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NATIONAL BOARD INSPECTION CODE

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PART I

INSTALLATION

THE NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS

NATIONAL BOARD INSPECTION CODE

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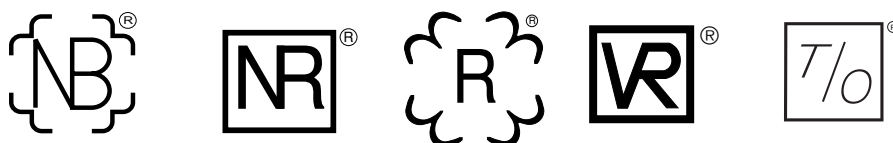
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INTRODUCTION

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 1, SECTION 1

INSTALLATION — GENERAL GUIDELINES

1.1 SCOPE

This part provides requirements and guidelines for the installation of power boilers, steam heating boilers, hot-water heating boilers, hot-water supply boilers, potable water heaters, pressure vessels and piping.

The proper installation of boilers, pressure vessels, piping, and other pressure-retaining items is essential for safe and satisfactory operation. The owner-user is responsible for ensuring that installations meet all the requirements of the Jurisdiction at the point of installation including licensing, registration, or certification of those performing installations. NBIC Part 1 identifies minimum safety requirements for installing pressure-retaining items when NBIC Part 1 is mandated by a Jurisdiction. Otherwise, the requirements specified in NBIC Part 1 provide information and guidance for installers, contractors, owners, inspectors, and Jurisdictions to ensure safe and satisfactory installation of specified pressure-retaining items. Jurisdictions may require other safety standards, including following manufacturer's recommendations. When a Jurisdiction establishes different requirements or where a conflict exists, the rules of the Jurisdiction prevail. Users of NBIC Part 1 are cautioned that other requirements may apply for a particular installation and NBIC Part 1 is not a substitute for sound engineering evaluations.

1.2 PURPOSE

- a) The purpose of these rules are to establish minimum requirements, which, if followed, will ensure that pressure-retaining items, when installed, may be safely operated, inspected, and maintained.
- b) It should be recognized that many of the requirements included in these rules must be considered in the design of the pressure-retaining item by the manufacturer. However, the owner-user is responsible for ensuring that the installation complies with all the applicable requirements contained herein. Further, the installer is responsible for complying with the applicable sections when performing work on behalf of the owner-user.

1.3 APPLICATION OF THESE RULES

- a) As referenced in lower case letters, the terms "owner," "user," or "owner-user" mean any person, firm, or corporation legally responsible for the safe operation of the boiler, pressure vessel, piping, or other pressure-retaining item. Further, where the term "owner" is used, it shall mean the owner, or user, or the owner's or user's designee.
- b) Where the owner is required to perform an activity, it is intended that the owner or the owner's designee may perform the activity; however, the owner retains responsibility for compliance with these rules.
- c) These rules refer to documentation obtained from the Jurisdiction (installation permit, operating permit). It is not intended to require the Jurisdiction to issue such permits but rather a caution to owners and installers that such permits may be required.

1.4 CERTIFICATION, INSPECTION, AND JURISDICTIONAL REQUIREMENTS

1.4.1 RESPONSIBILITY

- a) The owner is responsible for satisfying jurisdictional requirements for certification and documentation. When required by jurisdictional rules applicable to the location of installation, the boilers, pressure vessels, piping, and other pressure-retaining items shall not be operated until the required documentation has been provided by the installer to the owner and the Jurisdiction.

- b) The National Board Commissioned Inspector providing inservice inspection for the facility in which the pressure-retaining item is installed has the following responsibilities:
 - 1) Verify the *Boiler Installation Report* (I-1 Report) has been completed and signed by the installer, when required by the Jurisdiction;
 - 2) Verify pressure-retaining items comply with the laws and regulations of the Jurisdiction governing the specific type of boiler or pressure vessel;
 - 3) Verify any repairs or alterations to pressure-retaining items, which are conducted prior to, or during, the initial installation, are in accordance with the NBIC;
 - 4) Request or assign jurisdictional identification number, when required by the Jurisdiction; and
 - 5) Complete and submit the first inservice inspection/certificate report to the Jurisdiction when required by the Jurisdiction.
- c) Unless otherwise specifically required by the Jurisdiction, the duties of the inservice inspector do not include the installation's compliance with manufacturer's recommendations or applicability of, or compliance with, other standards and requirements (e.g., environmental, construction, electrical, undefined industry standards, etc.) for which other regulatory agencies have authority and responsibility to oversee.

1.4.2 EQUIPMENT CERTIFICATION

- a) All boilers, pressure vessels, piping, and other pressure-retaining items shall have documented certification from the manufacturer indicating that the boiler, pressure vessel, piping, or any other pressure-retaining items comply with the requirements of the code of construction. The certification shall identify the "Addenda" for a code of construction to which all pressure-retaining items were fabricated.
- b) Package boilers having external piping disassembled and shipped with the boiler shall have a method for traceability of the disassembled piping that can be verified at the time of installation and inspection. The manufacturer of the package boiler is responsible for determining a method of traceability.

1.4.3 JURISDICTIONAL REVIEW

- a) The owner shall determine jurisdictional requirements (e.g., certificates, permits, licenses, etc.) before installing the equipment. The organization responsible for installation shall obtain all permits required by the Jurisdiction prior to commencing installation.
- b) The owner shall determine jurisdictional requirements (e.g., certificates, permits, licenses, etc.) before operating the equipment. The owner shall obtain operating certificates, permits, etc., required by the Jurisdiction prior to commencing operation.

1.4.4 INSPECTION

All boilers, pressure vessels, piping, and other pressure-retaining items shall be inspected and tested after installation and prior to commencing operation.

