated by ASME B&PV Code as Code Case 2733 for classification as an F No. 43 filler material

(23) S8.2.2 WELD REPAIR OPTIONS FOR DISSIMILAR METAL WELDS

- a) For repairs in P-No. 15E, Group 1, Grade 91, CSEF steel joined to either P-No. 8, P-No. 42, P-No. 43, or P-No. 45, as permitted for welded construction by the applicable rules of the original code of construction, the filler metal shall be limited to an austenitic, nickel-base filler metal having a designation F-No. 43 and limited to the following consumables: ERNiCr-3, ENiCrFe-3, ENiCrFe-2, UNS N08087. This weld repair option does not require PWHT.
- b) For repairs in P-No. 15E, Group 1, Grade 91, CSEF steel joined to P-No. 4, Group 1, or P-No. 5A, Group 1, the filler metal shall be limited to:
- 1) A martensitic, iron-base filler metal having a designation F-No. 4 or F-No. 6 and limited to the following consumables: E8015-B8, E8018-B8 or ER80S-B8. This weld repair option does not require PWHT; Or
 - 2) A martensitic, iron-base filler metal having a designation F-No. 4 or F-No. 6 and limited to the following consumables: E9015-B9, E9016-B9, E9018-B9, E9015-B9¹, E9016-B9¹, E9018-B9¹, E91T1-B9, E91T1-B9¹, ER90S-B9 or ER90S-B9¹. This weld repair option requires PWHT at a minimum temperature of 1250°F (675°C).

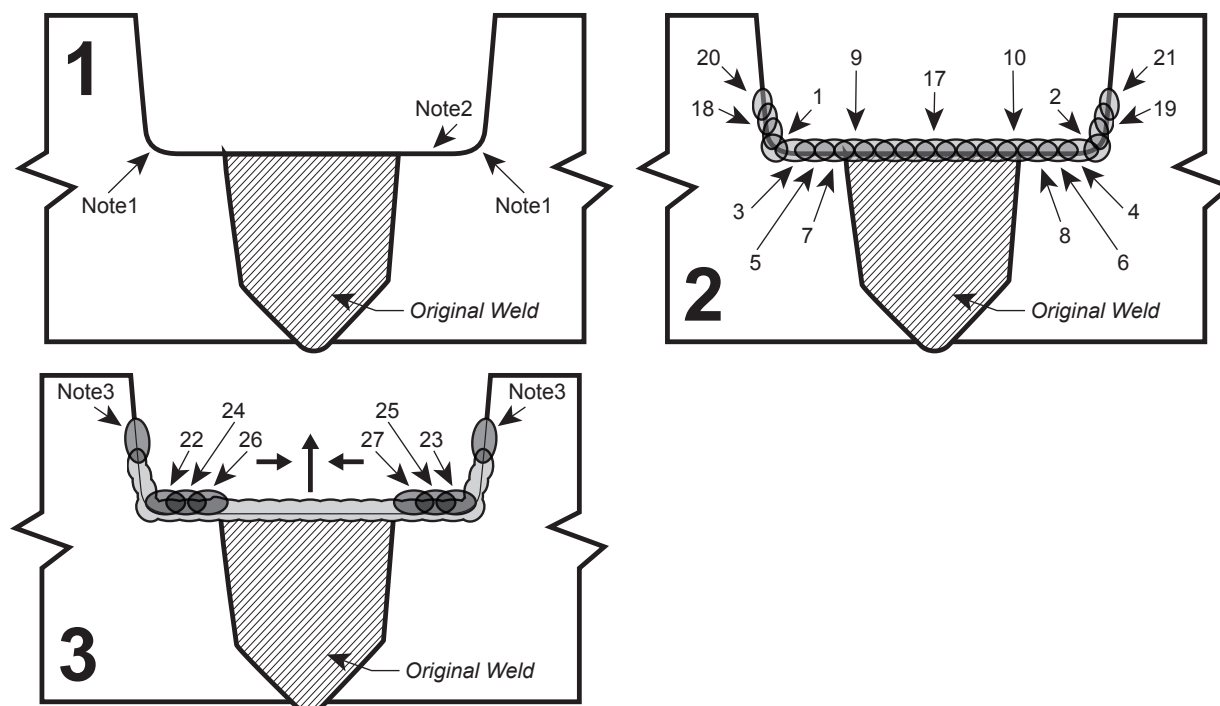
(23) S8.3 APPLICATION OF CONTROLLED FILL WELDING PROCEDURE

- a) The minimum preheat for the repair procedure shall be 300 °F (150 °C). The preheat temperature shall be checked to ensure the minimum preheat temperature is maintained during all welding and until welding is completed. The maximum interpass temperature shall be 550 °F (290 °C). At the completion of welding, a post weld hydrogen bake-out is not required nor prohibited.

- b) To control heat input the weld repair shall be performed using a “controlled fill” technique. In this technique, the first layer in contact with the repair groove can be identical or smaller in diameter than the fill passes.
- c) Figures S8.3-a through S8.3-d illustrate the types of acceptable weld joint details using the controlled fill technique for full or partial penetration weld repairs.
- d) The fill passes should be deposited working from the bevel of the excavation towards the center of the excavation with a minimum overlap of 25% and ideally 50%. As a rule of thumb, if the welder aims for the toe of the previously deposited weld bead, an overlap of at least 40% will be achieved.
- e) When the SMAW process is specified, the weld beads deposited onto the base material shall not exceed an electrode diameter of 1/8 in. (3.2 mm). The remaining fill passes shall not exceed an electrode diameter of 5/32 in. (4.0 mm). When the GTAW process is specified, any limits for filler metal size shall be reflected in the qualified PQR and WPS.

FIGURE S8.3-a.

SCHEMATIC OF THE CONTROLLED FILL WELDING PROCEDURE FOR GRADE 91 STEEL FOR A PARTIAL PENETRATION WELD REPAIR.



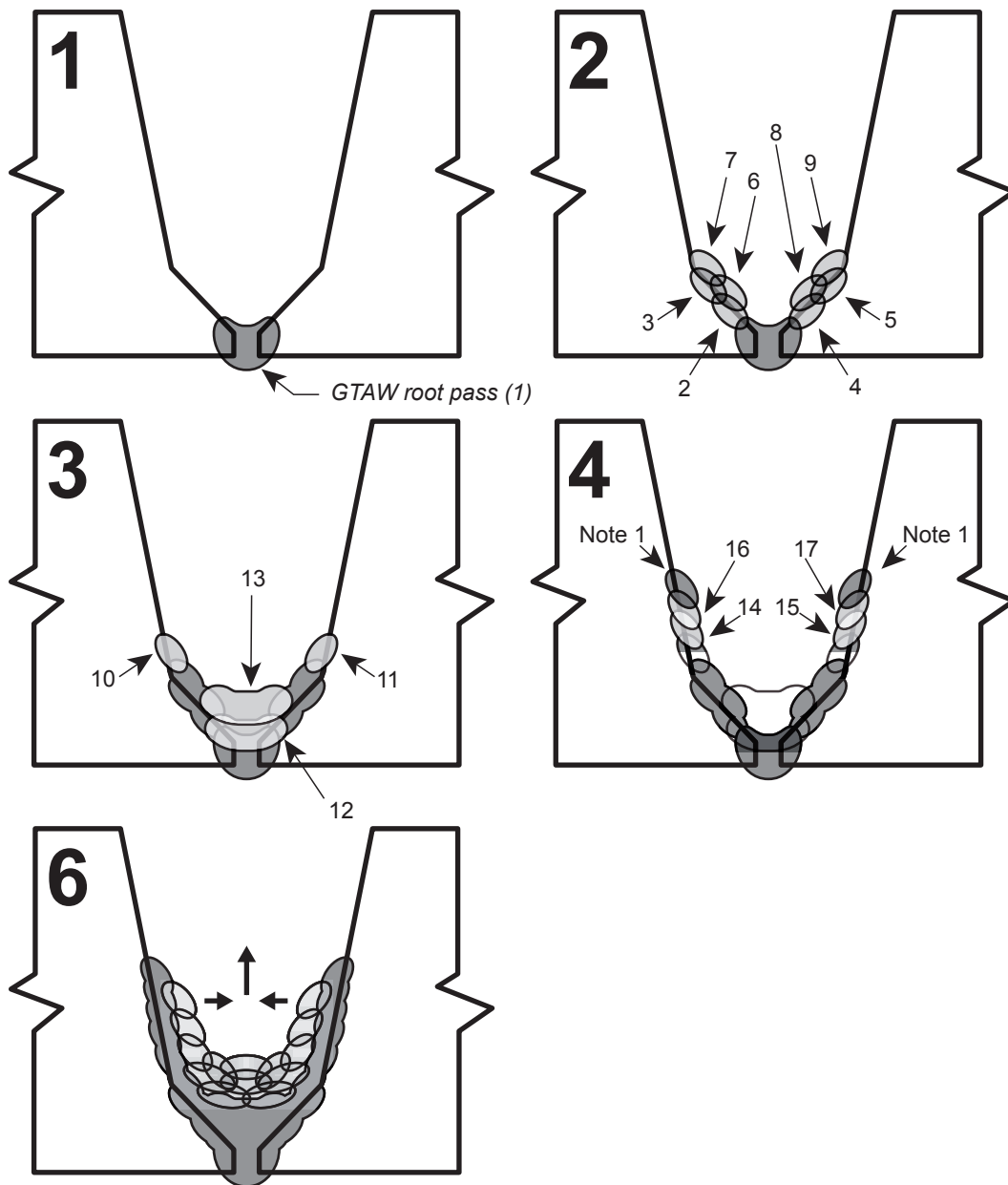
Note 1 – The excavation shall have rounded corners to prevent lack of fusion defects. In these locations it is recommended to use a smaller diameter electrode (such as 3/32 in. (2.4 mm)) to ensure acceptable fusion.

Note 2 – The repair cavity width shall extend at least 0.40 in. (10 mm) beyond the fusion line of the original weld

Note 3 – Where the excavation may pose challenges with electrode access, it is recommended that the fill passes in immediate contact with the machined excavation be restricted in height as the weld repair is performed.

FIGURE S8.3-b.

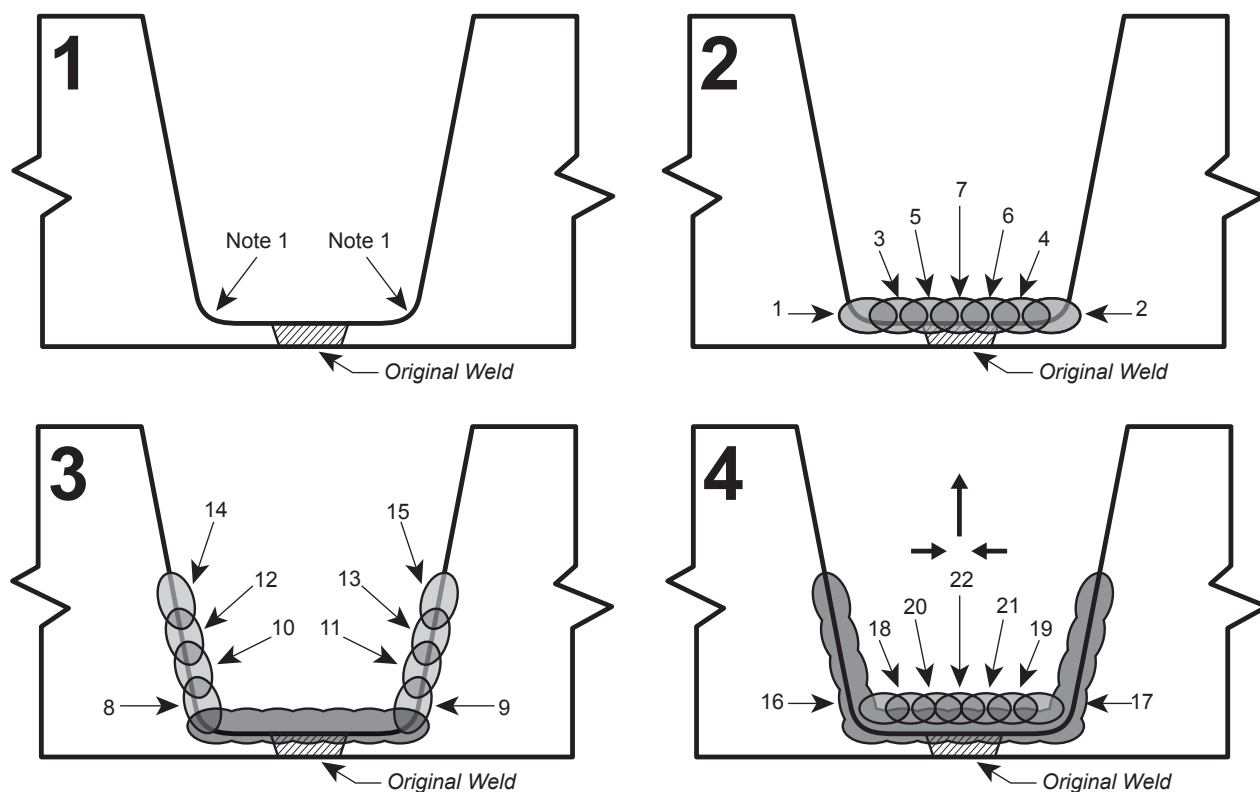
SCHEMATIC OF THE CONTROLLED FILL WELDING PROCEDURE FOR GRADE 91 STEEL FOR A FULL PENETRATION WELD REPAIR USING A COMPOUND BEVEL.



Note 1 – Where the excavation may pose challenges with electrode access, it is recommended that the fill passes in immediate contact with the machined excavation be restricted in height as the weld repair is performed.

FIGURE S8.3-c.

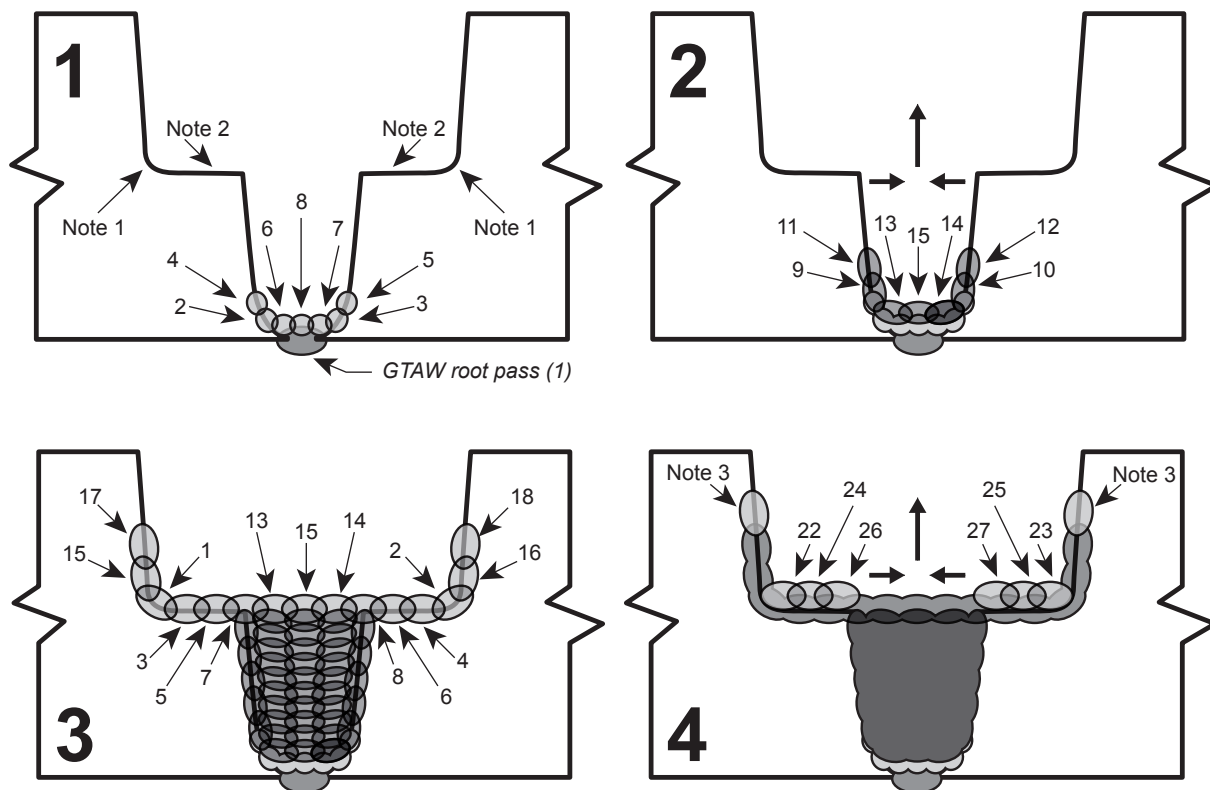
SCHEMATIC OF THE CONTROLLED FILL WELDING PROCEDURE FOR GRADE 91 STEEL FOR FULL PENETRATION WELD REPAIR USING A LAND.



Note 1 – The excavation shall have rounded corners to prevent lack of fusion defects. In these locations it is recommended to use a smaller diameter electrode (such as 3/32 in.(2.4 mm)) to ensure acceptable fusion.

FIGURE S8.3-d.

SCHEMATIC OF THE CONTROLLED FILL WELDING PROCEDURE FOR GRADE 91 STEEL FOR A FULL PENETRATION WELD REPAIR USING A STEP WELD PREPARATION.