1.4.5 BOILER INSTALLATION REPORT

- a) Upon completion, inspection, testing, and acceptance of the installation, the installer shall complete and certify the *Boiler Installation Report* (I-1 Report) for all power boilers, hot-water heating boilers, steam-heating boilers, hot-water supply boilers, and potable water heaters.

b) The *Boiler Installation Report* (I-1 Report) shall be submitted as follows:

- 1) One copy to the owner; and
- 2) One copy to the Jurisdiction, if required.

1.4.5.1 BOILER INSTALLATION REPORT FORM, see Pg. 6

1.4.5.1.1 GUIDE FOR COMPLETING NATIONAL BOARD BOILER INSTALLATION REPORT (23)

- 1) INSTALLATION: Indicate the type and date of installation — new, reinstalled, or second hand.
- 2) INSTALLER: Enter the installer's name and physical address.
- 3) OWNER-USER: Enter the name and mailing address of the owner-user of the boiler.
- 4) OBJECT LOCATION: Enter the name of the company or business and physical address where the installation was made.
- 5) JURISDICTION NO.: Enter the Jurisdiction number if assigned at the time of installation.
- 6) NATIONAL BOARD NO.: Enter the assigned National Board number.
Note:
Cast section boilers do not require National Board registration.
- 7) MANUFACTURER: Enter the boiler manufacturer's name.
- 8) MFG. SERIAL NO.: Enter the assigned boiler manufacturer's serial number.
- 9) YEAR BUILT: Enter the year the boiler was manufactured.
- 10) BOILER TYPE: Enter the type of boiler, e.g., watertube, firetube, cast, electric, etc.
- 11) BOILER USE: Enter the service for which or for how the boiler will be used, e.g., heating (steam or water), potable water, etc.
- 12) FUEL: Enter the type of fuel, e.g., natural gas, diesel, wood, etc. If more than one fuel type, enter the types for which the boiler is equipped.
- 13) METHOD OF FIRING: Enter the method of firing, e.g., automatic, hand, stoker, etc.
- 14) Btu/kW INPUT: Enter the Btu/hr or kW input of the boiler.
- 15) Btu/kW OUTPUT: Enter the Btu/hr or kW output of the boiler.
- 16) OPERATING PSI: Enter the allowed operating pressure.
- 17) ASME CODE DESIGNATOR'S: Check the ASME Code designator shown on the code nameplate or stamping of other certification mark (specify).
- 18) STAMPED MAWP: Enter the maximum allowable working pressure shown on the nameplate or stamping.
- 19) HEATING SURFACE SQ. FT.: Enter the boiler heating surface shown on the stamping or nameplate.
Note:
This entry is not required for electric boilers.

20) CAST BOILER: Enter the total number of sections for cast boilers.

Note:

Not all cast boilers are sectional. Mono-block cast boilers should be described as having one (1) section.

21) MANHOLE: Indicate whether the boiler has a manway.

22) SPECIFIC ON-SITE LOCATION: Enter the on-site location of the boiler in sufficient detail to allow location of that boiler.

23) PRESSURE RELIEF VALVE SIZE: Enter the inlet and outlet size of all installed boiler safety or safety relief valves.

24) PRESSURE RELIEF VALVE SET PRESSURE: Enter the set pressure of all installed boiler safety or safety relief valves.

25) PRESSURE RELIEF VALVE CAPACITY: Enter the capacity in either lbs. of steam per hour or Btu/hr for each installed boiler safety or safety relief valve.

26) MANUFACTURER: Enter the manufacturer of each installed boiler safety and safety relief valve.

27) LOW-WATER FUEL CUTOFF: Enter the manufacturer's name, type, number, and maximum allowable working pressure of all installed low-water fuel cutoff devices.

28) PRESSURE/ALTITUDE GAGE: Enter the dial range of the installed pressure or altitude gage, cutout valve or cock size, a maximum allowable working pressure, and gage pipe connection size. For steam boilers, indicate gage siphon or equivalent device installed.

29) EXPANSION TANK: Indicate code of construction of installed expansion tank, tank maximum allowable working pressure, and tank capacity in gallons.

30) VENTILATION AND COMBUSTION AIR: Indicate total square inches of unobstructed opening or total cubic feet per minute of power ventilator fan(s) available for ventilation and combustion air.

31) WATER LEVEL INDICATORS: Enter the number of gage glasses and/or remote indicators and connecting pipe size.

32) FEEDWATER SUPPLY: Enter the total number of feeding means, connecting pipe size, stop and check valve size, and maximum allowable working pressure.

33) STOP VALVE(S): Enter the number of stop valves installed, valve size, and maximum allowable working pressure.

34) POTABLE WATER HEATER UNIQUE REQUIREMENTS: Indicate if stop valves are installed and, if so, enter size and maximum allowable working pressure. Enter drain valve size and indicate installation of thermometer at or near boiler outlet.

35) MANUFACTURER'S CERTIFICATION ATTACHED: Indicate if manufacturer's certificate is attached (mandatory for new installations).

36) CLEARANCE REQUIREMENTS AND REPLACEMENT OF EXISTING BOILER: Indicate clearances and whether the installation replaced an existing boiler.

37) ADDITIONAL REMARKS: Enter any remarks or comments you deem appropriate.

38) INSTALLER'S NAME AND SIGNATURE: Print installer's name and registration number and sign completed report.

- 39) BOTTOM BLOWDOWN CONNECTIONS: Indicate number of valves, valve size, and MAWP. Indicate if piping run is full size to point of discharge.
- 40) EXTERNAL PIPING ASME CODE AND FUEL TRAIN: Indicate if external piping is ASME Code, if not, indicate what code or standard external piping is manufactured to. Indicate if the fuel train meets the requirements of ASME CSD-1, *Controls and Safety Devices for Automatically Fired Boilers* or the National Fire Protection Association (NFPA)'s NFPA-85, *Boiler and Combustion Systems Hazards Code*. If other, indicate code or standard used.



FORM I-1 REPORT OF BOILER INSTALLATION

in accordance with provisions of the *National Board Inspection Code*

INSTALLATION: (1) ☐ New ☐ Reinstalled ☐ Second Hand Date ____/____/____

(2) INSTALLER	(3) OWNER-USER	(4) OBJECT LOCATION
Name _____	Name _____	Name _____
Street _____	Street, PO Box, RR _____	Street _____
City, State, ZIP _____	City, State, ZIP _____	City, State, ZIP _____

Jurisdiction No. (5)	National Board No. (6)	Manufacturer (7)	Mfg. Serial No. (8)	Year Built (9)	Boiler Type (10)	Boiler Use (11)
Fuel (12)	Method of Firing (13)	Btu/kW input (14)	Btu/kW output (15)	Operating PSI (16)	ASME Code Designator(s) (17)	☐ A ☐ S ☐ U ☐ HLW ☐ M ☐ E ☐ H ☐ Other
Stamped MAWP (18)	Heating Surface, Sq. Ft. (19)	Cast Iron (20)	Manhole (21)	Specific On-Site Location, i.e., Utility Room (22)		
Pressure Relief Valve Size (23)	Pressure Relief Valve Set Pressure (24)	Pressure Relief Valve Capacity ☐ Btu/hr ☐ Lb/hr (25)	Manufacturer (26)	Low-Water Fuel Cutoff Mfg. (27) No. _____		
1. _____ 2. _____ 3. _____ 4. _____	1. _____ 2. _____ 3. _____ 4. _____	1. _____ 2. _____ 3. _____ 4. _____	1. _____ 2. _____ 3. _____ 4. _____	Probe Type _____ Flow Switch _____ Float & Chamber _____ Other (Specify) _____		

PRESSURE/ALTITUDE GAGE: (28) Dial Graduation _____ Valve/Cock Size _____ MAWP _____ Pipe Connection Size _____ Siphon or Equivalent Device ☐ Yes ☐ No	EXPANSION TANK: (29) ASME Constructed ☐ Yes ☐ No Other _____ MAWP _____ No. Gallons _____	VENTILATION AND COMBUSTION AIR (30) Unobstructed Opening (sq. in.) _____ Power Ventilator Fan (CFM) _____
WATER LEVEL INDICATORS: (31) Number of Gage Glasses _____ Number of Remote Indicators _____ Size of Connection Piping _____		FEED WATER SUPPLY: (32) Number of Feeding Means _____ Pipe Size _____ Stop Valve Size _____ MAWP _____ Check Valve Size _____ MAWP _____
STOP VALVES: (33) Number of Valves _____ Valve Size _____		EXTERNAL PIPING ASME CODE: (40) ☐ Yes ☐ No ☐ Other _____ FUEL TRAIN: ☐ CSD-1 ☐ NFPA-85 ☐ Other _____
BOTTOM BLOWDOWN CONNECTIONS: (39) Number of Valves _____ Valve Size _____ MAWP _____ Piping Run Full Size ☐ Yes ☐ No		POTABLE WATER HEATER UNIQUE REQUIREMENTS ☐ Yes ☐ No Inlet Stop Valve Size _____ MAWP _____ Outlet Stop Valve Size _____ MAWP _____ Drain Valve Size _____ Thermometer ☐ Yes (34)
Manufacturer's Certification Attached: ☐ Yes ☐ No (35)		Clearance from walls and floors: (36) Side _____ Bottom _____ Top _____
Does boiler replace existing one: ☐ Yes ☐ No (36)		

Additional recommendations and remarks by installer:

(37)	I HEREBY CERTIFY THAT THE INSTALLATION COMPLIES WITH NBIC, Part 1 (38)
(38)	(38)
Installer Name (PRINT)	Registration # Installer Signature

1.5 CHANGE OF SERVICE

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.

Whenever there is a change of service, the Jurisdiction where the pressure-retaining item is to be operated shall be notified for acceptance, when applicable. Any specific jurisdictional requirements shall be met.

1.6 GENERAL REQUIREMENTS

The following are general requirements for the boilers, potable water heaters, thermal fluid heaters and pressure vessels covered in NBIC Part 1, Sections 2, 3, 4, and Supplement 5. Refer to each referenced section for additional requirements specific to the type of equipment covered by each section.

1.6.1 SUPPORTS, FOUNDATIONS, AND SETTINGS

Each boiler, potable water heater, thermal fluid heater and pressure vessel and the associated piping must be safely supported. Design of supports, foundations, and settings shall consider vibration (including seismic where necessary), movement (including thermal expansion and contraction), grounding/bonding to minimize electrolytic corrosion and loadings (including the weight of the fluid in the system during a pressure test) in accordance with jurisdictional requirement, manufactures recommendations, and/or other industry standards, as applicable.

1.6.2 STRUCTURAL STEEL

- a) If the boiler, heater, or vessel is supported by structural steel work, the steel supporting members shall be so located or insulated that the heat from the furnace will not affect their strength.
- b) Structural steel shall be installed in accordance with jurisdictional requirements, manufacturer's recommendations, and/or other industry standards, as applicable.

1.6.3 EXIT

Two means of exit shall be provided for equipment rooms exceeding 500 ft.² (46.5 m²) of floor area and containing one or more boilers, potable water heaters, thermal fluid heaters or pressure vessels having a combined fuel capacity of 1,000,000 Btu/hr (293 kW) or more (or equivalent electrical heat input). Each elevation shall be provided with at least two means of exit, each to be remotely located from each other. A platform at the top of a single boiler, potable water heater, thermal fluid heater or pressure vessel is not considered an elevation.