Note 1 – The excavation shall have rounded corners to prevent lack of fusion defects. In these locations it is recommended to use a smaller diameter electrode (such as 3/32 in.(2.4 mm)) to ensure acceptable fusion.

Note 2 – The repair cavity width shall extend at least 0.40 in. (10 mm) beyond the fusion line of the original weld

Note 3 – Where the excavation may pose challenges with electrode access, it is recommended that the fill passes in immediate contact with the machined excavation be restricted in height as the weld repair is performed.

(23) **S8.4 QUALIFICATION OF CONTROLLED FILL WELDING PROCEDURE**

- The welding procedure qualification test coupon shall be ASME P-No. 15 E, Group 1, Grade 91 joined to itself, P-No. 4, P-No. 5A, P-No. 8, P-No. 42, P-No. 43, or P-No. 45.
- Qualification thickness for the test plates and repair groove depths shall be in accordance with ASME Section IX.
- The Welding Procedure Specification (WPS) shall be qualified in accordance with requirements of ASME Section IX.
- For qualification of weld repair procedures using 9Cr-1Mo filler metal and in the as-welded condition, the requirements for the bend test shall be performed using a bend radius which achieves a minimum of 14% elongation in the outer fibers.

S8.5 POST REPAIR INSPECTION

- a) After the completion of weld repairs to CSEF steels, post inspection requirements shall be developed and implemented based on acceptance from the Inspector, and if applicable, the Jurisdiction.
- b) Post-repair inspection intervals and methods of examination shall be implemented to ensure safe operation and margin to locate and monitor defect growth in the weld repair area. The selected non-destructive examination method shall provide meaningful results and shall follow NBIC Part 3, Section 4.
- c) Post repair inspection shall be ongoing until the component reaches end of life or is replaced. The Owner/User may revise the re-inspection interval based on inspection results from previous inspections.

SUPPLEMENT 9

REPAIR AND ALTERATION FORMS AND INSTRUCTIONS FOR COMPLETING FORMS

S9.1 SCOPE

- a) This supplement provides requirements and guidelines for completing the following National Board Forms
 - 1) R-1 (**Report of Repair**, form NB-66)
 - 2) R-2 (**Report of Alteration**, form NB-229)
 - 3) R-3 (**Report of Parts Fabricated by Welding**, form NB-230)
 - 4) R-4 (**Report Supplement Sheet**, form NB-231)
 - 5) NR-1 (**Report of Repair/Replacement Activities for Nuclear Facilities**, form NB-81)
 - 6) NVR-1 (**Report of Repair/Replacement Activities for Nuclear Pressure Relief Devices**, form NB-160).
- b) Immediately following each of the forms within this supplement is a guide for completing that form. The forms may be used for documenting specific requirements as indicated on the top of each form. The explanations included in the guides are keyed to the forms in the following manner:
 - 1) Circled numbers on each of the forms refer to the items listed on the applicable guide. The parenthesized numbers in the guides correspond to circled numbers on the forms.
 - 2) Numbers without circles appearing in the guides identify specific line or item numbers of the forms.
- c) When computer generated, the format of the form shall replicate the type and relative location of the information depicted on the applicable form for the specific requirements as indicated on the top of each form. Note that a fillable version of all forms is available on the National Board website.

FIGURE S9.2.2

FORM R-1, PAGE 2 OF 2



THE
NATIONAL BOARD
OF BOILER AND PRESSURE VESSEL INSPECTORS

NB-66, Rev. 16, (02/04/21)

(25)

(Form "R" Registration no.)

(26)

(P.O. no., job no., etc.)

CERTIFICATE OF COMPLIANCE

I, (27), _____, certify that to the best of my knowledge and belief the statements made in this report are correct and that all material, construction, and workmanship on this Repair conforms to the *National Board Inspection Code*. National Board "R" Certificate of Authorization No. (28) _____ Expiration date: (29) _____

Repair Organization: (30) _____

Signed: (31) _____

(authorized representative)

Date: (32) _____

CERTIFICATE OF INSPECTION

I, (33), _____, holding a valid commission issued by The National Board of Boiler and Pressure Vessel Inspectors and certificate of competency, where required, issued by the Jurisdiction of (34) _____ and employed by (35) _____ of (36) _____

have inspected the work described in this report on (37) _____, _____ and state that to the best of my knowledge and belief, this work complies with the applicable requirements of the *National Board Inspection Code*. By signing this certificate, neither the undersigned nor my employer makes any warranty, expressed or implied, concerning the work described in this report. Furthermore, neither the undersigned nor my employer shall be liable in any manner for any personal injury, property damage, or loss of any kind arising from or connected with this inspection.

Commissions: (38) _____
(National Board and Jurisdiction no. including endorsement)

Signed: (39) _____
(Inspector)

Date: (40) _____

TABLE S9.2**GUIDE FOR COMPLETING FORM R-1, REPORT OF REPAIR, NB-66**

Reference to Circled Numbers in the Form	Description
(1)	Initials of the authorized representative of the “R” Certificate Holder.
(2)	Initials of the Inspector reviewing the “R” Certificate Holders work.
(3)	When registering a Form R-1 Report with the National Board, this line is solely designated for a unique sequential number assigned by the “R” Certificate Holder. When the “R” Form is not to be registered, indicate so by “N/A”. As described in NBIC Part 3, 5.6, a log shall be maintained identifying sequentially, any Form “R” registered with the National Board.
(4)	If applicable, document the unique purchase order, job, or tracking number assigned by the organization performing the work.
(5)	The name and address of the National Board “R” Certificate Holder performing the work as it appears on the “ <i>Certificate of Authorization</i> ”.
(6)	Name and address of the owner of the pressure-retaining item.
(7)	Name and address of plant or facility where the pressure-retaining item is installed.
(8)	Description of the pressure-retaining item, such as boiler or pressure vessel, or piping. Include the applicable unit identification.
(9)	Name of the original manufacturer of the pressure-retaining item. If the original manufacturer is unknown, indicate by, “unknown.”
(10)	Document the serial number of the pressure-retaining item if assigned by the original manufacturer. If there is no serial number assigned or is unknown, indicate “unknown.”
(11)	When the pressure-retaining item is registered with the National Board, document the applicable registration number. If the pressure-retaining item is installed in Canada, indicate the Canadian design registration number (CRN), and list the drawing number under “other.” If the item is not registered, indicate, “none.”
(12)	Indicate the jurisdiction number assigned to the pressure retaining item, if available.
(13)	Indicate any other unique identifying nomenclature assigned to the pressure retaining item by the owner or user.
(14)	Identify the year in which fabrication/construction of the pressure retaining item was completed.
(15)	Indicate edition and addenda of the NBIC under which this work is being performed.
(16)	Indicate the name, section, division, edition, and addenda (if applicable) of the original code of construction for the pressure-retaining item.

TABLE S9.2 CONT'D

Reference to Circled Numbers in the Form	Description
(17)	Indicate the name, section, division, edition, and addenda (if applicable) of the construction code used for the work being performed. If code cases are used, they shall be identified in the "Remarks" section.
(18)	Check the repair type performed on the pressure retaining item.
(19)	Provide a detailed summary describing the scope of work that was completed to a pressure retaining item (PRI). The information to be considered when describing the scope of work should include such items as, the nature of the repair (i.e. welding, bonding, cementing), the specific location of the work performed to the PRI, the steps taken to remove a defect or as allowed by 3.3.4.8 to remain in place, the method of repair described as listed in the examples of Part 3, Section 3 or supplemental section if applicable, and the acceptance testing and or examination method used in accordance with the NBIC. When additional space is required to describe the scope of work, a Form R-4 shall be used and attached (check box). If a FITNESS FOR SERVICE Form (NB-403) is part of the Form R-1 repair package, check box and attach the form. Information determined to be of a proprietary nature need not be included, but shall be stated on the form.
(20)	Indicate type of pressure test applied (Liquid, Pneumatic, Vacuum, Leak). If no pressure test applied, indicate "none."
(21)	Indicate test pressure applied.
(22)	Indicate maximum allowable working pressure (MAWP) for the pressure retaining item, if known.
(23)	As applicable, identify what Replacement Parts manufactured by welding or bonding were introduced as needed to complete the scope of work. Indicate part, item number, manufacturer's name, stamped identification, and data report type or Certificate of Compliance.
(24)	Indicate any additional information pertaining to the work involved (e.g., routine repairs, code cases).
(25)	When registering a Form R-1 Report with the National Board, this line is solely designated for a unique sequential number assigned by the "R" Certificate Holder. When the "R" Form is not to be registered, indicate so by "N/A". As described in NBIC Part 3, 5.6, a log shall be maintained identifying sequentially, any Form "R" registered with the National Board.
(26)	If applicable, document the unique purchase order, job, or tracking number assigned by organization performing work.
(27)	Type or print name of authorized representative of the "R" Certificate Holder attesting to accuracy of the work described.
(28)	Indicate National Board "R" <i>Certificate of Authorization</i> number.
(29)	Indicate month, day, and year that the "R" <i>Certificate of Authorization</i> expires.

TABLE S9.2 CONT'D

Reference to Circled Numbers in the Form	Description
(30)	Record name of "R" Certificate Holder who performed the described work, using full name as shown on the <i>Certificate of Authorization</i> or an abbreviation acceptable to the National Board.
(31)	Signature of "R" Certificate Holder authorized representative.
(32)	Enter month, day, and year repair certified.
(33)	Type or print name of Inspector.
(34)	Indicate Inspector's Jurisdiction.
(35)	Indicate Inspector's employer.
(36)	Indicate address of Inspector's employer (city and state or province).
(37)	Indicate month, day, and year of final inspection by Inspector. For routine repairs this shall be the month, day, and year the Inspector reviews the completed routine repair package.
(38)	Inspector's National Board commission number and endorsement that qualifies the Inspector to sign this report, and when required by the Jurisdiction, the applicable State or Provincial numbers.
(38)	Signature of Inspector.
(40)	Indicate month, day, and year of Inspector signature

FIGURE S9.3.2
FORM R-2, PAGE 2 OF 2

 THE NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS	NB-229, Rev. 8, (03/04/21) (24) (Form "R" Registration no.) (25) (P.O. no., job no., etc.)
---	---

8. REPLACEMENT PARTS: (Attached are Manufacturer's Partial Data Reports or Form R-3's properly completed for the following items of this report):

(name of part, item number, data report type or Certificate of Compliance, mfg's. name and identifying stamp)

(26)

9. REMARKS: (27)

DESIGN CERTIFICATION

I, (28), certify that to the best of my knowledge and belief the statements in this report are correct and that the Design Change described in this report conforms to the *National Board Inspection Code*. National Board "R" Certificate of Authorization No. (29) expires on (30)

Date (31), (32) Signed (33)

(name of design organization) (authorized representative)

CERTIFICATE OF DESIGN CHANGE REVIEW

I, (34), holding a valid Commission issued by The National Board of Boiler and Pressure Vessel Inspector and certificate of competency, where required, issued by the jurisdiction of (35) and employed by (36) of (37) have reviewed the design change as described in this report and state that to the best of my knowledge and belief such change complies with the applicable requirements of the *National Board Inspection Code*. By signing this certificate, neither the undersigned nor my employer makes any warranty, expressed or implied, concerning the work described in this report. Furthermore, neither the undersigned nor my employer shall be liable in any manner for any personal injury, property damage or loss of any kind arising from or connected with this inspection.

Date (38) Signed (39) Commissions (40)

(inspector) (National Board and jurisdiction no. including endorsement)

CONSTRUCTION CERTIFICATION

I, (41), certify that to the best of my knowledge and belief the statements in this report are correct and that all material, construction, and workmanship on this Alteration conforms to the *National Board Inspection Code*. National Board "R" Certificate of Authorization No. (42) expires on (43)

Date (44), (45) Signed (46)

(name of alteration organization) (authorized representative)

CERTIFICATE OF INSPECTION

I, (47), holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and certificate of competency, where required, issued by the Jurisdiction of (48) and employed by (49) of (50) have inspected the work described in this report on (51) and state that to the best of my knowledge and belief, this work complies with the applicable requirements of the *National Board Inspection Code*. By signing this certificate, neither the undersigned nor my employer makes any warranty, expressed or implied, concerning the work described in this report. Furthermore, neither the undersigned nor my employer shall be liable in any manner for any personal injury, property damage, or loss of any kind arising from or connected with this inspection.

Date (52) Signed (53) (54)

(inspector) (National Board and jurisdiction no. including endorsement)

This form may be obtained from The National Board of Boiler and Pressure Vessel Inspectors • 1055 Crupper Avenue, Columbus, Ohio 43229-1183

Page 2 of 2

TABLE S9.3

GUIDE FOR COMPLETING FORM R-2, REPORT OF ALTERATION, NB-226

Reference to Circled Numbers in the Form	Description
(1)	Initials of the National Board “R” <i>Certificate of Authorization</i> authorized representative who registers the Form R-2.
(2)	Initials of the Inspector who certified the completed Form R-2 for registration.
(3)	When registering a Form R-2 with the National Board, this line is solely designated for a unique sequential number assigned by the “R” Certificate Holder. As described in NBIC Part 3, Paragraph 5.6, a log shall be maintained identifying unique and sequentially numbered Form “R” reports that are registered with the National Board. For rerating only, the Design Organization registers the Form R-2.
(4)	If applicable, document the unique purchase order, job, or tracking number assigned by the organization performing the work.
(5)	The name and address of the National Board “R” <i>Certificate of Authorization</i> holder performing the design as it appears on the “ <i>Certificate of Authorization</i> ”.
(6)	The name and address of the National Board “R” <i>Certificate of Authorization</i> holder performing the construction activity as it appears on the “ <i>Certificate of Authorization</i> ”.
(7)	Name and address of the owner of the pressure-retaining item.
(8)	Name and address of the plant or facility where the pressure-retaining item is installed.
(9)	Description of the pressure-retaining item, such as boiler or pressure vessel, or piping. Include the applicable unit identification.
(10)	Name of the original manufacturer of the pressure-retaining item. If the original manufacturer is unknown, indicate by, “unknown.”
(11)	Document the serial number of the pressure-retaining item if assigned by the original manufacturer. If there is no serial number assigned or it is unknown, indicate “unknown.”
(12)	When the pressure-retaining item is registered with the National Board, document the applicable registration number. If the pressure-retaining item is installed in Canada, indicate the Canadian design, registration number (CRN), and list the drawing number under “other.” If the item is not registered, indicate, “none.”
(13)	Indicate the jurisdiction number assigned to the pressure retaining item, if available.
(14)	Indicate any other unique identifying nomenclature assigned to the pressure retaining item by the owner or user.
(15)	Identify the year in which fabrication/construction of the pressure retaining item was completed.

TABLE S9.3 CONT'D

Reference to Circled Numbers in the Form	Description
(16)	Indicate edition and addenda of the NBIC under which this work is being performed, as applicable.
(17)	Indicate the name, section, division, edition, and addenda (if applicable) of the original code of construction for the pressure-retaining item.
(18)	Indicate the name, section, division, edition, and addenda (if applicable) of the construction code used for the work being performed. If code cases are used, they shall be identified in the "Remarks" section.
(19)	Provide a detailed summary of the scope of design that was performed. When additional space is required to describe the design scope, a Form R-4 shall be used and attached (check box if needed).
(20)	The information to be considered when describing the construction scope of work should include such items as, the nature of the alteration (i.e. welding, bonding, cementing), the specific location of the work performed to the pressure retaining item, the steps taken to remove a defect or as allowed by NBIC Part 3, Paragraph 3.3.4.8 to remain in place, and the method of alteration described as listed in the examples of NBIC Part 3, Paragraph 3.4.4 or applicable supplement. When additional space is required to describe the construction scope, a Form R-4 shall be used and attached (check box if needed).
(21)	Indicate type of pressure test applied (liquid, pneumatic, vacuum, leak). If no pressure test applied, indicate "none."
(22)	Indicate test pressure applied.
(23)	Indicate maximum allowable working pressure (MAWP) for the pressure retaining item. (As altered)
(24)	When registering a Form R-2 with the National Board, this line is solely designated for a unique sequential number assigned by the "R" Certificate Holder. As described in NBIC Part 3, Paragraph 5.6, a log shall be maintained identifying unique and sequentially numbered Form "R" reports that are registered with the National Board. For rerating only, the Design Organization registers the Form R-2.
(25)	If applicable, document the unique purchase order, job, or tracking number assigned by organization performing work.
(26)	As applicable, identify what parts manufactured by welding or bonding were introduced as needed to complete the scope of work. Indicate part, item number, manufacturer's name, stamped identification, and data report type or Certificate of Compliance.
(27)	Indicate any additional information pertaining to the work involved (e.g. code cases, interpretations used).
(28)	Type or print name of the National Board "R" <i>Certificate of Authorization</i> authorized representative responsible for design certification.