1.6.4 LADDERS AND RUNWAYS

- a) All walkways, runways, and platforms shall be:
 - 1) of metal construction or equivalent material;
 - 2) provided between or over the top of boilers, heaters, or vessels that are more than 8 ft. (2.4 m) above the operating floor to afford accessibility for normal operation, maintenance, and inspection;
 - 3) constructed of safety treads, standard grating, or similar material and have a minimum width of 30 in. (760 mm);
 - 4) of bolted, welded, or riveted construction; and

- 5) equipped with handrails 42 in. (1,070 mm) high with an intermediate rail and 4 in. (100 mm) toe board.
- b) Stairways that serve as a means of access to walkways, runways, or platforms shall not exceed an angle of 45 degrees from the horizontal and be equipped with handrails 42 in. (1,070 mm) high with an intermediate rail.
- c) Ladders that serve as a means of access to walkways, runways, or platforms shall:
 - 1) be of metal construction and not less than 18 in. (460 mm) wide;
 - 2) have rungs that extend through the side members and are permanently secured;
 - 3) have a clearance of not less than 30 in. (760 mm) from the front of rungs to the nearest permanent object on the climbing side of the ladder;
 - 4) have a clearance of not less than 6.5 in. (165 mm) from the back of rungs to the nearest permanent object; and
 - 5) have a clearance width of at least 15 in. (380 mm) from the center of the ladder on either side across the front of the ladder.
- d) There shall be at least two permanently installed means of exit from walkways, runways, or platforms that exceed 6 ft. (1.8 m) in length.

(23) 1.6.5 FUEL

All fuel systems shall be installed in accordance with jurisdictional and environmental requirements, manufacturer's recommendations, and/or industry standards, such as ASME CSD-1; ANSI Z/CSA; NFPA 85; Boiler and Combustion Systems Hazards Codes; or others as applicable. The following are requirements for Natural Gas, Propane, and #2 fuel oil.

a) Natural Gas and Propane

1) Cleaning

- a. It is recommended that strainers be installed in the main gas line leading to the boiler control equipment.
- b. A sediment trap is required prior to the gas controls. This trap shall be located in a vertical section of pipe as close as practical upstream of the gas controls.

2) Manual Valves

- a. A manual valve is required upstream of all controls and as close as practical to the boiler to isolate the fuel train when required. If a pilot line is upstream of the manual valve on the main fuel train, it shall also have a manual valve.
- b. These manual valves shall be accessible from a floor, platform, walkway, or runway. Accessibility shall mean within a 6 ft. (1.8m) elevation of the standing space and not more than 12 in. (305 mm) horizontally from the standing space edge. The manual valves shall be designed to be opened/closed without additional tools. They shall be a ball or a lubricated plug type with a non-removable handle that is perpendicular to the gas flow when closed and parallel when open, and the valves shall have stops.
- c. If the non-removable handle creates a hazard, the handle can be designed to be temporarily removed provided all of the following are incorporated:
 1. The valve handle is always on while the valve is in the open position.

2. At all times, the position of the valve shall be indicated.
3. When the valve is in the closed position and the handle is not attached, the valve shall be tagged/locked out and the handle shall be tethered and accessible.
- d. If the valve is not part of a listed and labeled assembly, the valve shall comply with a nationally recognized standard.

3) Vents

For gas components that are vented or bled, the following requirements apply:

- a. All vent or bleed lines from natural gas equipment such as regulators, controls, switches, relief, vent valves, etc., shall be vented outside to a safe point of discharge per the manufacturer's requirements or the authority having jurisdiction.
- b. Vent and bleed line shall be sized in accordance with a nationally recognized standard.
- c. Manifold of vent lines or of bleed lines shall be in accordance with a nationally recognized standard. Vent lines shall not be manifolded with bleed lines.
- d. No vent or bleed line shall discharge into a flue.
- e. Vent materials shall be selected such that they shall have suitable strength and durability for their intended purpose and shall be listed for the intended purpose by the jurisdiction having authority or a nationally recognized standard.

b) Fuel Oil

A properly sized and rated oil strainer or filter shall be installed upstream of the safety shutoff valves.

1.6.6 VENTILATION AND COMBUSTION AIR

(23)

- a) The equipment room shall have adequate air supply to permit clean, safe combustion, minimize soot formation, and maintain a minimum of 19.5% oxygen in the air of the equipment room and sufficient to maintain ambient temperatures as recommended by the boiler, heater, or vessel manufacturer. The combustion and ventilation air should be supplied by either an unobstructed air opening or by power ventilation or fans.
- b) When combustion air is supplied to the boiler, heater, or vessel by an independent duct, with or without the employment of power ventilators or fans, the duct shall be sized and installed in accordance with the manufacturer's recommendations. However, ventilation for the equipment room must still be considered.
- c) Unobstructed air openings shall be sized on the basis of the manufacturer's recommendations, or as specified by the NFPA standards for oil and gas burning installations for the particular job conditions, or 1 in.² (650 mm²) free area per 2000 Btu/hr (586 W) maximum fuel input of the combined burners located in the equipment room. The equipment room supply openings shall be kept clear at all times.
- d) Power ventilators or fans shall be sized on the basis of 0.2 cfm (0.0057 m³/min) for each 1000 Btu/hr (293 W) of maximum fuel input for the combined burners of all boilers and heaters located in the equipment room. Additional capacity may be required for other fuel burning equipment in the equipment room.
- e) When power ventilators or fans are used to supply combustion air, they shall be installed with interlock devices so that burners will not operate without an adequate number of ventilators/fans in operation.
- f) The size of openings specified in c) above may be reduced when special engineered air supply systems approved by the Jurisdiction are used.

- g) Care should be taken to ensure that steam, water and fluid lines are not routed across combustion air openings, where freezing may occur.

1.6.7 LIGHTING

The equipment room should be well lighted and it should have an emergency light source for use in case of power failure.

1.6.8 CHIMNEY OR STACK

Chimneys or stacks shall be installed in accordance with jurisdictional requirements, manufacturer's recommendations, and/or industry standards, as applicable.

1.6.9 CARBON MONOXIDE (CO) DETECTOR/ALARM

The owner or user shall install a carbon monoxide (CO) detector/alarm in equipment rooms where fuel fired boilers and/or fuel fired pressure vessels are located in accordance with the authority having Jurisdiction.