TABLE S9.3 CONT'D

Reference to Circled Numbers in the Form	Description
(29)	Indicate National Board "R" <i>Certificate of Authorization</i> number.
(30)	Indicate month, day, and year that the "R" <i>Certificate of Authorization</i> expires.
(31)	Indicate month, day, and year the alteration was certified.
(32)	Record the name of National Board "R" <i>Certificate of Authorization</i> holder who performed the design portion of the work, using full name as shown on the " <i>Certificate of Authorization</i> " or an abbreviation acceptable to the National Board.
(33)	Signature of National Board "R" <i>Certificate of Authorization</i> authorized representative for the design change.
(34)	Type or print the name of Inspector certifying the design review.
(35)	Indicate Inspector's Jurisdiction.
(36)	Indicate Inspector's employer.
(37)	Indicate address of Inspector's employer (city and state or province).
(38)	Indicate the month, day and year of the design certification by the Inspector.
(39)	Signature of the Inspector certifying the design review.
(40)	Inspectors National Board commission number and endorsement that qualifies the Inspector to sign this report, and when required by the Jurisdiction, the applicable State or Provincial numbers.
(41)	Type or print name of the National Board "R" <i>Certificate of Authorization</i> authorized representative responsible for any construction.
(42)	Indicate the National Board "R" <i>Certificate of Authorization</i> number.
(43)	Indicate month, day, and year the National Board "R" <i>Certificate of Authorization</i> expires.
(44)	Indicate the date the alteration was certified.
(45)	Record the name of National Board "R" <i>Certificate of Authorization</i> holder who performed the construction portion of the described work, using full name as shown on the <i>Certificate of Authorization</i> or an abbreviation acceptable to the National Board.
(46)	Signature of National Board "R" <i>Certificate of Authorization</i> authorized representative.
(47)	Type or print the name of Inspector certifying the construction inspection.
(48)	Indicate the Inspector's Jurisdiction.
(49)	Indicate Inspector's employer.
(50)	Indicate address of Inspector's employer (city and state or province).

TABLE S9.3 CONT'D

Reference to Circled Numbers in the Form	Description
(51)	Indicate the month, day and year of the final inspection by the Inspector.
(52)	Indicate the month, day and year the completed Form R-2 was signed by the Inspector.
(53)	Signature of the Inspector certifying the construction inspection.
(54)	Inspector's National Board commission number and endorsement that qualifies the Inspector to sign this report, and when required by the Jurisdiction, the applicable State or Provincial numbers.

S9.4

FORM R-3, PAGE 1 OF 2

THE NATIONAL BOARD
OF BOILER AND PRESSURE VESSEL INSPECTORS

NB-230, Rev. 4 (12/08/16)

FORM R-3 REPORT OF PARTS FABRICATED BY WELDING

in accordance with provisions of the *National Board Inspection Code*

1
(Authorized Rep. initials)

2
(Inspectors initials)

3
(Form "R-3" Registration no.)

5
(P.O. no., job no., etc.)

1. MANUFACTURED BY: 4
(name of "R" certificate holder)

(address)

2. MANUFACTURED FOR: 6
(name)

(address)

3. DESIGN CONDITION SPECIFIED BY: 7 CODE DESIGN BY: 8

4. DESIGN CODE: 9 10 11 12

5. REPAIR/ALTERATION/MODIFICATION ACTIVITIES

Name of Part	Qty.	Line No.	Manufacturer's Identifying No.	Manufacturer's Drawing No.	MAWP	Shop Hydro PSI	Year Built
13	14	15	16	17	18	19	20

6. DESCRIPTION OF PARTS

	(a) Connections other than tubes			Heads or Ends			(b) Tubes		
Line No.	Size and Shape	Material Spec. No.	Thickness (in.)	Shape	Thickness (in.)	Material Spec. No.	Diameter (in.)	Thickness (in.)	Material Spec. No.
15	21	22	23	24	25	26	27	28	29

7. REMARKS: 30

This form may be obtained from The National Board of Boiler and Pressure Vessel Inspectors • 1055 Crupper Avenue, Columbus, Ohio 43229-1183

Page 1 of 2

FIGURE S9.4.2
FORM R-3, PAGE 2 OF 2

 THE NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS	NB-230, Rev. 4 (12/08/16)
(31) (Form "R-3" Registration no.) (32) (P.O. no., job no., etc.)	
CERTIFICATE OF COMPLIANCE I, (33) _____, certify that to the best of my knowledge and belief the statements made in this report are correct and that all material, fabrication, construction, and workmanship of the described parts conforms to the <i>National Board Inspection Code</i> and the standards of construction cited. National Board "R" Certificate of Authorization No. (34) _____ expires on: (35) _____, _____ Date (36) _____, _____ (37) _____ Signed (38) _____ (name of "R" Certificate holder) (Authorized Representative)	
CERTIFICATE OF INSPECTION I, (39) _____, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and certificate of competency, where required, issued by the Jurisdiction of (40) _____ and employed by (41) _____ of (42) _____ have inspected the part described in this report on (43) _____, _____ and state that to the best of my knowledge and belief the parts comply with the applicable requirements of the <i>National Board Inspection Code</i>. By signing this certificate, neither the undersigned nor my employer makes any warranty, expressed or implied, concerning the work described in this report. Furthermore, neither the undersigned nor my employer shall be liable in any manner for any personal injury, property damage, or loss of any kind arising from or connected with this inspection. Date (44) _____, _____ Signed (45) _____ Commissions (46) _____ (inspector) (National Board and jurisdiction No. including endorsement)	
This form may be obtained from The National Board of Boiler and Pressure Vessel Inspectors • 1055 Crupper Avenue, Columbus, Ohio 43229-1183 Page 2 of 2	

TABLE S9.4

GUIDE FOR COMPLETING FORM R-3, REPORT OF PARTS FABRICATED BY WELDING, NB-230

Reference to Circled Numbers in the Form	Description
(1)	Initials of the National Board "R" <i>Certificate of Authorization</i> authorized representative who registers the Form R-3.
(2)	Initials of the Inspector who certified the completed Form R-3 for registration.
(3)	When registering a Form R-3 Report with the National Board, this line is solely designated for a unique sequential number assigned by the "R" Certificate Holder. When the "R" Form is not to be registered, indicated so by "N/A". As described in NBIC Part 3, Paragraph 5.6, a log shall be maintained identifying unique and sequentially numbered Form "R" reports that are registered with the National Board.
(4)	The name and address of the National Board "R" Certificate Holder who manufactured the welded parts as it appears on the " <i>Certificate of Authorization</i> ."
(5)	If applicable, document the unique purchase order, job, or tracking number assigned by organization performing work.
(6)	Document name and address of organization that purchased the parts for incorporation into the repair or alteration. If the part's origin is unknown or the part was built for stock, so state.
(7)	Document name of organization responsible for specifying the code design conditions, if known. If origin of design conditions are not known, state "unknown."
(8)	Document name of organization responsible for performing the code design, if known. If code design organization is not known, state "unknown."
(9)	Name, section, and division of the design code, if known. If the design is not known, state "unknown."
(10)	Indicate code edition year used for fabrication.
(11)	Indicate code addenda date used for fabrication, if applicable.
(12)	Indicate the code paragraph reference for formula used to establish the MAWP, if known. If the code reference of the formula is not known, state "unknown."
(13)	If available, identify component by part's original name, function, or use the original equipment manufacturer's "mark or item number."
(14)	Indicate quantity of named parts.
(15)	Match line number of part references for Identification of Parts in item 5 and the Description of Parts in item 6.
(16)	Indicate manufacturer's serial number or identification number for the named part.

TABLE S9.4 CONT'D

Reference to Circled Numbers in the Form	Description
(17)	Indicate drawing number for the named part.
(18)	Indicate maximum allowable working pressure (MAWP) for the part, if known.
(19)	Indicate test pressure, if applied.
(20)	Identify the year in which fabrication/construction of the item was completed.
(21)	Use inside diameter for size: indicate shape as square, round, etc.
(22)	Indicate the complete material specification number and grade.
(23)	Indicate nominal thickness of plate and minimum thickness after forming.
(24)	Indicate shape as flat, dished, ellipsoidal, or hemispherical.
(25)	Indicate minimum thickness after forming.
(26)	Indicate the complete material specification number and grade for the head or end.
(27)	Indicate outside diameter.
(28)	Indicate minimum thickness of tubes.
(29)	Indicate the complete material specification number and grade for tubes.
(30)	Indicate any additional information pertaining to the work involved (e.g. code cases). The part manufacturer is to indicate the extent he has performed any or all of the design function. If only a portion of the design, state which portion.
(31)	When registering a Form R-3 Report with the National Board, this line is solely designated for a unique sequential number assigned by the "R" Certificate Holder. When the "R" Form is not to be registered, indicated so by "N/A". As described in NBIC Part 3, Paragraph 5.6, a log shall be maintained identifying unique and sequentially numbered Form "R" reports that are registered with the National Board.
(32)	If applicable, document the unique purchase order, job, or tracking number assigned by organization performing work.
(33)	Type or print name of authorized representative of the "R" Certificate Holder attesting to accuracy of the work described.
(34)	Indicate National Board "R" <i>Certificate of Authorization</i> number.
(35)	Indicate month, day, and year that the "R" <i>Certificate of Authorization</i> expires.
(36)	Indicate the date the repair was certified.
(37)	Record name of "R" Certificate Holder who performed the described work, using full name as shown on the Certificate of Authorization or an abbreviation acceptable to the National Board.

TABLE S9.4 CONT'D

Reference to Circled Numbers in the Form	Description
(38)	Signature of National Board “R” <i>Certificate of Authorization</i> authorized representative.
(39)	Type or print name of Inspector.
(40)	Indicate Inspector’s Jurisdiction.
(41)	Indicate Inspector’s employer.
(42)	Indicate address of Inspector’s employer (city and state or province).
(43)	Indicate month, day, and year of final inspection by Inspector.
(44)	Indicate the month, day and year the completed Form “R” was signed by the Inspector.
(45)	Signature of Inspector.
(46)	Inspector’s National Board commission number and endorsement that qualifies the Inspector to sign this report, and when required by the Jurisdiction, the applicable State or Provincial numbers.

TABLE S9.5

GUIDE FOR COMPLETING FORM R-4, REPORT SUPPLEMENT SHEET, NB-231

Reference to Circled Numbers in the Form	Description
(1)	When registering a Form "R" Report with the National Board, this line is solely designated for a unique sequential number assigned by the "R" Certificate Holder. When the "R" Form is not to be registered, indicate so by "N/A". As described in NBIC Part 3, Paragraph 5.6, a log shall be maintained identifying unique and sequentially numbered Form "R" reports that are registered with the National Board. Complete information identical to that shown on the Form "R" to which this sheet is a supplement.
(2)	If applicable, document the unique purchase order, job, or tracking number, assigned by the organization performing work.
(3)	The name and address of the Certificate Holder performing the work as it appears on the "Certificate of Authorization."
(4)	Name and address of the owner of the pressure-retaining item.
(5)	Name and address of plant or facility where the pressure-retaining item is installed.
(6)	Indicate the Form "R" type to which this report is supplementary. Example: Form R-1, Form R-2, Form R-3
(7)	Indicate the reference line number from the Form "R" to which this report is supplementary.
(8)	Complete information for which there was insufficient space on the reference Form "R".
(9)	Indicate the date certified.
(10)	Signature of the repair organizations authorized representative.
(11)	Record name of "R" Certificate Holder who performed the described work, using full name as shown on the Certificate of Authorization or an abbreviation acceptable to the National Board.
(12)	Indicate the date the form was completed by the Inspector.
(13)	Signature of the Inspector.
(14)	Inspector's National Board commission number and endorsement that qualifies the Inspector to sign this report, and when required by the Jurisdiction, the applicable State or Provincial numbers.

FIGURE S9.6.3
FORM NR-1, PAGE 3 OF 3



NB-81, Rev. 8, (03/04/21)

(NR Form Registration No.)

(R/R Plan No., Job No., etc.)

CERTIFICATE OF COMPLIANCE

I, (26), employed by (27)
certify that to the best of my knowledge and belief the statements made in this report are correct and the repair/replacement activities or re-rating described above conform to (28) and the *National Board Inspection Code "NR"* rules.

National Board *Certificate of Authorization* No. (29) Expiration date: (30)

Signed: (31) Date: (32)

Title: (33)
(authorized representative)

CERTIFICATE OF INSPECTION

I, (34), holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and certificate of competency, where required, issued by the Jurisdiction of (35) and employed by (36) have inspected the repair/replacement and/or re-rating activities described in this report on (37) and state that to the best of my knowledge and belief, these activities have been completed in accordance with the Code specified and the *National Board Inspection Code "NR"* rules.

By signing this certificate, neither the undersigned nor my employer makes any warranty, expressed or implied, concerning the work described in this report. Furthermore, neither the undersigned nor my employer shall be liable in any manner for any personal injury, property damage, or loss of any kind arising from or connected with this inspection.

Signed: (38) Date: (39) Commissions (40)
(inspector) (National Board and endorsement)

TABLE S9.6

GUIDE FOR COMPLETING FORM NR-1, REPORT OF REPAIR/REPLACEMENT ACTIVITIES FOR NUCLEAR FACILITIES, NB-81

Reference to Circled Numbers in the Form	Description
	Title Block: Check type of activity, repair/replacement and/or rerating, as applicable.
	Check category of activity, 1, 2, or 3, as described in Part 3, Paragraph 1.6.2.
(1)	Name and address of the organization, as shown on the National Board "NR" <i>Certificate of Authorization</i> , which performed the activity.
(2)	Indicate NR Form Registration Number.
(3)	Indicate the repair/replacement plan, job number, etc., as applicable, assigned by the organization that performed the work for traceability to documentation.
(4)	Name and address of the owner of the nuclear facility.
(5)	Name and address of the nuclear power plant and, if applicable, identification of the unit.
(6)	Identify the system or component (e.g., residual heat removal, reactor coolant) with which the repair/replacement and/or re-rating activity is associated.
(7)	Identify the original design specification number and revision for the system or component listed in line 4.
(8)	Identify the original construction code, section, edition/addenda and applicable code cases used for the system or component identified in line 4.
(9)	NBIC Edition used for performing activities specified on this form.
(10)	Organization having responsibility for design when there is a change from the original design specification.
(11)	Identify code, section, edition/addenda and applicable code cases used for design, when applicable.
(12)	Check the type of test conducted (e.g., hydrostatic, pneumatic, system leakage, exempt, or other) and indicate the pressure applied when applicable.
(13)	Indicate the number of components where work was performed. Each component shall be indicated on page 2 of the form NR-1.
(14)	Provide a detailed summary describing the scope of work completed. Information to be considered should include type of work (welding, brazing, fusing), location, steps taken for removal or acceptance of defects, examinations, testing, heat treat, and other special processes or methods utilized. If Necessary, attach additional data, sketch, drawing, Form R-4, etc. In the remarks section state if additional data is attached.
(15)	Indicate any additional information pertaining to the work, including manufacturer's data reports.

TABLE S9.6 CONT'D

Reference to Circled Numbers in the Form	Description
(16)	Number in sequence beginning with No. 1 to identify each component work was performed. This number may be used to correspond with the detailed description of work performed.
(17)	Identify the type of item. i.e. piping, pump, valve, etc.
(18)	Identify the manufacturer's name of component.
(19)	Identify the manufacturer's serial no. or other assigned number for traceability.
(20)	Identify the National Board registration number, if previously assigned.
(21)	Identify the code class criteria, as assigned for each component.
(22)	Identify the code section used to perform work.
(23)	Identify Code section year and/or addenda used to perform work.
(24)	Identify any code cases used for work performed.
(25)	Identify any revisions to be made to the design specifications or if any design reconciliations were performed.
(26)	Type or print name of authorized representative from the certificate holder.
(27)	Name of the organization that performed the identified work, using the full name as shown on the Certificate of Authorization, or an abbreviation acceptable to the National Board.
(28)	Indicate code section as applicable to the repair/replacement activity and/or re-rating activity performed.
(29)	Indicate National Board Certificate of Authorization number.
(30)	Indicate month, day, and year the certificate expires.
(31)	Signature of authorized representative from the NR certificate holder.
(32)	Indicate month, day and year of signature by the Authorized Representative.
(33)	Title of authorized representative as defined in the Quality Program.
(34)	Type or print name of Authorized Nuclear Inspector.
(35)	Indicate the Jurisdiction where the activity is performed, when required.
(36)	Indicate Authorized Nuclear Inspector's employer.
(37)	Indicate month, day, and year of inspection by the Authorized Nuclear Inspector.

TABLE S9.6 CONT'D

Reference to Circled Numbers in the Form	Description
(38)	Signature of Authorized Nuclear Inspector.
(39)	Indicate month, day, and year of signature by the Authorized Nuclear Inspector.
(40)	National Board Commission number and required endorsements.

FIGURE S9.7.2
FORM NVR-1, PAGE 2 OF 3



(form "NVR" registration no.)

(R/R Plan No., Job No., etc.)

CERTIFICATE OF COMPLIANCE

I, _____(33)_____, certify that to the best of my knowledge and belief the statements made in this report are correct and the repair/replacement of the pressure relief devices described above conform to _____(34)_____ and the National Board Inspection Code "VR" & "NR" rules.

National Board Certificate of Authorization No. _____ to use the "VR" stamp expires _____

National Board Certificate of Authorization No. _____ to use the "NR" stamp expires _____

Date _____ Signed _____ (authorized representative) _____ (title) _____

CERTIFICATE OF INSPECTION

I, (42), holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and certificate of competency, where required, issued by the Jurisdiction of (43) and employed by (44) of (45) have inspected the repair/replacement described in this report on (46) and state that to the best of my knowledge and belief, this repair/replacement has been completed in accordance with the Code specified and the *National Board Inspection Code "VR" & "NR"* rules.