1.6.10 TESTING AND FINAL ACCEPTANCE

- a) The completed boiler/ pressure vessel shall be pressure tested in the shop and/or in the field in accordance with the original code of construction and documented on the appropriate Manufacturer's Data Report.
- b) The installer shall exercise care during installation to prevent loose weld material, welding rods, small tools, and miscellaneous scrap metal from getting into the vessel. Prior to making the final closure the installer shall inspect the interior of the vessel and its appurtenances for the presence of foreign debris, if present it shall be removed.
- c) Subject to the jurisdictional requirements, a leak test may be performed on any components whose pressure test is not documented under the items' Manufacturer's Data Report. This leak test should not exceed 90% of the lowest pressure relief device setpoint. The test data shall be recorded, and the data made available as required.
- d) Prior to final acceptance, an operational test shall be performed on the completed installation. The test shall include operating controls, limit controls and safety devices and witnessed as required by the Jurisdiction. The test data shall be recorded, and the data made available to the Jurisdictional Authorities as evidence that the installation complies with provisions of the governing code(s) of construction.
- e) All fuel fired boiler and/or fuel fired pressure vessel combustion air-fuel ratios shall be analyzed, adjusted, and values documented during commissioning to meet emission requirements of the Jurisdiction and/or limits of the manufacturer, as required.

PART 1, SECTION 2 INSTALLATION — POWER BOILERS

2.1 SCOPE

This section provides requirements and guidelines for the installation of power boilers.

2.2 DEFINITIONS

See NBIC Part 1, Section 9, *Glossary*.

2.3 GENERAL REQUIREMENTS

2.3.1 SUPPORTS, FOUNDATIONS, AND SETTINGS

See NBIC Part 1, Section 1.6.1, *Supports, Foundations and Settings*.

2.3.2 STRUCTURAL STEEL

See NBIC Part 1, Section 1.6.2, *Structural Steel*.

2.3.3 CLEARANCES

- a) Boiler installations shall allow for normal operation, maintenance, and inspections. There shall be at least 36 in. (915 mm) of clearance on each side of the boiler to enable access for maintenance and/or inspection activities. Boilers operated in battery shall not be installed closer than 48 in. (1220 mm) from each other. The front or rear of any boiler shall not be located nearer than 36 in. (915 mm) from any wall or structure.

Note:

Alternative clearances in accordance with the manufacturer's recommendations are subject to acceptance by the Jurisdiction.

- b) Boilers shall be installed to allow for removal and installation of tubes.
- c) Boilers with a top-opening manhole shall have at least 84 in. (2135 mm) of unobstructed clearance above the manhole to the ceiling of the equipment room.
- d) Boilers without top-opening manholes shall have at least 36 in. (915 mm) of clearance from the top of the boiler or as recommended by the manufacturer.
- e) Boilers with a bottom opening used for inspection or maintenance shall have at least 12 in. (305 mm) of unobstructed clearance.

2.4 EQUIPMENT ROOM REQUIREMENTS

2.4.1 EXIT

See NBIC Part 1, Section 1.6.3, *Exit*.

2.4.2 LADDERS AND RUNWAYS

See NBIC Part 1, Section 1.6.4, *Ladders and Runways*.

2.4.3 DRAINS

At least one floor drain shall be installed in the equipment room.

2.4.4 WATER (CLEANING)

A convenient water supply shall be provided for flushing out the boiler and its appurtenances, adding water to the boiler while it is not under pressure, and cleaning the equipment room floor.

2.5 SOURCE REQUIREMENTS

2.5.1 FEEDWATER

2.5.1.1 VOLUME

The source of feedwater shall be capable of supplying a sufficient volume of water as determined by the boiler manufacturer in order to prevent damage to the boiler when all the safety relief valves are discharging at full capacity.

2.5.1.2 CONNECTION

- a) To prevent thermal shock, feedwater shall be introduced into a boiler in such a manner that the water will not be discharged directly against surfaces exposed to high temperature gases or to direct radiation from the flame.
- b) For boiler operating pressures of 400 psig (2.8 MPa) or higher, the feedwater inlet through the drum shall be fitted with shields, sleeves, or other suitable means to reduce the effects of temperature differentials in the shell or head.
- c) Feedwater other than condensate return shall not be introduced through the blowoff.
- d) Boilers having more than 500 sq. ft. (46.5 sq. m) of water heating surface shall have at least two means of supplying feedwater. For boilers that are fired with solid fuel not in suspension, and boilers whose setting or heat source can continue to supply sufficient heat to cause damage to the boiler if the feedwater supply is interrupted, one such means of supplying feedwater shall not be subject to the same interruption as the first method. Boilers fired by gaseous, liquid, or solid fuel in suspension may be equipped with a single means of supplying feedwater, provided means are furnished for the immediate removal of heat input if the supply of feedwater is interrupted.
- e) For boilers having a water heating surface of not more than 100 sq. ft. (9 sq. m), the feedwater piping and connection to the boiler shall not be smaller than NPS 1/2 (DN 15). For boilers having a water heating surface more than 100 sq. ft. (9 sq. m), the feedwater piping and connection to the boiler shall not be less than NPS 3/4 (DN 20).
- f) Electric boiler feedwater connections shall not be smaller than NPS 1/2 (DN 15).
- g) High-temperature water boilers shall be provided with a means of adding water to the boiler or system while under pressure.

2.5.1.3 PUMPS

- a) Boiler feedwater pumps shall have discharge pressure in excess of the highest set pressure relief valve in order to compensate for frictional losses, entrance losses, regulating valve losses, and normal static head, etc. Each source shall be capable of supplying feedwater to the boiler at a minimum pressure of 3% higher than the highest setting of any pressure relief valve on the boiler proper. Detailed engineering evaluation of the pump selection shall be performed and available. Table 2.5.1.3 is a guideline for estimating feedwater pump differential.
- b) For forced-flow steam generators with no fixed steam or water line, each source of feedwater shall be capable of supplying feedwater to the boiler at a minimum pressure equal to the expected maximum sustained pressure at the boiler inlet corresponding to operation at maximum designed steaming capacity with maximum allowable pressure at the superheater outlet.
- c) Control devices may be installed on feedwater piping to protect the pump against overpressure.