By signing this certificate, neither the undersigned nor my employer makes any warranty, expressed or implied, concerning the repair/ replacement described in this report. Furthermore, neither the undersigned nor my employer shall be liable in any manner for any personal injury, property damage, or loss of any kind arising from or connected with this inspection.

Signed _____ Date _____

(inspector) (National Board and endorsement)

TABLE S9.7

GUIDE FOR COMPLETING FORM NVR-1, REPORT OF REPAIR/REPLACEMENT ACTIVITIES FOR NUCLEAR PRESSURE RELIEF DEVICES, NB-160

Reference to Circled Numbers in the Form	Description
	Title Block: Check type of activity, repair/replacement and/or rerating, as applicable.
	Check category of activity, 1, 2, or 3, as described in Part 3, Paragraph 1.6.2.
(1)	Name and address of the organization, as shown on the National Board “VR” and “NR” Certificates of Authorization, which performed the activity.
(2)	Indicate NVR Form Registration Number.
(3)	Indicate the repair/replacement plan number, job number, etc., as applicable for traceability, assigned by the organization that performed the work.
(4)	Name and address of the organization for which the work was performed.
(5)	Name and address of the owner nuclear facility.
(6)	Name and address of the nuclear facility and, if applicable, identification of the unit.
(7)	Identify the edition, addenda, and as applicable, code cases of the code used for the inservice inspection activity.
(8)	Identify the edition, addenda, and as applicable, code cases of the code used for the repair/replacement activity.
(9)	Identify the NBIC edition used for the repair/replacement activity.
(10)	Identify the organization responsible for design or design reconciliation, if applicable.
(11)	Indicate the set pressure of the valve.
(12)	Indicate the blowdown, if applicable, as a percentage of set pressure.
(13)	Indicate the location of testing.
(14)	Indicate medium (steam, air, etc.) used for the adjustment of the set pressure and, if applicable, blowdown.
(15)	Provide a detailed summary describing the scope of work completed. Information to be considered should include type of work (welding, brazing, fusing), location, steps taken for removal or acceptance of defects, examinations, testing, heat treat, and other special processes or methods utilized. If Necessary, attach additional data, sketch, drawing, Form R-4, etc. If additional data is attached, so state in the remarks section.
(16)	Indicate any additional information pertaining to the work, such as, additional documentation that is attached to this form to further support item 15.
(17)	Manufacturer’s name of the affected item.

TABLE S9.7 CONT'D

Reference to Circled Numbers in the Form	Description
(18)	Describe the type of pressure relief device (e.g., safety valve, safety relief valve, pressure relief valve).
(19)	Manufacturer's serial number of the affected item.
(20)	National Board number, if applicable, of the affected item.
(21)	Indicate the service as steam, liquid, air/gas, etc.
(22)	Indicate the pressure relief device by inlet size, in inches.
(23)	Indicate the year the affected item was manufactured.
(24)	Indicate the name, section and division of the original construction code for the affected item.
(25)	Indicate the code class for the affected item as applicable, i.e. Class 1, 2 or 3.
(26)	Indicate the construction code edition for the affected item.
(27)	Indicate the construction code addenda, as applicable, for the affected item.
(28)	Indicate any applicable code cases used for manufacturing of the affected item.
(29)	Name of the replacement part.
(30)	Identifying number of the replacement part.
(31)	Number/quantity of each replacement part used.
(32)	Indicate the Serial number or other traceability used by the manufacturer of the replacement part.
(33)	Type or print name of authorized representative from the certificate holder.
(34)	Indicate code as applicable to the repair/replacement activity performed.
(35)	Indicate National Board Certificate of Authorization number, if applicable for the "VR" Stamp.
(36)	Indicate month, day, and year the certificate expires, if applicable for the "VR" Stamp.
(37)	Indicate National Board Certificate of Authorization number, if applicable for the "NR" Stamp.
(38)	Indicate month, day, and year the certificate expires, if applicable for the "NR" Stamp.
(39)	Signature of authorized representative from the certificate holder defined in item 27 above.

TABLE S9.7 CONT'D

Reference to Circled Numbers in the Form	Description
(40)	Indicate month, day, and year of signature by the authorized representative.
(41)	Title of authorized representative as defined in the Quality Program.
(42)	Type or print name of Authorized Nuclear Inspector.
(43)	Indicate the Jurisdiction where the activity is performed, when required.
(44)	Indicate Authorized Nuclear Inspector's employer.
(45)	Indicate address of Authorized Nuclear Inspector's employer (city and state or province).
(46)	Indicate month, day, and year of inspection by the Authorized Nuclear Inspector.
(47)	Signature of Authorized Nuclear Inspector defined in item 42 above.
(48)	Indicate month, day, and year of signature by the Authorized Nuclear Inspector.
(49)	National Board Commission number and required endorsements.

(23) S9.8 CORRECTIONS TO COMPLETED NATIONAL BOARD REPORT FORMS

- a) Corrections to completed National Board Form R Reports shall not be made without acceptance from the Inspector.
- b) Corrected copies of Form R Reports shall be distributed in the same manner as the original, in accordance with NBIC Part 3, and the jurisdiction when applicable.
- c) For Form R Reports previously distributed, the words "Corrected Copy" shall be placed on the top of the first page of the corrected Form R Report. Do not mark "Corrected Copy" on a corrected Form R Report if the original had not been previously distributed.
- d) Methods for correcting Form R Reports:
 - 1) Complete a new, corrected Form R Report with revised certifications. The requirements in NBIC Part 3, 1.3.2 shall apply when completing a Form R Report with revised certifications. A brief description of changes including line number shall be listed in the "Remarks" section of the Form R Report.
 - 2) Correcting by strike-through; Place a single line through the incorrect data and insert the correct data in the appropriate block on the Form R Report. The Certificate Holder and Inspector shall indicate acceptance of the correction(s) by legibly placing their initials and date adjacent to the correction(s).
- e) At the time corrections are made to a Form R Report, if the Inspector or AIA differ from that which is indicated on the original Form R report, a new corrected Form R Report shall be generated. The new

Inspector shall certify the corrected Form R Report. The new Inspector certification on the corrected Form R Report is for documentation purposes only, and not for acceptance of the work performed. The following shall be noted in the "Remarks" section of the corrected Form R Report;

- 1) A brief description of changes including line number.
- 2) The original certifying Inspector's name and National Board commission number, and the name of the original AIA if applicable.
- 3) The statement "Inspector signature for documentation purposes only."

PART 3, SECTION 7

REPAIRS AND ALTERATIONS — NBIC POLICY FOR METRICATION

7.1 GENERAL

This policy provides guidance for the use of US customary units and metric units. Throughout the NBIC, metric units are identified and placed in parentheses after the US customary units referenced in the text and associated tables. For each repair or alteration performed, selection of units shall be based on the units used in the original code of construction. For example, items constructed using US customary units shall be repaired or altered using US customary units. The same example applies to items constructed using metric units. Whichever units are selected, those units are to be used consistently throughout each repair or alteration. Consistent use of units includes all aspects of work required for repairs or alterations (i.e. materials, design, procedures, testing, documentation, stamping, etc.).

7.2 EQUIVALENT RATIONALE

The rationale taken to convert metric units and US customary units involves knowing the difference between a *soft* conversion and a *hard* conversion. A soft conversion is an exact conversion. A hard conversion is simply performing a soft conversion and then rounding off within a range of intended precision. When values specified in the NBIC are intended to be approximate values, a hard conversion is provided. If an exact value is needed to maintain safety or required based on using good engineering judgment, then a soft conversion will be used. In general, approximate accuracy is acceptable for most repairs or alterations performed using the requirements of the NBIC. Therefore, within the NBIC, metric equivalent units are primarily hard conversions.

The following examples are provided for further clarification and understanding of soft conversions versus hard conversions:

Example 1: Using 1 in. = 25.4 mm;
12 in. = 304.8 mm (soft conversion)

Example 2: Using the above conversion, a hard conversion may be 300 mm or 305 mm depending on the degree of precision needed.

7.3 PROCEDURE FOR CONVERSION

The following guidelines shall be used to convert between US customary units and metric units within the text of the NBIC:

- a) All US customary units will be converted using a soft conversion;
- b) Soft conversion calculations will be reviewed for accuracy;
- c) Based on specified value in the NBIC, an appropriate degree of precision shall be identified;
- d) Once the degree of precision is decided, rounding up or down may be applied to each soft conversion in order to obtain a hard conversion; and
- e) Use of hard conversion units shall be used consistently throughout the NBIC wherever soft conversions are not required.

Note:

Care shall be taken to minimize percentage difference between units.

7.4 REFERENCING TABLES

The following tables are provided for guidance and convenience when converting between US customary units and metric units. (See NBIC Part 1, 2, 3, 4, Tables 7.4-a through 7.4-j)

TABLE 7.4-a

SOFT CONVERSION FACTORS (US X FACTOR = METRIC)

US Customary	Metric	Factor
in.	mm	25.4
ft.	m	0.3048
in. ²	mm ²	645.16
ft. ²	m ²	0.09290304
in. ³	mm ³	16,387.064
ft. ³	m ³	0.02831685
US gal.	m ³	0.003785412
US gal.	liters	3.785412
psi	MPa	0.0068948
psi	kPa	6.894757
ft-lb	J	1.355818
°F	°C	5/9 x (°F–32)
R	K	5/9
lbm	kg	0.4535924
lbf	N	4.448222
in.-lb	N-mm	112.98484
ft.-lb	N-m	1.3558181
ksiVin	MPaVm	1.0988434
Btu/hr	W	0.2930711
lb/ft ³	kg/m ³	16.018463
in.-wc	kPa	0.249089

Note:

The actual pressure corresponding to the height of a vertical column of fluid depends on the local gravitational field and the density of the fluid, which in turn depends upon the temperature. This conversion factor is the conventional value adopted by ISO. The conversion assumes a standard gravitational field ($g_n = 9.80665 \text{ N/kg}$) and a density of water equal to $1,000 \text{ kg/m}^3$. 7.4-a through 7.4-j.

Temperature shall be converted to within 1°C as shown in NBIC Part 1, 2, 3, 4, Table 7.4-b.

TABLE 7.4-b
TEMPERATURE EQUIVALENTS

Temperature °F	Temperature °C
60	16
70	21
100	38
120	49
350	177
400	204
450	232
800	427
1,150	621

Fractions of an inch shall be converted according to NBIC Part 1, 2, 3, Table 7.4-c. Even increments of inches are in even multiples of 25 mm. For example, 40 inches is equivalent to 1,000 mm. Intermediate values may be interpolated rather than converting and rounding to the nearest mm.

TABLE 7.4-c
US FRACTIONS/METRIC EQUIVALENTS

Inches	Millimeters
1/32	0.8
3/64	1.2
1/16	1.5
3/32	2.5
1/8	3
5/32	4
3/16	5
7/32	5.5
1/4	6
5/16	8
3/8	10
7/16	11
1/2	13
9/16	14
5/8	16
11/16	17
3/4	19
7/8	22
1	25

For nominal pipe sizes, the following relationships were used as shown in NBIC Parts 1, 2 or 3, Table 7.4-d.

TABLE 7.4-d
PIPE SIZES/EQUIVALENT

US Customary Practice	Metric Practice
NPS 1/8	DN 6
NPS 1/4	DN 8
NPS 3/8	DN 10
NPS 1/2	DN 15
NPS 3/4	DN 20
NPS 1	DN 25
NPS 1-1/4	DN 32
NPS 1-1/2	DN 40
NPS 2	DN 50
NPS 2-1/2	DN 65
NPS 3	DN 80
NPS 3-1/2	DN 90
NPS 4	DN 100
NPS 5	DN 125
NPS 6	DN 150
NPS 8	DN 200
NPS 10	DN 250
NPS 12	DN 300
NPS 14	DN 350
NPS 16	DN 400
NPS 18	DN 450
NPS 20	DN 500
NPS 22	DN 550
NPS 24	DN 600
NPS 26	DN 650
NPS 28	DN 700
NPS 30	DN 750
NPS 32	DN 800
NPS 34	DN 850
NPS 36	DN 900
NPS 38	DN 950
NPS 40	DN 1000
NPS 42	DN 1050
NPS 44	DN 1100
NPS 46	DN 1150
NPS 48	DN 1200
NPS 50	DN 1250
NPS 52	DN 1300
NPS 54	DN 1350
NPS 56	DN 1400
NPS 58	DN 1450
NPS 60	DN 1500

Areas in square inches (in²) were converted to square mm (mm²) and areas in square feet (ft²) were converted to square meters (m²). See examples in NBIC Parts 1, 2 or 3, Tables 7.4-e and 7.4-f.

TABLE 7.4-e

Area (US Customary)	Area (Metric)
3 in ²	650 mm ²
6 in ²	3,900 mm ²
10 in ²	6,500 mm ²

TABLE 7.4-f

Area (US Customary)	Area (Metric)
5 ft ²	0.46 m ²

Volumes in cubic inches (in.³) were converted to cubic mm (mm³) and volumes in cubic feet (ft³) were converted to cubic meters (m³). See examples in NBIC Parts 1, 2 or 3, Tables 7.4-g and 7.4-h.

TABLE 7.4-g

Volume (US Customary)	Volume (Metric)
1 in ³	16,000 mm ³
6 in ³	96,000 mm ³
10 in ³	160,000 mm ³

TABLE 7.4-h

Volume (US Customary)	Volume (Metric)
5 ft ³	0.14 m ³

Although the pressure should always be in MPa for calculations, there are cases where other units are used in the text. For example, kPa is used for small pressures. Also, rounding was to two significant figures. See examples in Table 7.4-i. (Note that 14.7 psi converts to 101 kPa, while 15 psi converts to 100 kPa. While this may seem at first glance to be an anomaly, it is consistent with the rounding philosophy.)

TABLE 7.4-i
PRESSURE/EQUIVALENTS

Pressure (US Customary)	Pressure (Metric)
0.5 psi	3 kPa
2 psi	15 kPa
3 psi	20 kPa
10 psi	70 kPa
15 psi	100 kPa
30 psi	200 kPa
50 psi	350 kPa
100 psi	700 kPa
150 psi	1.03 MPa
200 psi	1.38 MPa
250 psi	1.72 MPa
300 psi	2.10 MPa
350 psi	2.40 MPa
400 psi	2.8 MPa
500 psi	3.45 MPa
600 psi	4.14 MPa
1,200 psi	8.27 MPa
1,500 psi	10.34 MPa

TABLE 7.4-j

Strength (US Customary)	Strength (Metric)
95,000 psi	655 MPa

Material properties that are expressed in psi or ksi (e.g., allowable stress, yield and tensile strength, elastic modulus) were generally converted to MPa to three significant figures. See example in NBIC Parts 1, 2, 3 or 4, Table 7.4-h.

(23) **PART 3, SECTION 8**
REPAIRS AND ALTERATIONS — PREPARATION OF TECHNICAL
INQUIRIES TO THE *NATIONAL BOARD INSPECTION CODE*
COMMITTEE

The process for submitting Interpretation, Code Revision, and Code Addition requests has been moved to the Introduction of this book.

PART 3, SECTION 9

REPAIRS AND ALTERATIONS — GLOSSARY OF TERMS

9.1 DEFINITIONS

For the purpose of applying the rules of the NBIC, the following terms and definitions shall be used herein as applicable to each part:

Additional terms and definitions specific to DOT Transport Tanks are defined in NBIC Part 2, Supplement 6.

Accumulator — A vessel in which the test medium is stored or accumulated prior to its use for testing.

Alteration — A change in the item described on the original Manufacturer's Data Report which affects the pressure containing capability of the pressure-retaining item. (See NBIC Part 3, 3.4.3, *Examples of Alteration*) Nonphysical changes such as an increase in the maximum allowable working pressure (internal or external), increase in design temperature, or a reduction in minimum temperature of a pressure-retaining item shall be considered an alteration.

ANSI — The American National Standards Institute.

Appliance — A piece of equipment that includes all controls, safety devices, piping, fittings, and vessel(s) within a common frame or enclosure that is listed and labeled by a nationally recognized testing agency for its intended use.

ASME — The American Society of Mechanical Engineers.

ASME Code — The American Society of Mechanical Engineers Boiler and Pressure Vessel Code published by that Society, including addenda and Code Cases, approved by the associated ASME Board.

Assembler — An organization who purchases or receives from a manufacturer the necessary component parts of valves and assemblies, adjusts, tests, seals, and ships safety or safety relief valves at a geographical location, and using facilities other than those used by the manufacturer.

Authorized Inspection Agency (AIA)

Inservice: An Authorized Inspection Agency is either:

- a) a Jurisdictional authority as defined in the National Board Constitution; or
- b) an entity that is accredited by the National Board meeting NB-369, *Accreditation of Authorized Inspection Agencies Performing Inservice Inspection Activities*; NB-371, *Accreditation of Owner-User Inspection Organizations (OUIO)*; or NB-390, *Accreditation of Federal Inspection Agencies (FIA)*.

New Construction: An Authorized Inspection Agency is one that is accredited by the National Board meeting the qualification and duties of NB-360, *National Board Acceptance of Authorized Inspection Agencies (AIA) Accredited by the American Society of Mechanical Engineers (ASME)*.

Authorized Nuclear Inspection Agency — An Authorized Inspection Agency meeting the qualification and duties of NB-360, National Board Acceptance of Authorized Inspection Agencies (AIA) Accredited by the American Society of Mechanical Engineers (ASME) and intending to perform nuclear inspection activities and employing Authorized Nuclear Inspectors / Supervisors. The Certificate of Accreditation from ASME must include the performance of inspection activities covering Section III and Section XI of the ASME Boiler and Pressure Vessel Code in accordance with the applicable parts of ASME QAI-1.

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Biomass — Fuels which result from biological sources requiring a relatively short time for replenishment: Wood and bagasse are typical examples.

Biomass Fired Boiler — A boiler which fires biomass as its primary fuel.

Brazing — A group of metal joining processes which produce coalescence of materials by heating them to a suitable temperature, and by using a filler metal having a liquidus above 840°F (450°C) and below the solidus of the base materials. The filler metal is distributed between the closely fitted surfaces of the joint by capillary action.

Boiler — A boiler is a closed vessel in which water or other liquid is heated, steam or vapor generated, steam or vapor is superheated, or any combination thereof, under pressure for use external to itself, by the direct application of energy from the combustion of fuels or from electricity or solar energy. The term boiler also shall include the apparatus used to generate heat and all controls and safety devices associated with such apparatus or the closed vessel.

High-Temperature Water Boiler — A power boiler in which water is heated and operates at a pressure in excess of 160 psig (1.1 MPa) and/or temperature in excess of 250°F (121°C).

Hot-Water Heating Boiler — A hot water boiler installed to operate at pressures not exceeding 160 psig (1,100 kPa) and/or temperatures not exceeding 250°F (121°C), at or near the boiler outlet.

Hot-Water Supply Boiler — A boiler that furnishes hot water to be used externally to itself at a pressure less than or equal to 160 psig (1,100 kPa gage) or a temperature less than or equal to 250°F (120°C) at or near the boiler outlet.

Power Boiler — A boiler in which steam or other vapor is generated at a pressure in excess of 15 psig (100 kPa) for use external to itself. The term power boiler includes fired units for vaporizing liquids other than water, but does not include fired process heaters and systems. (See also High-Temperature Water Boiler).

Steam Heating Boiler — A steam boiler installed to operate at pressures not exceeding 15 psig (100 kPa).

Capacity Certification — The verification by the National Board that a particular valve design or model has successfully completed all capacity testing as required by the ASME Code.

Carbons Recycle — See Flyash Recycle.

CGA — Compressed Gas Association

Changeover Valve — A three-way stop (or diverter) valve with one inlet port and two outlet ports designed to isolate either one of the two outlet ports from the inlet port, but not both simultaneously during any mode of operation.

Chimney or Stack — A device or means for providing the venting or escape of combustion gases from the operating unit.

Confined Space — Work locations considered “confined” because their configurations hinder the activities of employees who must enter, work in and exit them. A confined space has limited or restricted means for entry or exit, and it is not designed for continuous employee occupancy. Confined spaces include, but are not limited to, underground vaults, tanks, storage bins, manholes, pits, silos, process vessels, and pipelines. Regulatory Organizations often use the term “permit-required confined space” (permit space) to describe a confined space that has one or more of the following characteristics: contains or has the potential to contain a hazardous atmosphere; contains a material that has the potential to engulf an entrant; has walls that converge inward or floors that slope downward and taper into a smaller area which could trap or asphyxiate an entrant; or contains any other recognized safety or health hazard, such as unguarded machinery, exposed live wires, or heat stress. Confined space entry requirements may differ in many locations and the Inspector is cautioned of the need to comply with local or site- specific confined space entry requirements.

Conversion

Pressure Relief Devices — The change of a pressure relief valve from one capacity-certified configuration to another by use of manufacturer's instructions.

Units of Measure — Changing the numeric value of a parameter from one system of units to another.

Conveyor System(s) — A fuel transport system utilized on biomass boilers that drops fuel onto a moving belt, bucket elevator, drag link conveyor, or a screw or auger mechanism. (The speed of the conveyor may be varied to meet fuel demand.)

Covered Piping Systems (CPS) — Not to be confused with insulated piping, ASME B31.1 pressure piping systems or other piping systems where safety risks to personnel and equipment may exist during facility operations.

Cryogenic — Products stored at or below -238°F (-150°C)

Demonstration — A program of making evident by illustration, explanation, and completion of tasks documenting evaluation of an applicant's ability to perform code activities, including the adequacy of the applicant's quality program, and by a review of the implementation of that program at the address of record and/or work location.

Dense Phase Pneumatic System(s) — A batch feed transport system used on solid fuel fired boilers for both fuel delivery and/or ash removal. In this system the material to be transported is dropped through a valve in a pressure vessel. When the vessel is filled the valve closes and air at a pressure from 30 to 100 psig (200 to 700 kPa) is admitted and the material leaves the vessel in the form of a "slug". The sequence then repeats.

Dutchman — Generally limited to tube or pipe cross-section replacement. The work necessary to remove a compromised section of material and replace the section with material meeting the service requirements and installation procedures acceptable to the Inspector. Also recognized as piecing.

Emissions — The discharge of various Federal or State defined air pollutants into the surrounding atmosphere during a given time period.

Emissions Control System — An arrangement of devices, usually in series, used to capture various air pollutants and thereby reduce the amount of these materials, or gases, being admitted to the surrounding atmosphere, below Federal or State defined standards.

Examination — In process work denoting the act of performing or completing a task of interrogation of compliance. Visual observations, radiography, liquid penetrant, magnetic particle, and ultrasonic methods are recognized examples of examination techniques.

Existing Material — The actual material of the pressure retaining item at the location where the repair or alteration is to be performed.

Exit — A doorway, hallway, or similar passage that will allow free, normally upright unencumbered egress from an area.

Field — A temporary location, under the control of the Certificate Holder, that is used for repairs and/or alterations to pressure-retaining items at an address different from that shown on the Certificate Holder's *Certificate of Authorization*.

Fluidized Bed — A process in which a bed of granulated particles are maintained in a mobile suspension by an upward flow of air or gas.

Fluidized Bed (Bubbling) — A fluidized bed in which the fluidizing velocity is less than the terminal velocity of individual bed particles where part of the fluidizing gas passes through as bubbles.

Fluidized Bed (Circulating) — A fluidized bed in which the fluidizing velocities exceed the terminal velocity of the individual bed particles.

Flyash — Suspended ash particles carried in the flue gas.

Flyash Collector — A device designed to remove flyash in the dry form from the flue gas.

Flyash Recycle — The reintroduction of flyash/unburned carbon from the flyash collector into the combustion zone, in order to complete the combustion of unburned fuel, thereby improving efficiency.

Forced-Flow Steam Generator — A steam generator with no fixed steamline and waterline.

Fuel Transport Fan — A fan which generates airflow capable of moving fuel particles, in suspension, from a metering device to the combustion zone.

Fusing — The coalescence of two plastic members by the combination of controlled heating and the application of pressure approximately normal to the interface between them.

Grate — The surface on which fuel is supported and burned and through which air is passed for combustion.

Hydrostatic Test — A liquid pressure test which is conducted using water as the test medium.

Inspection — A process of review to ensure engineering design, materials, assembly, examination, and testing requirements have been met and are compliant with the code.

Induced Draft Fan — A fan exhausting hot gases from the heat absorbing equipment.

Inspector — See National Board Commissioned Inspector and National Board Owner-User Commissioned Inspector.

- (23) **Interference Fit** — An interference fit, also known as a press fit or friction fit, is a form of fastening between two tight fitting mating parts that produces a joint which is held together by friction after the parts are pushed together.

Intervening — Coming between or inserted between, as between the test vessel and the valve being tested.

Jurisdiction — A governmental entity with the power, right, or authority to interpret and enforce law, rules, or ordinances pertaining to boilers, pressure vessels, or other pressure-retaining items where the pressure retaining item is installed. It includes National Board member Jurisdictions defined as “Jurisdictional Authorities.” Where there is no National Board Member Jurisdiction, the National Board shall act on behalf of the Jurisdiction.

Jurisdictional Authority — A member of the National Board, as defined in the *National Board Constitution*.

- (23) **Labeled** — Equipment or materials that comply with nationally or internationally recognized standards and are so labeled. The label of a nationally or internationally recognized testing agency that maintains periodic inspection of production of labeled equipment or materials has been applied.

Lean Phase Pneumatic System(s) — A fuel transport system utilized on biomass boilers that drops fuel into a moving airstream, mixes with the air, and travels through a pipe at a velocity in the region of 5,000 ft/min (1,525 m/min). Air pressures are in the region of 25 inches (635 mm) water column.

Lift Assist Device — A device used to apply an auxiliary load to a pressure relief valve stem or spindle, used to determine the valve set pressure as an alternative to a full pressure test.

- (23) **Listed** — Equipment or materials that are included in a list published by a nationally or internationally recognized testing agency that maintains periodic inspection of production of listed equipment or materials. Listing indicates compliance with nationally or internationally recognized standards.

Liquid Pressure Test — A pressure test using water or other incompressible fluid as a test medium.

Manufacturer's Documentation — The documentation that includes technical information and certification required by the original code of construction.

Mechanical Assembly — The work necessary to establish or restore a pressure retaining boundary, under supplementary materials, whereby pressure-retaining capability is established through a mechanical, chemical, or physical interface, as defined under the rules of the NBIC.

Mechanical Repair Method — A method of repair, which restores a pressure retaining boundary to a safe and satisfactory operating condition, where the pressure retaining boundary is established by a method other than welding or brazing, as defined under the rules of the NBIC.

Metering Device — A method of controlling the amount of fuel, or air, flowing into the combustion zone.

"NR" Certificate Holder — An organization in possession of a valid "NR" *Certificate of Authorization* issued by the National Board.

National Board — The National Board of Boiler and Pressure Vessel Inspectors.

National Board Commissioned Inspector — An individual who holds a valid and current National Board Commission.

NBIC — The *National Board Inspection Code* published by The National Board of Boiler and Pressure Vessel Inspectors.

Nuclear Items — Items constructed in accordance with recognized standards to be used in nuclear power plants or fuel processing facilities.

Original Code of Construction — Documents promulgated by recognized national standards writing bodies that contain technical requirements for construction of pressure-retaining items or equivalent to which the pressure-retaining item was certified by the original manufacturer.

Overfire Air — Air admitted to the furnace above the grate surface /fuel bed. Used to complete the combustion of fine particles, in suspension. Also aids in reducing NOx formation.

Owner or User — As referenced in lower case letters means any person, firm, or corporation legally responsible for the safe operation of any pressure-retaining item.

Owner-User Inspection Organization — An owner or user of pressure-retaining items that maintains an established inspection program, whose organization and inspection procedures meet the requirements of the National Board rules and are acceptable to the Jurisdiction or Jurisdictional Authority wherein the owner or user is located.

Owner-User Inspector — An individual who holds a valid and current National Board Owner-User Commission.

Piecing — A repair method used to remove and replace a portion of piping or tubing material with a suitable material and installation procedure.

Pilot Operated Pressure Relief Valve — A pressure relief valve in which the disk is held closed by system pressure, and the holding pressure is controlled by a pilot valve actuated by system pressure.

Plate Heat Exchanger (PHE) — An assembly of components consisting of heat transfer plates and their supporting frame. The frame provides structural support and pressure containment and may consist of fixed endplates, moveable endplates, an upper carrying bar and lower guide bar which provide plate alignment, and frame compression bolts.

Pneumatic Test — A pressure test which uses air or another compressible gas as the test medium.

Potable Water Heaters — A corrosion resistant appliance that includes the controls and safety devices to supply potable hot water at pressure not exceeding 160 psig (1,100 kPa) and temperature not in excess of 210°F (99°C).

Fired Storage Water Heater — A potable water heater in which water is heated by electricity, the combustion of solid, liquid, or gaseous fuels and stores water within the same appliance.

Indirect Fired Water Heater — A potable water heater in which water is heated by an internal coil or heat exchanger that receives its heat from an external source. Indirect fired water heaters provide water directly to the system or store water within the same appliance.

Circulating Water Heater — A potable water heater which furnishes water directly to the system or to a separate storage tank. Circulating water heaters may be either natural or forced flow.

Potable Water Storage Tank — An unfired pressure vessel used to store potable hot water at temperatures not exceeding 210°F (99°C).

(23) **Practicable** — Capable of being accomplished based on technical consideration of the nature and scope of activities, design, or arrangement.

Pressure Relief Device — A device designed to prevent pressure or vacuum from exceeding a predetermined value in a pressure vessel by the transfer of fluid during emergency or abnormal conditions.

Pressure Relief Valve (PRV) — A pressure relief device designed to actuate on inlet static pressure and reclose after normal conditions have been restored.

Pressure Relief Valve Shelf Life — For a pressure relief valve or pilot valve, the length of time for which the device can be stored, after it has been set and tested or repaired, prior to installation, without requiring a retest or reduced service interval.

Pressure-Retaining Items (PRI) — Any boiler, pressure vessel, piping, or material used for the containment of pressure, either internal or external. The pressure may be obtained from an external source, or by the application of heat from a direct source, or any combination thereof.

Pressure roll load — The terms line load, and nip load are used interchangeably to refer to the interaction between the pressure roll(s) and the Yankee dryer. It is called “nip” load because the pressure roll is rubber-covered and is pressed up against the Yankee with enough force to create a nip (or pinch) that forces the paper into line contact between the rolls and provides some mechanical dewatering. The paper then sticks onto the Yankee surface and follows the Yankee dryer for thermal dewatering by the steam-heated Yankee surface. This “nip load” is called a “line load” because the units are load (force) per length of line contact. The units are pounds per linear inch (PLI) and kilonewtons per meter (kN/m).

Pressure Test — A test that is conducted using a fluid (liquid or gas) contained inside a pressure-retaining item.

Pressure Vessel — A pressure vessel is a container other than a boiler or piping used for the containment of pressure.

“R” Certificate Holder — An organization in possession of a valid “R” *Certificate of Authorization* issued by the National Board.

Re-ending — A method used to join original code of construction piping or tubing with replacement piping or tubing material for the purpose of restoring a required dimension, configuration or pressure-retaining capacity.

Regulatory Authority — A government agency, such as the United States Nuclear Regulatory Commission, empowered to issue and enforce regulations concerning the design, construction, and operation of nuclear power plants.

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Relief Valve — A pressure relief valve characterized by gradual opening that is generally proportional to the increase in pressure. It is normally used for incompressible fluids.

Remote Visual Inspection — The examination of a PRI via a camera affixed to a mobile platform not operated by the Inspector, where the Inspector does not have direct line of sight with the area being examined.

Repair — The work necessary to restore pressure-retaining items to a safe and satisfactory operating condition.

Re-rating (re-rate) — See alteration. Re-rate does not apply to pressure relief devices.

Safe Point of Discharge — A location that will not cause property damage, equipment damage, or create a health or safety threat to personnel in the event of discharge.

Safety Relief Valve — A pressure relief valve characterized by rapid opening or by gradual opening that is generally proportional to the increase in pressure. It can be used for compressible or incompressible fluids.

Safety Valve — A pressure relief valve characterized by rapid opening and normally used to relieve compressible fluids.

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Scrapped — Permanent removal from service by owner's or user's procedures.

Seal Weld — Any weld designed primarily to provide a specific degree of tightness against leakage. A seal weld is not intended to provide structural integrity to a pressure retaining item.

Settings — Those components and accessories required to provide support for the component during operation and during any related maintenance activity.

Shop — A permanent location, the address that is shown on the *Certificate of Authorization*, from which a Certificate Holder controls the repair and/or alteration of pressure-retaining items.

Suspension Burner — A combustion system in which the fuel is in the form of relatively small particles, Their buoyancy is maintained in the transport airstream and the fuel/air mixture flow stream, until combustion is completed.

Testing Laboratory — National Board accepted laboratory that performs functional and capacity tests of pressure relief devices.

Thermal Fluid Heater — A thermal fluid heater is a closed vessel in which a fluid other than water is heated by the direct application of heat from a thermal energy source. Depending on the process heating requirements, the fluid may be vaporized with normal circulation but, more often, the fluid is heated and circulated by a pump.

Transient — An occurrence that is maintained only for a short interval as opposed to a steady state condition.

Underfire Air — A method of introducing air beneath the grate surface/fuel bed.

“VR” Certificate Holder — An organization in possession of a valid “VR” *Certificate of Authorization* issued by the National Board.

Velocity Distortion — The pressure decrease that occurs when fluid flows past the opening of a pressure sensing line. This is a distortion of the pressure that would be measured under the same conditions for a non or slowly moving fluid.

Verify — To determine that a particular action has been performed in accordance with the requirements either by witnessing the action or reviewing records.

Volumetric NDE — A method capable of detecting imperfections that may be located anywhere within the examined volume. Volumetric NDE is limited to radiographic (RT) and ultrasonic (UT) examination methods.

Water Head — The pressure adjustment that must be taken into account due to the weight of test media (in this case, water) that is 0.433 psi/ft (10 kPa/m) added (subtracted) from the gage pressure for each foot the gage is below (above) the point at which the pressure is to be measured.

Welding — A group of processes which produce a localized coalescence of metallic or nonmetallic materials by heating the materials to the suitable temperature, with or without the application of pressure, and with or without the use of filler material.