TABLE 2.5.1.3
GUIDE FOR FEEDWATER PUMP DIFFERENTIAL

Boiler Pressure		Boiler Feedwater Pump Discharge Pressure	
psig	(MPa)	psig	(MPa)
200	(1.38)	250	(1.72)
400	(2.76)	475	(3.28)
800	(5.52)	925	(6.38)
1,200	(8.27)	1,350	(9.31)

2.5.1.4 VALVES

- a) The feedwater piping shall be provided with a check valve and a stop valve. The stop valve shall be located between the check valve and the boiler.
- b) When two or more boilers are fed from a common source, there shall also be a globe or regulating valve on the branch to each boiler located between the check valve and the feedwater source.
- c) When the feedwater piping is divided into branch connections and all such connections are equipped with stop and check valves, the stop and check valve in the common source may be omitted.
- d) On single boiler-turbine unit installations, the boiler feedwater stop valve may be located upstream from the boiler feedwater check valve.
- e) If a boiler is equipped with duplicate feedwater supply arrangements, each such arrangement shall be equipped as required by these rules.
- f) A check valve shall not be a substitute for a stop valve.
- g) A combination feedwater stop-and-check valve in which there is only one seat and disk and a valve stem is provided to close the valve when the stem is screwed down shall be considered only as a stop valve. A separate check valve shall be installed.
- h) Whenever globe valves are used on feedwater piping, the inlet shall be under the disk of the valve.
- i) Stop valves and check valves shall be placed on the inlet of economizers or feedwater-heating devices.

- j) The recirculating return line for a high-temperature water boiler shall be provided with the stop valve, or valves, required for the main discharge outlet on the boiler.

2.5.2 FUEL

See NBIC Part 1, Section 1.6.5, *Fuel*.

2.5.3 ELECTRICAL

A disconnecting means capable of being locked in the open position shall be installed at an accessible location at the boiler so that the boiler can be disconnected from all sources of potential energy. This disconnecting means shall be an integral part of the boiler or adjacent to it.

2.5.3.1 WIRING

All wiring for controls, heat generating apparatus, and other appurtenances necessary for the operation of the boiler or boilers should be installed in accordance with the provisions of national or international standards and comply with the applicable local electrical codes.

2.5.3.2 REMOTE EMERGENCY SHUTDOWN SWITCHES

- a) A manually operated remote shutdown switch(es) or circuit breaker shall be located just outside the equipment room door and marked for easy identification. Consideration should also be given to the type and location of the switch(es) in order to safeguard against tampering. Where approved by the Jurisdiction, alternate locations of remote emergency switch(es) may be provided.
- b) For equipment rooms exceeding 500 ft.² (46 m²) floor area or containing one or more boilers having a combined fuel capacity of 1,000,000 Btu/hr. (293 kW) or more, additional manually operated remote emergency shutdown switches shall be located at suitably identified points of egress acceptable to the Jurisdiction.
- c) Where a boiler is located indoors in a facility and not in an equipment room, a remote emergency shutdown switch shall be located within 50 ft. (15 m) of the boiler along the primary egress route from the boiler area.
- d) For atmospheric-gas burners and for oil burners where a fan is on the common shaft with the oil pump, the emergency remote shutdown switch(es) or circuit breaker(s) must disconnect all power to the burner controls.
- e) For power burners with detached auxiliaries, the emergency remote shutdown switch(es) or circuit breaker(s) need only shut off the fuel input to the burner.
- f) When existing boiler installations do not include remote emergency shutdown switches, it is not required that these switches be retroactively installed unless required by the Jurisdiction.

2.5.3.3 CONTROLS AND HEAT-GENERATING APPARATUS

- a) Oil and gas-fired and electrically heated boilers shall be equipped with suitable primary (flame safeguard) safety controls, safety limit switches and controls, and burners or electric elements as required by a nationally or internationally recognized standard.
- b) The symbol of the certifying organization that has investigated such equipment as having complied with a nationally recognized standard shall be affixed to the equipment and shall be considered as evidence that the unit was manufactured in accordance with that standard.

- c) These devices shall be installed in accordance with jurisdictional and environmental requirements, manufacturer's recommendations, and/or industry standards, as applicable.

2.5.4 VENTILATION AND COMBUSTION AIR

See NBIC Part 1, Section 1.6.6, *Ventilation and Combustion Air*.

2.5.5 LIGHTING

See NBIC Part 1, Section 1.6.7, *Lighting*.

2.5.6 EMERGENCY VALVES AND CONTROLS

All emergency shut-off valves and controls shall be accessible from a floor, platform, walkway, or runway. Accessibility shall mean within a 6 ft. (1.8 m) elevation of the standing space and not more than 12 in. (305 mm) horizontally from the standing space edge.

2.6 DISCHARGE REQUIREMENTS

2.6.1 CHIMNEY OR STACK

See NBIC Part 1, Section 1.6.8, *Chimney or Stack*.

2.6.2 ASH REMOVAL

Ash removal systems shall be installed in accordance with jurisdictional and environmental requirements, manufacturer's recommendations, and/or industry standards, as applicable.

2.6.3 DRAINS

2.6.3.1 CONNECTION

- a) Each boiler shall have at least one drain pipe fitted with a stop valve at the lowest point of the boiler. If the connection is not intended for blowoff purposes, a single valve is acceptable if it can be locked in the closed position or a blank flange can be installed downstream of the valve. If the connection is intended for blowoff purposes, requirements of NBIC Part 1, 2.7.5 shall be followed.
- b) For high-temperature water boilers, the minimum size of the drain pipe shall be NPS 1 (DN 25).
- c) Drain pipes, valves, and fittings within the same drain line shall be the same size.
- d) The discharge from the drain shall be piped to a safe location.