Witness — To be present at an event and have first-hand knowledge of the action and be able to attest that it occurred.

PART 3, SECTION 10

REPAIRS AND ALTERATIONS — NBIC APPROVED INTERPRETATIONS

10.1 SCOPE

- a) This section provides a list of all approved interpretations for previous editions and addenda of the NBIC. A complete list of interpretations including approved interpretations for this edition is provided on the National Board website.
- b) Each interpretation references the edition and addenda applicable to the committee response and approval. Use of interpretations, for other than the approved edition and addenda, may not be appropriate for reference.
- c) Technical inquiries (also known as “request for interpretation”) may be submitted to the NBIC committee to clarify the meaning or intent of existing rules to the NBIC. The requirements for submitting technical inquiries are described in NBIC Parts 1, 2, and 3 (Section 8), Preparation of Technical Inquiries to the NBIC Committee.

2021 INTERPRETATIONS

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Interpretation	Edition	Part	Section	Subject
21-16	2021	3	1.3.2	Jurisdictional requirements not meeting NBIC requirements
21-15	2021	3	5.7.1	Stamping Requirements for Repairs and Alterations
21-14	2021	3	3.4.3	Encapsulation of Shells and Heads
21-13	2021	3	3.3.4.8	Repair of pressure-retaining items without complete removal of defect
21-12	2021	3	3.2.2 b) and e)	Overlaid Replacement Parts
21-11	2021	3	3.3.3 h)	Mechanical Replacement of Shell or Head
21-10	2021	1	1.6.3	Boiler Room Exit
21-09	2021	3	3.3.2 e) 1)	Routine Repairs
21-08	2021	3	3.3.2 e)	Routine Repair Scope
21-07	2021	3	3.3.3 s) and 3.4.4 d)	Repairs and Alterations of Tube Bundles
21-06	2021	2	2.3.6.2 b) 4)	Air Receiver Tank Manual Drain Valve
21-05	2021	3	3.3.5 and 3.4.5	ASME Section VIII, Div. 1 Design Personnel Requirements and NBIC Repairs/Alterations
21-04	2021	3	1.3.1	Repair or Alteration Activity Allowed Prior to Certification
21-03	2021	3	4.2	NDE Requirements When Repairing Minor Defect on Pressure Vessel with RT4 Marking
21-02	2021	3	1.5.1 and 3.3.3 c)	Subcontracted Weld-Overlay Repair
21-01	2021	3	3.3.6	Repair and Alterations of Impact Tested Vessels

(23) 2019 INTERPRETATIONS

Interpretation	Edition	Part	Section	Subject
19-26	2019	1	S3.1	Scope of Installation of Liquid Carbon Dioxide Storage Vessel
19-25	2019	3	3.3.3 and 3.4.4	Examples of Repairs and Alterations
19-24	2019	3	5.7.5	Stamping Requirements for Small Parts
19-23	2019	3	3.3.2 e) 1	Mechanical Replacement of Valves, Fittings, Tubes, and/or Pipes
19-23	2019	3	3.3.2 e) 1)	Mechanical replacement of valves, fittings, tubes, and/or pipes
19-22	2019	3	3.3.2 e)	Repair of a Stiffening Ring
19-21	2019	3	1.4.1	Accreditation Process/Certification of Scope
19-20	2019	3	4.4.1 & 4.4.2	Liquid Pressure Test Examination Methods Applicable to Alterations
19-19	2019	3	1.3.2	Authorization of Repair/Alteration Activities
19-18	2019	3	3.3.2 e)	Addition of Non-Load Bearing Attachments
19-17	2019	3	3.3.3	Scope of Repairs
19-16	2019	3	4.4.2 c)	Alternative Method in lieu of Pressure Testing or Examination
19-15	2019	3	3.4.4	PV Cycles of operations change as an alteration
19-14	2019	3	3.4.5.1 b)	Alteration of ASME Section VIII Div.2 vessels
19-13	2019	3	4.4.1 e)	Nondestructive Examination
19-12	2019	3	3.3.3 & 3.3.4.3	Weld build of wasted areas with different material
19-11	2019	3	3.2.2, 3.3.3, & 5.12.4.1	Mechanical Installation of Replacement Parts in ASME Section VIII Division 3 Pressure Vessels
19-10	2019	3	2.2.6 & S6.9.6	Continuity of qualified personnel
19-09	2019	3	Table 2.3	Acceptance of latest AWS SWPS for use in the 2019 NBIC
19-08	2019	3	3.3.2	Routine Repairs for ASME B31.3 Normal Fluid Service and Severe Cyclic piping
19-07	2019	3	5.6	Form Registration Log
19-06	2019	3	2.2 & 2.2.1	National Certified Pipe Welding Bureau (NCPWB) welding procedure specifications
19-05	2019	3	1.5.1 d) 1)	Clarification of Part 3, 1.5.1 d) 1)
19-04	2019	3	2.5.3.6	Welding Method 6 on Grade 92 steel
19-03	2019	3	1.6.6.2 m), 1.6.7.2 m), & 1.6.8.2 m)	ISO/IEC 17025 edition reference in NBIC Part 3, 1.6.6.2, 1.6.7.2, and 1.6.8.2
19-02	2019	3	3.3.4.3-a	Wastage/Wasted Areas
19-01	2019	3	3.3.2	"R" Certificate Holder manufacturing parts and subassemblies

2017 INTERPRETATIONS

Interpretation	Edition	Part	Section	Subject
17-22	2017	3	3.3.2, 3.3.5	Repair of Section VIII Div. 2 and Div. 3 Pressure Vessels
17-21	2017	3	3.3.2 e)	Determining the Pressure Used for Hydrostatic Test
17-20	2017	3	3 4.4.2 c)	NDE methods in lieu of a hydrostatic test
17-19	2017	All Parts	8.1 b)	Interpretations issued to earlier NBIC editions
17-18	2017	3	3.2.6	Reference to Other Codes and Standards
17-17	2017	3	3.3.5, 3.4.5	Repair and alteration of Section VIII Division 2 items
17-16	2017	3	3.4.1	Certifying engineer of UDS for re-rating of pressure vessel
17-15	2017	3	2.5.3.2, 2.5.3.3, 2.5.3.4	Alternative Welding Methods
17-14	2017	1, 4	Part 1, 2.9.6 h) and Part 4, 2.2.10 h)	Plugging a Valve Casing Drain
17-13	2017	3	2.5.3 e)	Alternative NDE methods acceptable to the Inspector and the Jurisdiction
17-12	2017	3	3.3.4	Reducing a pressure vessel's overall shell length
17-11	2017	3	2.5.3.6 e)	Changing of Welding Consumables
17-10	2017	3	3.4.5	ASME Section VIII, Division 2, Class 1 Vessels.
17-09	2017	3	2.5.2	Post-Weld Heat Treatment of full penetration groove weld
17-08	2017	3	3.3.5.2.a and 3.4.5.1.a	Repair/Alteration Plans for ASME VIII, Division 2, Class 1 Pressure Vessels
17-07	2017	3	2.5.3	Omission of PWHT by an R Certificate holder
17-06	2017	3	2.5.3.6	Part 3, Section 2.5.3.6, Welding Method 6
17-05	2017	3	3	Repairs to a Pressure Retaining Part
17-04	2017	2	All	Evaluation of existing equipment with minimal documentation
17-03	2017	3	3, Figure 3.3.4.3- b and 3, 3.3.2(e)(5)	Adding Handhole Ring on Pressure Side of Pressure Retaining Item
17-02	2017	3	1.5.1	Continuity Records Retention
17-01	2017	3	All	Application of Term "Practicable"

2015 INTERPRETATIONS

Interpretation	Edition	Part	Section	Subject
15-15	2015	1	2.10, 3.10	Installation Pressure Test
15-14	2017	3	1.5.1	Continuity Records Retention
15-13	2015	3	5.7.2	Routine Repair Stamping Requirements
15-12	2015t	3	3.3.2	Surface Repair of Corrugating Rolls
15-11	2013	3	3	Repair/Replacement of Bolting Material
15-10	2017	3	All	Application of Term "Practicable"

2015 INTERPRETATIONS

Interpretation	Edition	Part	Section	Subject
15-09	2015	3	3	Use of Backing Strips to Install Flush Patches
15-08	2015	3	5.7	Alteration to One Side of Shell/Tube Heat Exchanger
15-07	2015	3	3.4.3	Local Stress from Bracket Loading
15-06	2015	3	3.4.3	Change in Boiler Heat Input from HRSG
15-05	2015	3	1.3.2 c)	Verification of Installation of Repair Nameplate
15-04	2015	3	3	Explosive Weld Plugs Tube Repair
15-03	2015	3	3.2.6	Fillet Welded Patches
15-02	2015	3	5.12.2	Valve Repair Nameplate Field Labels
15-01	2015	1	3.3.4	Boiler Clearance Less than Recommended

2013 INTERPRETATIONS

Interpretation	Edition	Part	Section	Subject
13-11	2013	3	3	Repair/Replacement of Bolting Material
13-10	2013	3	3	Use of Backing Strips to Install Flush Patches
13-09	2013	3	4	Penetrant Examination in Lieu of Hydrostatic Test
13-08	2013	3	1.6.1	Quality Control System Responsibilities
13-07	2013	3	3.2	Weld Buildup of Wasted Areas
13-06	2013	3	2.5.2	Postweld Heat Treatment Requirements
13-05	2013	1	3.8.2.3	Operating Limit Control Location on Hot Water Supply Boilers
13-04	2013	3	3.3.2 e)	Seal Welding of Inspection Opening Covers
13-03	2011	3	3.3.2 d) 1)	Standard Threaded Fitting Welded through ASME VIII, Div. 1 Vessel
13-02	2011	3	5.7.5	Stamping Requirements for Alterations
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04-21	2004	2005	RC-1130	Inspector Involvement in NDE in Lieu of Pressure Test
04-20	2004	2005	RC-2051(d) & RC-3031(b)	Pneumatic Test in Lieu of Liquid Pressure Test
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01-34	2001	2002	RD-1040(i)(6)	Shielding Gas Dewpoint Temperature
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PART 3, SECTION 11

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Authorized Nuclear Inservice Inspector (ANII)

(1.6.9)

Authorized Nuclear Inspection Agency (ANIA)

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Authorized Nuclear Inspector Supervisor (ANIS)

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Authorized Nuclear Inspector (ANI)

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(5.12.5.1), (5.12.6.1), (S2.4), (S2.13.9.5), (S4.6),
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(4.4), (4.4.1), (4.4.2), (5.12.4.1), (5.12.5.1),
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(3.3.4.3), (S2.13.14.2), (S2.13.14.4)

Hardness

(2.5.3.2), (2.5.3.3), (2.5.3.4), (2.5.3.5), (3.2.1), (S4.12), (S4.18.2.1), (S4.18.2.2), (S4.18.2.4)

Heated Band (HB)

(2.5.2)

Heat Treatment

(1.5.1), (1.6.7.2), (2.1), (2.5.2), (2.5.3), (2.5.3.1), (2.5.3.2), (2.5.3.6), (3.2.1), (3.2.2), (3.3.2), (3.3.4.3), (S1.2.10), (S1.2.11.2), (S2.10), (S2.13), (S2.13.9.2), (S2.13.9.3), (S6.8.1), (S6.10.2), (S6.10.3)

Hold Time

(4.4.1), (4.4.2), (S4.15), (S4.17.6), (S6.18.1)

Hot Tapping

(2.5.3)

Hydrogen

(2.5.3), (2.5.3.1), (2.5.3.2), (2.5.3.4), (2.5.3.5), (2.5.3.6), (S1.1.3), (S2.7), (S6.9), (S6.10.3)

Hydrophilic Solvent

(S3.5.1), (S3.5.3.1)

Hydrostatic Test

(5.12.5.1), (5.12.6.1), (S2.13.8), (S6.8.1), (9.1)

I**Identification Mark**

(1.6.6.2), (1.6.7.2), (1.6.8.2), (2.2.5), (3.2.2), (S4.10.4), (5.12.5.1), (S6.6), (S6.9.5)

Impervious

(S3.5.1), (S3.5.3)

Impregnated

(S3.1), (S3.2), (S3.5.4), (S3.5.6), (S3.5.6.1)

Inspection

(Foreword), (Introduction), (1.3), (1.3.2), (1.4.2), (1.5.1), (1.6.1), (1.6.3), (1.6.6.2), (1.6.7.2), (1.6.8.2), (3.2.2), (3.3.4.3), (3.3.4.8), (3.4.1), (3.4.2), (5.3.), (5.4), (5.12.1), (5.12.2), (5.12.4.1), (5.12.5), (5.12.5.1), (5.12.6), (5.12.6.1), (S1.2.11.4), (S1.2.12.2), (S2.1), (S2.3), (S2.8), (S2.13.3), (S2.13.10.4), (S2.13.14.1), (S3.2), (S3.4), (S4.2), (S4.9), (S4.12), (S4.14), (S4.17.5), (S4.17.6), (S5.1), (S5.6.1), (S6.6), (S6.8.1), (S6.8), (S6.8.1), (S6.12), (S6.14), (S7.7), (S8.5)

Inquiries

(Foreword)

Install/Installation

(1.2), (1.6.2), (1.6.6.2), (1.6.7.2), (2.5.3), (3.2.1), (3.3.3), (3.3.4.1), (3.3.4.2), (3.3.4.6), (3.3.4.8), (3.4.1), (S1.2.1), (S1.2.2), (S1.2.3), (S1.2.5), (S1.2.6), (S1.2.6.1), (S1.2.6.2), (S1.2.6.3), (S1.2.9.2), (S1.2.9.4), (S1.2.10), (S1.2.11.1), (S1.2.11.4), (S1.2.11.6), (S1.2.12.1), (S1.2.12.2), (S2.13.1), (S2.13.2), (S2.13.4), (S2.13.5), (S2.13.8), (S2.13.9.1), (S2.13.9.2), (S2.13.9.4), (S2.13.10.3), (S2.13.10.4), (S2.13.11.1), (S2.13.11.2), (S2.13.14.2), (S3.2), (S3.3), (S3.5.1), (S3.5.3.1), (S4.7), (S4.17.5), (S4.17.6), (S4.18.2.5), (S5.6.3), (S6.5)

Insulation

(2.5.2), (3.4.1), (4.4), (S8.3)

Internal

(3.2.2), (3.3.4.3), (3.4.4), (S3.2), (S3.5.4), (S4.9), (S4.17.5), (S4.18.2.3), (S4.18.2.5), (S5.5), (S6.6), (S6.8.1)

Interpretations

(Introduction), (10.1)

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(4.4.1), (S4.2)

Jurisdiction

(Foreword), (Introduction), (1.2), (1.3), (1.3.1), (1.4.1), (1.6.4), (1.6.7.2), (1.6.8.1), (1.6.9), (2.5.3), (3.2.4), (3.2.7), (3.3.2), (3.3.3), (3.3.4.2), (3.3.4.3), (3.3.4.8), (3.3.4.9), (3.3.5.2), (3.4.1), (3.4.5.1), (4.2), (4.4.1), (5.2), (5.5), (5.7.2), (5.8.1), (5.11), (5.12.4.1), (5.12.5.1), (5.12.6.1), (S1.1.1), (S2.8), (S4.6), (S4.16.3), (S4.17.2), (S4.17.3), (S4.17.4), (9.1)

Jurisdictional Authority

(Foreword), (1.6.7.2), (S4.15), (S4.17.6)

Jurisdictional Requirements

(1.4), (1.5.1), (1.6.5), (1.6.6.2), (2.5.2), (3.3.4.1), (3.3.4.2), (3.3.4.4), (3.3.4.8), (3.4.1), (3.4.2), (4.2), (4.4), (4.4.1), (4.4.2), (5.3), (5.4), (5.5), (5.7.2), (5.8.1), (5.11), (5.12.4.1), (5.12.6.1), (S1.1.2), (S1.1.3), (S1.2.10), (S2.2), (S2.3), (S2.5), (S2.6), (S2.7), (S2.7.2), (S3.2), (S4.7), (S4.16.3), (S4.16.4), (S4.17.5)

K**Knuckles**

(3.3.4.2), (S1.2.9.4), (S1.2.11.2), (S1.2.11.5), (S2.13.10.3), (S2.13.10.4), (S2.13.11.1), (S2.13.11.2), (S2.13.11.3), (3.2.6), (3.3.2)

L**Laminate**

(3.3.4.2), (S4.10.1), (S4.10.2), (S4.10.5), (S4.18.1), (4.18.2.1), (S4.18.2.2), (S4.18.2.3), (S4.18.2.4), (S4.18.2.7), (S4.18.2.8)

Lap Joints

(3.3.4.2), (3.3.4.4), (S2.13.9.2)

Leakage

(5.12.5.1), (S1.2.5.1), (S2.13), (S3.5.4), (S4.15), (S4.17.6), (S4.18.2.7)

Leak Testing

(4.4.1), (S3.5.4)

Ligaments

(S1.2.11.6), (S2.13.12.2), (S3.5.4)

Linings

(3.3.3), (S6.12)

Liquefied Petroleum Gas

(S7.1), (S7.5)

Liquid Penetrant Examination

(2.5.3), (3.3.4.1), (3.3.4.2), (3.3.4.3), (S1.2.10), (S2.13), (S5.6.2)

Liquid Pressure Test

(4.4.1), (4.4.2), (S6.18.1)

Liquid Temperature

(4.4.1), (4.4.2)

Loading

(1.2), (S1.2.3), (S1.2.5), (S4.17.6), (S5.6.1), (S5.6.4)

Local Post Weld Heat Treatment (PWHT)

(2.5.2), (2.5.3.6), (S6.10.2)

Local Thinning

(S5.6.1), (S5.6.4)

Location

(1.4.1), (1.4.2), (1.6.2), (1.6.4), (1.6.6.2), (1.6.7.2), (2.5.3), (2.5.3.6), (3.3.4.9), (3.4.1), (5.8.2), (5.9), (5.11), (5.12.4.1), (5.12.5.1), (5.12.6.1), (S4.17.5), (S5.6.1), (S5.6.2)

Locomotive Boilers**Arch Tube**

(S1.1.3.1), (S1.2.9), (S1.2.9.2), (S1.2.9.3), (S1.2.9.5), (S1.2.9.7)

Ferrules

(S1.2.9.7)

Flue

(S1.1.3.1), (S1.2.9), (S1.2.9.1), (S1.2.9.6), (S1.2.9.7), (S1.2.9.8), (S1.2.11.6), (S1.2.13.1)

Inspection

(S1.2.11.4), (S1.2.12.2)

Installation

(S1.2.1), (S1.2.2), (S1.2.3), (S1.2.5), (S1.2.6), (S1.2.6.1), (S1.2.6.2), (S1.2.6.3), (S1.2.9.2), (S1.2.9.4), (S1.2.9.6), (S1.2.9.7), (S1.2.10), (S1.2.11.1), (S1.2.11.2), (S1.2.11.4), (S1.2.11.6), (S1.2.12.1), (S1.2.12.2)

Minimum Wall Thickness

(S1.2.9), (S1.2.9.2), (S1.2.9.3), (S2.13.7)

Riveted Patches

(S1.2.10)

Riveted Seam(S1.2.10), (S1.2.11.1), (S1.2.11.2),
(S1.2.12.1)**M****Magnetic Particle Examination**(2.5.3), (3.3.4.1), (3.3.4.2), (3.3.4.3), (S1.2.10),
(S2.13), (S5.6.2)**Manual Control**

(1.5.1), (1.6.2)

Material Inlay

(3.5.1), (3.5.3)

**Maximum Allowable Working Pressure
(MAWP)**(2.5.3), (3.4.1), (3.4.4), (4.4.1), (4.4.2), (5.12.4.1),
(S1.2.9), (S2.13.7), (S2.13.8), (S3.4), (S4.5),
(S4.15), (S4.17.5), (S4.17.6), (S6.18.1)**Mechanical Assembly**

(1.4.1), (1.5.1), (9.1)

Mechanical Repair Method

(3.3.4.2), (S2.13.2), (9.1)

Metallographic Examination

(S5.2), (S5.6.2)

Metrication Policy

(Introduction), (7.1), (7.2), (7.3), (7.4)

Minimum Thickness

(3.3.4.5), (3.4.2), (5.13.4.1)

Modifications (DOT)(S6.1), (S6.3), (S6.4), (S6.5), (S6.7), (S6.8),
(S6.8.1), (S6.10.3), (S6.11), (S6.14), (S6.15),
(S6.16.1), (S6.17.1), (S6.17.3), (S6.17.4), (S6.17.5),
(S6.18), (S6.18.3), (S6.19), (S6.20), (S6.20.1),
(S6.20.2), (S6.20.3)**Mudring**

(S1.2.11.3), (S1.2.11.4), (S2.13.10.4)

N**“NR” Accreditation**(Introduction), (1.1), 1.6(1.6), (1.6.6.2), (1.6.7.2),
(1.6.8.2), (5.13.5.1)**“NR” Certificate Holder**(1.6.1), (1.6.2), (1.6.3), (1.6.4), (1.6.5), (1.6.6.2),
(1.6.7.2), (1.6.8.1), (1.6.8.2), (1.6.9), (5.12.5),
(5.12.5.1), (5.12.6), (S9.1)**“NR” Symbol Stamp**

(1.6.1), (5.5.4), (5.7.5), (S9.3)

“NV” Stamped Pressure Relief Devices

(S9.3)

Nameplates(1.2), (1.6.9), (5.2.2), (5.7.1), (5.7.2), (5.7.3), (5.7.5),
(5.8), (5.8.1), (5.8.2), (5.10), (5.11), (S3.2), (S3.4),
(S5.5), (S5.7.2), (S6.8.1), (S6.15), (S6.15.1), (S7.6)**NBIC Committee**

(Foreword), (Introduction), (1.2), (1.4.1)

Neutralized

(S3.5.1)

Nonconforming Items

(1.5.1), (1.6.6.2), (1.6.7.2), (S4.2)

Nondestructive Examination(Introduction), (1.5.1), (1.6.7.2), (2.5.3), (3.3.2),
(3.3.4.1), (3.3.4.2), (3.3.4.3), (3.3.4.4), (3.3.4.6),
(4.2), (4.4.1), (4.4.2), (S1.2.10), (S1.2.11.4),
(S1.2.11.5), (S1.2.11.6), (S2.8), (S2.11), (S2.13),
(S2.13.9.2), (S2.13.9.4), (S2.13.10.4), (S2.13.11.2),
(S3.2), (S4.2), (S4.12), (S4.14), (S5.4), (S5.6.2),
(S6.8.1), (S6.11), (S6.18.1), (S7.4)**Non-Load Bearing**

(S3.3), (S4.16.4)

Notch Toughness(2.5.3.1), (2.5.3.2), (2.5.3.3), (2.5.3.4), (2.5.3.5),
(3.4.1), (4.4.1), (4.4.2), (S5.6.1)**Nuclear Items**

(1.1), (1.6.1), (1.6.9), (5.13.5)

Nuclear Valves

(5.7.5), (5.12.6)

O**Operating Parameters (Yankee Dryers)**

(S5.6.1), (S5.6.2)

Orifices

(S8.4)

Overheating

(3.3.4.2)

Overlay

(3.2.1), (3.3.2), (3.3.3), (3.3.4.3), (S4.18.2.4), (S4.18.2.5)

Owner

(1.4.1), (1.6.3), (1.6.6.1), (1.6.6.2), (1.6.7.1), (1.6.7.2), (1.6.8.1), (1.6.9), (1.6.8.2), (3.3.4.3), (3.3.4.9), (4.4.1), (4.4.2), (5.3), (5.12.4.1), (5.12.5.1), (5.12.6.1), (S2.3), (S2.12), (S3.2), (S4.15), (S4.17.6), (S4.18.2.1), (S6.16.3), (S6.18.1), (S6.20)

Owner-User

(Introduction), (5.4), (S1.1.1), (S5.5), (S6.20)

Owner-User Inspection Organization

(Introduction), (1.3), (3.3.5.2), (3.4.4.1)

P**Partial Penetration Weld**

(2.5.2), (S1.2.9.2)

Patch Bolts

(S1.2.6.1), (S1.2.8), (S2.13.6)

Patches

(3.3.3), (3.3.4.1), (3.3.4.2), (3.3.4.3), (3.3.4.6), (S1.2.1), (S1.2.6.1), (S1.2.8), (S1.2.10), (S1.2.11.1), (S1.2.11.2), (S1.2.11.3), (S1.2.11.4), (S1.2.11.5), (S1.2.11.6), (S2.13), (S2.13.1), (S2.13.6), (S2.13.9.1), (S2.13.9.2), (S2.13.9.3), (S2.13.9.4), (S2.13.10.3), (S2.13.10.4), (S2.13.11.1), (S2.13.11.2), (S2.13.11.3), (S2.13.12.2), (S2.13.12.3), (S2.13.14.1), (S2.13.14.2), (S2.13.14.3), (S4.18.2.1), (S4.18.2.2), (S4.18.2.4)

Performance Qualification

(2.2.3), (2.2.4), (2.2.6), (2.4), (2.5.3), (S4.10.2), (S4.10.5), (S6.9.3), (S6.9.4), (S6.9.6)

Personnel Safety

(Foreword), (Introduction), (S2.3), (7.2)

Piecing

(3.3.4.5)

Pipe/Piping

(1.2), (1.6.7.2), (2.3), (2.5.2), (2.5.3), (3.2.2), (3.2.6), (3.3.2), (3.3.4.5), (5.12.4.1), (5.12.5.1), (5.12.6.1), (S1.1.3.1), (S1.2.13.1), (S2.7.1), (S2.13.14.1), (S6.6), (7.4)

Pit

(3.3.4.2), (S1.2.11.4), (S2.13.10.4), (S4.12)

Plug

(S1.1.3.1), (S1.2.12.2), (S2.7.1), (S2.13.14.3), (S3.3), (S3.3.4.9), (S3.5.2.3), (S3.5.2.4), (S3.5.3), (S3.5.3.1), (S3.5.3.2), (S3.5.4), (S5.5), (S5.6.3), (S5.6.4)

Plug Stitching

(S3.5.2.3), (S3.5.3), (S3.5.3.1), (S3.5.3.2)

Pneumatic Testing

(4.4.1), (4.4.2), (5.12.5.1), (5.12.6.1), (S4.15), (S4.17.6), (S6.8.1), (S6.18.1), (9.1)

Portable Tank (DOT)

(S6.20)

Postweld Heat Treatment

(1.5.1), (2.5.2), (2.5.3), (2.5.3.1), (2.5.3.6), (3.2.1), (3.3.2), (3.3.4.3), (S1.2.10), (S1.2.11.2), (S2.10), (S2.13), (S2.13.9.2), (2.13.9.3), (S6.10.2), (S6.10.3), (S8.2)

Precision Bores

(S4.18.2), (S4.18.2.2)

Preheating

(2.5.1), (2.5.3), (2.5.3.1), (2.5.3.2), (2.5.3.3), (2.5.3.4), (2.5.3.6), (3.2.1), (S1.2.10), (S2.10), (S2.13), (S2.13.9.2), (S6.10.1)

Preparation of Forms

(5.2.1), (5.2.2), (S6.19)

Pressure Control

(S8.3)

Pressure Gages

(4.3), (S4.13.1), (S6.13)

Pressure Relief Devices

(Organization), (Foreword), (1.1), (1.6.2), (1.6.9), (4.4.1), (4.4.2), (5.12.6), (5.12.6.1), (S4.15), (S4.17.6), (S6.18.1)

Pressure-Retaining

(Foreword), (Introduction), (1.1), (1.2), (1.3), (1.3.1), (1.4), (1.4.1), (1.5.1), (2.1), (2.2), (2.5.2), (2.5.3), (2.5.3.2), (2.5.3.4), (2.5.3.5), (3.1), (3.2.1), (3.2.6), (3.2.7), (3.3.1), (3.3.2), (3.3.3), (3.3.4.3), (3.3.4.8), (3.4.1), (3.4.2), (3.4.4), (4.1), (4.2), (4.4), (4.4.1), (4.4.2), (5.1), (5.2.1), (5.2.2), (5.4), (5.5.2), (5.7.1), (5.7.2), (5.7.3), (5.7.5), (5.8.1), (5.9), (5.12.4.1),

(S1.1.3), (S1.1.3.1), (S2.7), (S2.7.1), (S2.13),
(S3.2), (S3.3), (S4.1), (S4.7), (S4.10), (S4.12),
(S4.15), (S4.16.1), (S4.16.3), (S4.16.4), (S4.17.1),
(S4.17.3), (S4.17.5), (S4.18.2.6), (S5.3), (S5.3.1),
(S5.4), (S5.5), (S5.6.1), (S5.6.2), (S5.7.1), (S5.7.2),
(S6.15), (S6.17.1), (S6.17.3), (S6.17.5), (S6.18),
(S6.18.1), (S7.4)

Pressure Testing

Alterations

(1.3.2), (3.4.1), (3.4.2), (4.4.2), (S3.4),
(S4.17.6), (S5.7.3), (S6.8.1)

FRP Vessels

(S4.13), (S4.15), (S4.18.2.4), (S4.18.2.5)

Parts

(4.5.4)

Repairs

(1.3.2), (3.2.2), (4.4.1), (S2.8), (S3.2),
(S3.5.4), (S4.13), (S4.15), (S4.18.2.4),
(S4.18.2.5), (S6.8.1), (S6.18.1)

Pressure Vessels

(Foreword), (2.5.3), (2.5.3.2), (2.5.3.4), (3.3.3),
(3.3.5), (3.3.5.1), (3.3.5.2), (3.4.4), (3.4.5), (3.4.5.1),
(5.2.2), (5.12.4.1), (S3.2), (S4.6), (S4.16.3),
(S4.17.3), (S4.17.4), (S4.17.5), (S6.9), (S6.11),
(S7.1), (9.1)

Plastic

(1.5.1), (5.7.5), (5.12.4.1), (S4.1), (S4.2), (S4.17.5),
(S4.18.2), (S4.18.2.7)

Procedure Qualification

(2.2.2), (2.2.4), (2.5.3.2), (2.5.3.3), (2.5.3.4),
(2.5.3.6), (S3.2), (S4.10.1), (S4.10.3), (S6.9.2),
(S6.9.4), (S8.4)

Provisions for Expansion/Support

(S1.2.3), (S1.2.5), (S1.2.6.3), (S1.2.10), (S2.13)

Q

Qualifications

Engineer

(3.3.5.2), (3.4.5.1), (S4.6), (S4.16.3),
(S4.17.3), (S4.17.4)

FRP Performance

(S4.10.2)

Inspector

(S4.2)

Lift Assist

(4.5.3)

NDE

(1.6.6.2), (1.6.7.2), (S2.11), (4.2), (S4.12),
(S6.11)

Secondary Bond

(S4.10.2), (S4.10.3), (S4.10.5)

Welding

(1.5.1), (2.2.2), (2.2.3), (2.2.4), (2.2.6),
(2.2.6.1), (2.4), (2.5.3), (2.5.3.2), (2.5.3.3),
(2.5.3.4), (2.5.3.5), (2.5.3.6), (S2.9),
(S6.9.3), (S6.9.4), (S6.9.6)

Quality Records

(1.6.7.2)

Quality Systems

(Introduction), (1.4.1), (1.4.2), (1.5), (1.5.1),
(1.6.7.2), (2.2.6.1), (3.3.2), (4.2), (5.2), (5.5.2),
(S3.5.4), (S4.16.4), (S6.11)

R

“R” Certificate Holder

(1.2), (1.3.1), (1.5.1), (2.2.2), (2.2.4), (2.2.5),
(2.2.6.1), (3.2.1), (3.2.2), (3.2.4), (3.3.2), (3.3.4.9),
(3.4.1), (3.4.2), (3.4.3), (3.4.5.1), (4.2), (4.4), (5.2),
(5.2.1), (5.2.2), (5.4), (5.5), (5.6), (5.7.1), (5.7.3),
(5.12.4.1), (S1.1.1), (S3.2), (S4.2), (S4.7), (S7.6)

“R” Symbol Stamp

(1.4.1), (1.4.2), (1.5.1), (3.2.2), (3.3.4.8), (5.5.3),
(5.5.5), (5.7.5), (5.10), (S2.6), (S3.2), (S3.4), (S4.9),
(S4.14.3)

Radiography

(1.6.6.2), (1.6.7.2), (2.5.3), (S1.2.9.4), (S1.2.9.5),
(S1.2.10), (S1.2.11.2), (S1.2.11.5), (S2.13.9.2),
(S2.13.9.3), (S2.13.10.3), (S2.13.11.2), (S2.13.11.3),
(S2.13.14.1), (S5.6.2), (S7.4)

Records Review

(3.4.1), (S2.12), (S3.2), (S3.3), (S4.10.3), (S4.17.5),
(S6.5), (S7.4)

Re-Ending

(3.3.4.5), (S1.2.9.1), (S2.13.7)

Reference to Other Codes and Standards

(1.2), (3.2.6), (S4.7), (S6.3), (S6.10.3)

Registration of “R” Forms

(5.5), (5.5.1), (5.5.2), (5.6), (5.12.1), (5.12.2), (S6.4),
(S6.19.2)

Removal of Stamping

(5.11)

Reinforced Thermoplastic

(S4.2), (S4.18.2), (S4.18.2.7)

Reinforced Thermosetting Plastic

(1.6.1), (S4.1)

Renewal

(1.4.1), (1.6.3), (1.6.5)

Repair Guide

(S3.5), (S5.4)

Repair Organization

(Introduction), (1.1), (1.3.1), (1.5.1), (1.6.6), (2.3), (S1.1.3), (S2.7), (S2.8), (S2.9), (S3.2), (S3.5.1), (S6.8.1), (S6.20), (S6.20.1)

Replacement Parts

(1.6.6.2), (1.6.7.2), (1.6.8.2), (1.6.9), (3.1), (3.2.2), (3.3.2), (3.3.3), (3.3.4.9), (3.4.4), (4.4), (4.4.1), (4.4.2), (5.12.1), (5.12.2), (5.12.5), (5.12.5.1), (5.12.6), (5.12.6.1), (S1.2.4), (S1.2.9.3), (S1.2.12.1), (S2.7.2), (S2.13.3), (S2.13.5), (S2.13.9.5), (S2.13.14.4), (S3.2), (S3.3), (S3.5.4), (S4.9), (S4.15), (S4.17.6), (S5.3.1), (S5.7.2), (S6.6), (S6.18)