2.6.3.2 PRESSURE RATING

Drain piping from the drain connection, including the required valve(s) or the blanked flange connection, shall be designed for the temperature and pressure of the drain connection. The remaining piping shall be designed for the expected maximum temperature and pressure. Static head and possible choked flow conditions shall be considered. In no case shall the design pressure and temperature be less than 100 psig (700 kPa) and 220°F (104°C), respectively.

2.6.3.3 PARTS

- a) When parts (e.g., economizers, etc.) are installed with a stop valve between the part and the boiler or the part cannot be completely drained through the drain on the boiler, a separate drain shall be installed on each such part. These drains shall meet the additional requirements of NBIC Part 1, 2.6.3, as applicable.
- b) Each water column shall have a drain pipe fitted with a stop valve at the lowest point of the water column. The stop valve shall have the capability of being locked in the closed position while the boiler is under pressure. The minimum size of the drain shall be NPS 3/4 (DN 20) and all other requirements of NBIC Part 1, 2.6.3, as applicable.

2.7 OPERATING SYSTEMS

2.7.1 BREECHING AND DAMPERS

Breeching and dampers shall be installed in accordance with jurisdictional and environmental requirements, manufacturer's recommendations, and/or industry standards, as applicable.

2.7.2 BURNERS AND STOKERS

Burners and stokers shall be installed in accordance with jurisdictional and environmental requirements, manufacturer's recommendations, and/or industry standards, as applicable.

2.7.3 STEAM SUPPLY

- a) Provisions shall be made for the expansion and contraction of steam mains connected to boiler(s) so that there shall be no undue stress transmitted to the boiler(s). Steam reservoirs shall be installed on steam mains when heavy pulsations of the steam flow cause vibration of the boiler shell plates.
- b) Each discharge outlet of the boiler drum or superheater outlet shall be fitted with a stop valve located at an accessible point in the steam-delivery line and as near the boiler nozzle as is convenient and practicable. The valve shall be equipped to indicate from a distance whether it is closed or open, and shall be equipped with a slow-opening mechanism. When such outlets are over NPS 2 (DN 50), the valve or valves used on the connection shall be of the outside screw-and-yoke rising spindle type, so as to indicate from a distance by the position of its spindle whether it is closed or open and the wheel should be carried either on the yoke or attached to the spindle. In the case of a single boiler and prime mover installation, the stop valve may be omitted provided the prime mover throttle valve is equipped with an indicator to show whether the valve is open or closed and is designed to withstand the required hydrostatic test pressure of the boiler.
- c) Stop valves and fittings shall comply with the appropriate national standard except that austenitic stainless steel is not permitted for water wetted service.
- d) Stop valves and fittings shall be rated for the maximum allowable working pressure of the boiler and shall be at least rated for 100 psig (700 kPa) at the expected steam temperature at the valve or fitting, in accordance with the appropriate national standard.
- e) The nearest stop valve or valves to the superheater outlet shall have a pressure rating at least equal to the minimum set pressure of any safety valve on the superheater and at the expected superheated steam temperature; or at least equal to 85% of the lowest set pressure of any safety valve on the boiler drum at the expected steam temperature of the superheater outlet, whichever is greater.

- f) Provision for an ample gravity drain shall be provided when a stop valve is so located that water or condensation may accumulate. The gravity drain(s) shall be located such that the entire steam supply system can be drained.
- g) When boilers are connected to a common header, the connection from each boiler having a manhole opening shall be fitted with two stop valves having an ample free-blow drain between them. The discharge of this drain shall be visible to the operator while operating the valve. The stop valves shall consist of one stop check valve (set next to the boiler) and a second valve of the outside screw-and-yoke type; or two valves of the outside screw-and-yoke type.
- h) The second steam stop valve shall have a pressure rating at least equal to that required for the expected steam temperature and pressure at the valve; or the pressure rating shall be not less than 85% of the lowest set pressure of any safety valve on the boiler drum and for the expected temperature of the steam at the valve, whichever is greater.
- i) Pressure-reducing valves may be installed in the steam supply piping downstream from the required stop valve or valves.

2.7.4 CONDENSATE AND RETURN

Each condensate return pump, where practicable, shall be provided with an automatic water level control set to maintain an adequate water level in the condensate tank. Condensate tanks not constructed in accordance with an accepted code or standard shall be vented to the atmosphere.

2.7.5 BLOWOFF

- a) Except for forced-flow steam generators with no fixed steam or water line, each boiler shall have a blowoff pipe, fitted with a stop valve, in direct connection with the lowest water space practicable. When the maximum allowable working pressure of the boiler exceeds 100 psig (700 kPa), there shall be two valves installed.
- b) The blowoff piping for each electric boiler pressure vessel having a nominal water content not exceeding 100 gal. (378 l) is required to extend through only one valve.
- c) When two valves are required, each bottom blowoff pipe shall have two slow-opening valves, or one quick-opening valve, at the boiler nozzle followed by a slow-opening valve.
- d) Two independent slow-opening valves or a slow-opening valve and quick-opening valve may be combined in one body provided the combined fitting is the equivalent of two independent slow-opening valves or a slow-opening valve and a quick-opening valve, and the failure of one to operate cannot affect the operation of the other.
- e) Straight-run globe valves or valves where dams or pockets can exist for the collection of sediment shall not be used.
- f) The blowoff valve or valves and the pipe and fittings between them and the boiler shall be of the same size. The minimum size of pipe and fittings shall be NPS 1 (DN 25), except boilers with 100 ft.² (9.3 m²) or less of heating surface should be NPS 3/4 (DN 20). The maximum size of pipe and fittings shall not exceed NPS 2-1/2 (DN 65).
- g) For electric boilers, the minimum size of blowoff pipes and fittings shall be NPS 1 (DN 25), except for boilers of 200 kW input or less. The minimum size should be NPS 3/4 (DN 20).
- h) Fittings and valves shall comply with the appropriate national standard except that austenitic stainless steel and malleable iron are not permitted.