Replacement Stamping

(5.11)

Replacement Valves

(3.3.2), (5.7.5)

Report Forms

(1.3.2), (1.5.1), (S4.14), (5.12.1), (5.12.2), 5.12.3(5.12.3), (5.12.4), (5.12.5), (5.13.6)

Request

(Foreword), (Introduction), (1.4.1), (1.6.4), (1.6.7.2)

Re-rating

(3.4.1), (3.4.2), (5.2.2), (5.4), (5.7.1), (5.7.3), (5.7.5), (5.12.4.1), (S2.13.9.5), (S4.5), (S4.6), (S4.17.5), (S6.15)

Re-Rolling

(S1.2.9.6)

Resin

(S3.1), (S3.5.4), (S4.6), (S4.8), (S4.11), (S4.12), (S4.18.2.1), (S4.18.2.2)

Responsibility

(Foreword), (Introduction), (1.5.1), (1.6.5), (1.6.6.2), (1.6.7.2), (1.6.8.2), (2.3), (5.2.1), (5.2.2), (5.3), (5.4), (5.7.3), (S3.2), (S6.20)

Return of Stamp

(1.4.2)

Review

(1.4.1), (1.5), (1.6.4), (1.6.5), (1.6.6.2), (1.6.7.2), (1.6.8.2), (1.6.9), (3.2.5), (3.2.6), (3.3.4.8), (3.3.4.9), (3.3.5.2), (3.4.1), (3.4.5.1), (5.2.2), (5.12.4.1), (S3.2), (S3.3), (S4.14), (S4.16.3), (S4.17.3), (S4.17.4), (S4.18.2.3), (S4.18.2.6), (S5.4), (S5.7.2), (7.3)

Revisions

(Foreword), (Introduction), (1.5.1), (1.6.6.2), (1.6.7.2), (1.6.8.2), (2.3), (3.4.5.1), (5.12.5.1), (S4.6)

Risk-Based Inspection

(Introduction), (3.3.4.8)

Rivets/Riveted Joints

(3.3.3), (3.3.4.2), (3.3.4.4), (3.3.4.6), (S1.1.3), (S1.1.3.1), (S1.1.4), (S1.2.2), (S1.2.6), (S1.2.6.1), (S1.2.6.2), (S1.2.6.3), (S1.2.8), (S1.2.10), (S1.2.11.1), (S1.2.11.2), (S1.2.11.3), (S1.2.11.5), (S1.2.12.1), (S2.1), (S2.7.1), (S2.13), (S2.13.2), (S2.13.9.1), (S2.13.9.2), (S2.13.9.3), (S2.13.9.4), (S2.13.10.1), (S2.13.10.3), (S2.13.10.4), (S2.13.11.3), (S2.13.12.3), (S2.13.13.1), (S2.13.13.2), (S2.13.13.3), (S2.13.13.4), (S2.13.13.5), (S2.13.14.1)

Routine Repairs

(1.3.1), (3.3.2), (4.4.1), (5.7.2), (5.8.1), (5.12.4.1), (S3.3), (S4.16.3), (S4.16.4)

S**Safety**

(Foreword), (Introduction), (3.3.4.8), (S2.3), (7.2)

Scale and Sludge

(2.5.3.2), (2.5.3.3), (2.5.3.4)

Scope of Activities (Accreditation)

(Introduction), (1.4.1)

Seal Welding

(3.3.3), (3.3.4.4), (S1.2.3), (S1.2.4), (S1.2.7), (S1.2.8), (S1.2.9.2), (S1.2.9.6), (S1.2.9.7), (S1.2.9.8), (S1.2.12.1), (S1.2.12.2), (S2.13.3), (S2.13.5), (S2.13.6), (S2.13.8), (S2.13.13.5), (S2.13.14.1)

Seams

(3.3.3), (3.3.4.6), (S1.2.10), (S1.2.11.1), (S1.2.11.2), (S1.2.11.5), (S1.2.12.1), (S2.13), (S2.13.9.2), (S2.13.9.3), (S2.13.9.4), (S2.13.10.3), (S2.13.11.3), (S2.13.13.1), (S2.13.13.5), (S4.18.2.8)

Secondary Bonding

(S4.2), (S4.4.), (S4.8), (S4.9), (S4.10), (S4.10.1), (S4.10.2), (S4.10.3), (S4.10.4), (S4.10.5), (S4.12), (S4.14), (S4.17.6), (S4.18.2.1), (S4.18.2.2), (S4.18.2.4)

Service Conditions

(1.2), (2.5.3), (3.3.4.8), (3.4.1), (3.4.2), (S3.2), (S4.17.5)

Set Pressure

(4.4.1), (4.4.2), (5.7.5), (5.12.6), (5.12.6.1), (S4.15), (S4.17.6), (S6.18.1)

Shipping and Transporting

(1.6.6.2), (1.6.7.2), (1.6.8.2), (S6.10.3)

Shop

(1.4.1), (S1.1.4), (S3.2), (S3.5.1), (S4.9), (S6.6), (9.1)

Siphon (Thermic)

(S1.2.9), (S1.2.9.4)

Sleeve

(S1.1.3.1), (S1.2.3), (S1.2.5), (S3.5.4)

Soak Band (SB)

(2.5.2)

Specifications

(1.2), (1.5.1), (1.6.6.2), (1.6.7.2), (2.2.1), (2.2.2), (2.2.3), (2.2.6), (2.2.6.1), (2.3), (2.4), (2.5.1), (2.5.3.1), (2.5.3.2), (2.5.3.3), (2.5.3.4), (2.5.3.6), (3.2.1), (3.2.4), (3.3.4.2), (3.3.5.2), (3.4.5.1), (4.4.1), (4.4.2), (5.12.4.1), (5.12.5.1), (S1.1.3.1), (S2.7.1), (S2.9), (S2.10), (S3.2), (S3.3), (S4.2), (S4.7), (S4.10.1), (S4.10.5), (S4.16.3), (S4.17.2), (S4.17.3), (S4.18.2.2), (S4.18.2.4), (S4.18.2.7), (S4.18.2.8), (S5.4), (S5.6.3), (S6.3), (S6.5), (S6.6), (S6.9.1), (S6.9.2), (S6.9.3), (S6.9.6), (S6.10.1), (S6.10.3)

Stamping

(Introduction), (1.6.6.2), (1.6.9), (3.3.2), (5.1), (5.7.1), (5.7.2), (5.7.3), (5.7.4), (5.7.5), (5.8), (5.8.1), (5.8.2), (5.9), (5.10), (5.11), (S3.2), (S3.4), (S4.14.1), (S4.16.4), (S5.5), (S6.9.5), (S6.15), (S6.15.1), (S7.6), (7.1)

Standard Welding Procedures

(1.5.1), (2.2.2), (2.2.3), (2.3), (S2.9), (S6.9.2), (S6.9.3)

Stays/Staybolts

(3.3.4.2), (3.3.4.3), (3.3.4.6), (3.3.4.7), (S1.1.3.1), (S1.2.1), (S1.2.2), (S1.2.3), (S1.2.4), (S1.2.5), (S1.2.5.1), (S1.2.6), (S1.2.6.1), (S1.2.6.2), (S1.2.6.3), (S1.2.10), (S1.2.11.1), (S1.2.11.2), (S1.2.11.3), (S1.2.11.5), (S2.7.1), (S2.13.1), (S2.13.2), (S2.13.3), (S2.13.4), (S2.13.9.5), (S2.13.10.1), (S2.13.10.2), (S2.13.10.3), (S2.13.10.4), (S2.13.11.3), (S2.13.12.2), (S2.13.12.3), (S2.13.13.2), (S2.13.14.1), (S5.3.1)

Stayed Surfaces

(S1.2.11.2), (S2.13.10.3)

Storage Methods

(S2.1)

Stress Corrosion Cracking (SCC)

(2.5.3)

Structural Attachments

(S4.6), (S4.13)

Structural Steel

(S6.12)

Superheaters

(S1.1.3.1)

Superimposed Back Pressure (BP)

(5.12.2)

Supports

(Introduction), (1.6.6.2), (3.3.3), (5.7.5), (S1.2.8), (S4.18.2.5)

Surface Preparation

(3.2.1), (S4.8), (S4.18.2.1), (S4.18.2.2), (S4.18.2.3), (S4.18.2.4), (S4.18.2.5), (S4.18.2.6), (S4.18.2.7), (S4.18.2.8), (S7.12)

Surfaces (FRP)

(S4.6), (S4.12), (S4.18.2.1), (S4.18.2.2), (S4.18.2.3), (S4.18.2.4), (S4.18.2.5), (S4.18.2.6), (S4.18.2.7), (S4.18.2.8)

T**Telltale Holes**

(S1.2.2), (S1.2.5), (S1.2.6.1), (S1.2.6.3), (S2.13.4)

Temper Bead

(2.5.3), (2.5.3.2), (2.5.3.3), (2.5.3.4), (2.5.3.5),
(S2.10)

Test Only

(5.12.4)

Testing

(Introduction), (1.6.6.2), (1.6.7.2), (1.6.8.2), (2.2.3),
(2.5.3.1), (2.5.3.2), (2.5.3.3), (2.5.3.4), (2.5.3.5),
(2.5.3.6), (3.2.1), (3.3.4.2), (3.4.1), (3.4.2), (4.1),
(4.2), (4.3), (4.4), (4.4.1), (4.4.2), (1.8), 1.6(5.12.4.1),
(5.12.5.1), (5.12.6.1), (S2.8), (S3.5.4), (S4.3),
(S4.15), (S4.17.6), (S5.2), (S5.6.2), (S6.9.3),
(S6.11), (S6.18.1), (S7.5), (S8.4), (7.1)

Thermic Siphon

(S1.2.9), (S1.2.9.4)

Thermoplastic Repairs

(S4.2), (S4.18.2), (S4.18.2.7)

Thinning

(3.3.4.3), (S5.4), (S5.6.1)

Threaded Connections

(S1.2.12.2)

Threaded Opening

(S1.2.12.2), (S2.13.14.1), (S2.13.14.3)

Threaded Stays, Bolts, Studs

(3.3.4.2), (3.3.4.3), (3.3.4.7), (S1.1.3.1), (S1.2.1),
(S1.2.2), (S1.2.3), (S1.2.4), (S1.2.5), (S1.2.7),
(S2.13.1), (S2.13.2), (S2.13.3), (S2.13.4), (S2.13.5),
(S2.13.10.1), (S2.13.10.2)

Ton Tanks (DOT)

(S6.5), (S6.20)

Training

(1.6.6.2), (1.6.7.2), (1.6.8.2), (4.2), (S2.3), (S6.8.1)

Transient

(1.2), (9.1)

Transport Tanks

(Introduction), (1.2), (S6.1), (S6.7), (S6.8.1),
(S6.10.3), (S6.17.1), (S6.18), (S6.18.1), (7.1), (9.1)

Tube Segments

(S3.2)

Tubes

(2.5.3.6), (3.2.2), (3.3.2), (3.3.3), (3.3.4.2), (3.3.4.3),
(3.3.4.4), (3.3.4.5), (3.3.4.6), (3.3.4.9), (5.12.4.1),

(S1.1.3.1), (S1.2.9), (S1.2.9.1), (S1.2.9.2),
(S1.2.9.3), (S1.2.9.5), (S1.2.9.6), (S1.2.9.7),
(S1.2.11.2), (S1.2.11.5), (S1.2.13.1), (S2.7.1),
(S2.13), (S2.13.7), (S2.13.8), (S2.13.10.3),
(S2.13.11.3), (S2.13.12.1), (S2.13.12.2),
(S2.13.12.3), (S2.13.14.1), (S3.2), (S3.3), (S3.5.4),
(S6.6), (S7.6)

Tubesheet

(3.2.2), (3.3.3), (3.5.7), (S1.2.6), (S1.2.9.4),
(S1.2.11.5), (S1.2.11.6), (S2.13.11.1), (S2.13.11.2),
(S2.13.11.3), (S2.13.12.1), (S2.13.12.2),
(S2.13.12.3), (S3.5.1), (S3.5.4)

U**Ultrasonic Examination**

(3.3.4.2), (3.3.4.3), (S5.6.2), (S7.4)

Unique Identifier

(2.2.5), (5.6), (5.12.4.1), (S4.10.4), (S5.6.1), (S6.9.5)

Units of Measurement

(Introduction), (2.3), (5.12.4.1), (7.1), (7.2), (7.3),
(7.4)

Unstayed Areas

(3.3.4.2), (3.3.4.3), (S1.2.9.4), (S1.2.10),
(S2.13.9.1), (S2.13.9.2), (S2.13.9.3), (S2.13.9.4)

User

(Introduction), (1.3), (1.4.1), (2.1), (2.3), (3.2.6),
(3.3.5.2), (3.4.5.1), (5.3), (5.4), (S1.1.1), (S2.1),
(S2.2), (S2.3), (S3.2), (S4.16.3), (S4.17.3), (S5.4),
(S5.5), (S6.16.3), (S7.8), (9.1)

V**Vacuum Test**

(4.4.1), (S3.5.4), (S4.15), (S4.17.6)

Valves

(1.1), (1.2), (1.4.1), (1.6.6.2), (3.3.2), (4.4.1), (4.4.2),
(5.7.5), (5.12.5.1), (5.12.6.1), (S1.2.13.1), (S6.18.1)

Verification

(1.5.1), (1.6.4), (1.6.6.2), (1.6.7.2), (1.6.8.2), (1.6.9),
(9.1)

Visual Acuity

(4.4.1), (S4.2)

Visual Examination

(3.3.2), (3.4.3), (4.4.1), (4.4.2), (S4.2), (S4.12),
(S6.8.1)

“VR” Authorization

(Introduction), (1.1)

“VR” Certificate Holder

(9.1)

“VR” Certificate of Authorization

(5.12.6.1)

“VR” Stamp

(5.12.6)

W**Wasted Areas**

(3.3.2), (3.3.3), (3.3.4.2), (3.3.4.3), (S2.13.9.1), (S2.13.10.1), (S2.13.11.1), (S2.13.12.1), (S2.13.14.2)

Water Column

(S1.2.13.1)

Water Gage Connection

(S1.2.13.1)

Water Gage Glass

(S1.2.13.1)

Waterside

(3.3.4.9), (S1.2.11.2), (S1.2.11.3), (S1.2.11.4), (S2.13.9.3), (S2.13.10.4)

Weld Buildup

(3.3.2), (3.3.3), (3.3.4.3), (S1.2.3), (S1.2.6.1), (S1.2.10), (S1.2.11.3), (S1.2.11.4), (S1.2.11.5), (S1.2.11.6), (S1.2.12.2), (S2.13), (S2.13.9.1), (S2.13.10.1), (S2.13.10.4), (S2.13.11.1), (S2.13.12.1), (S2.13.14.1), (S2.13.14.2), (S2.13.14.3)

Welder

(1.5.1), (2.2.3), (2.2.5), (2.2.6), (2.2.6.1), (2.5.3)

Welders Continuity

(2.2.6), (S6.9.6)

Welders Identification

(2.2.5), (S6.9.5), (S7.12.5)

Welding

(1.4.1), (1.5.1), (1.6.6.2), (1.6.7.2), (1.6.8.2), (2.1), (2.2), (2.2.1), (2.2.1.1), (2.2.2), (2.2.3), (2.2.4), (2.2.5), (2.2.6), (2.2.6.1), (2.3), (2.4), (2.5.1), (2.5.3), (2.5.3.1), (2.5.3.2), (2.5.3.3), (2.5.3.4), (2.5.3.5), (2.5.3.6), (3.2.1), (3.2.2), (3.3.2), (3.3.3), (3.3.4.2),

(3.3.4.3), (3.3.4.4), (3.3.4.6), (3.3.4.9), (3.4.3), (5.7.5), 5.12.3(5.12.3), (5.12.4.1), (5.12.5.1), (5.12.6.1), (S1.1.2), (S1.1.3), (S1.2.1), (S1.2.3), (S1.2.4), (S1.2.6), (S1.2.6.1), (S1.2.6.2), (S1.2.6.3), (S1.2.8), (S1.2.9.1), (S1.2.9.2), (S1.2.9.6), (S1.2.9.7), (S1.2.10), (S1.2.11.1), (S1.2.11.2), (S1.2.11.3), (S1.2.11.4), (S1.2.11.5), (S1.2.11.6), (S1.2.12.1), (S1.2.12.2), (S2.7), (S8.1), (S8.2), (S8.3), (S8.4), (S8.5)

Welding Methods

(2.5.3.1), (2.5.3.2), (2.5.3.3), (2.5.3.4), (2.5.3.5), (2.5.3.6)

Welding Operator

(1.5.1), (2.2.3), (2.2.5), (2.2.6), (S6.8.1), (S6.9.3), (S6.9.5), (S6.9.6)

Welding Procedures

(2.2.1), (2.2.2), (S8.4)

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(2.2.4), (S6.9.4)

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(3.3.3), (3.3.4.3), (3.3.4.8), (4.2), (S1.2.9.4), (S8.1), (S8.2), (S8.3), (S8.4), (S8.5)

Wrapper Sheet

(S1.2.3), (S1.2.11.5)

X**Y****Yankee Dryers**

(5.9), (S5.1), (S5.2), (S5.3), (S5.4), (S5.5), (S5.6), (S5.7)

Z

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