- i) When the maximum allowable working pressure exceeds 100 psig (700 kPa), blowoff piping shall be at least Schedule 80 and the required valves and fittings shall be rated for at least 1.25 times the maximum allowable working pressure of the boiler. When the maximum allowable working pressure exceeds 900 psig (6.2 MPa), blowoff piping shall be at least Schedule 80 and the required valves and fittings shall be rated for at least the maximum allowable working pressure of the boiler plus 225 psi (1.6 MPa).
- j) All blowoff piping, when exposed to furnace heat, shall be protected by fire brick or other heat resisting material so constructed that the piping may be readily inspected.
- k) On a boiler having multiple blowoff pipes, a single master stop valve should be placed on the common blowoff pipe from the boiler and one stop valve on each individual blowoff. Either the master valve or the valves on the individual blowoff lines shall be of the slow-opening type.
- l) The discharge of blowoff pipes shall be located so as to prevent injury to personnel.
- m) All waterwalls or water screens that do not drain back into the boiler and integral economizers forming part of a boiler shall be equipped with blowoff piping and valves conforming to the requirements of this paragraph.
- n) Blowoff piping from a boiler should not discharge directly into a sewer. A blowoff tank, constructed to the provisions of a code of construction acceptable to the Jurisdiction, shall be used where conditions do not provide an adequate and safe open discharge.
- o) Galvanized pipe shall not be used.
- p) Boiler blowoff systems should be constructed in accordance with the *Guide for Blowoff Vessels* (NB-27); which can be found on the National Board website, www.nationalboard.org.
- q) Where necessary to install a blowoff tank underground, it shall be enclosed in a concrete or brick pit with a removable cover so that inspection of the entire shell and heads of the tank can be made.
- r) Piping connections used primarily for continuous operation, such as deconcentrators on continuous blowdown systems, are not classed as blowoffs; but the pipe connections and all fittings up to and including the first shutoff valve shall be equal at least to the pressure requirements for the lowest set pressure of any safety valve on the boiler drum and with the corresponding saturated-steam temperature. Further, such connections shall not exceed NPS 2-1/2 (DN 65).

2.8 CONTROLS AND GAGES

2.8.1 WATER

- a) The water column shall be directly connected to the boiler. Outlet connections (except for damper regulator, feedwater regulator, low-water fuel cutoff, drains, steam gages, or such apparatus that does not permit the escape of an appreciable amount of steam or water) should not be placed on the piping that connects the water column to the boiler.
- b) Straight-run globe valves of the ordinary type shall not be used on piping that connects the water column to the boiler. Where water columns are 7 ft. (2.1 m) or more above the floor level, adequate means for operating gage cocks or blowing out the water glass shall be provided.
- c) When automatic shutoff valves are used on piping that connects the water column to the boiler, they shall conform to the requirements of the code of construction for the boiler.

- d) When shutoff valves are used on the connections to a water column, they shall be either outside-screw-and-yoke or lever-lifting-type gate valves or stop cocks with levers permanently fastened thereto and marked in line with their passage, or of such other through-flow constructions to prevent stoppage by deposits of sediment and to indicate by the position of the operating mechanism whether they are in open or closed position; and such valves or cocks shall be locked or sealed open.
- e) Each steam boiler having a fixed waterline shall have at least one water-gage glass except that boilers operated at pressures over 400 psig (2.8 MPa) shall be provided with two water-gage glasses that may be connected to a single water column or connected directly to the drum. The gage glass connections and pipe connection shall be not less than NPS 1/2 (DN 15). Each water-gage glass shall be equipped with a valved drain.
- f) Electric steam boilers shall have at least one water-gage glass. On electrode-type electric boilers, the gage glass shall be located as to indicate the water levels both at startup and maximum steam load conditions, as established by the boiler manufacturer. On resistance element type electric steam boilers, the lowest visible part of the gage glass shall be located at least 1 in. (25 mm) above the lowest permissible water level established by the boiler manufacturer.
- g) The lowest visible part of the water-gage glass shall be at least 2 in. (50 mm) above the lowest permissible water level established by the boiler manufacturer.
- h) For all installations where the water-gage glass or glasses are not easily viewed by the operator, consideration should be given to install a method of remote transmission of the water level to the operating floor.
- i) Boilers of the horizontal firetube type shall be so set that when the water is at the lowest reading in the water-gage glass, it shall be 3 in. (75 mm) above the lowest permissible water level as determined by the manufacturer. Horizontal firetube boilers that do not exceed 16 in. (400 mm) in inside diameter shall have the lowest visible level in the gage glass at least 1 in. (25 mm) above the lowest permissible level as determined by the manufacturer.
- j) Each water-gage glass shall be equipped with a top and a bottom shutoff valve of such through-flow construction as to prevent blockage by deposits of sediment and to indicate by the position of the operating mechanism whether they are in the open or closed position. The pressure-temperature rating shall be at least equal to that of the lowest set pressure of any safety valve on the boiler drum and the corresponding saturated steam temperature.

2.8.2 PRESSURE GAGE

- a) Each steam boiler shall have a pressure gage connected to the steam space or to the steam connection to the water column. When a pressure-reducing valve is installed in the steam supply piping, a pressure gage shall be installed on the low pressure side of the pressure-reducing valve.
- b) The dial range shall not be less than 1.5 times and no greater than approximately two times the pressure at which the lowest pressure relief valve is set.

2.8.2.1 CONNECTION

- a) For a steam boiler the gage or connection shall contain a siphon or equivalent device that will develop and maintain a water seal that will prevent steam from entering the gage tube. A valve or cock shall be placed in the gage connection adjacent to the gage. An additional valve or cock should be located near the boiler providing it is locked or sealed in the open position. No other shut-off valves shall be located between the gage and the boiler.
- b) Pressure gage connections shall be suitable for the maximum allowable working pressure and temperature, but if the temperature exceeds 406°F (208°C), brass or copper pipe or tubing shall not be used.

The connections to the boiler, except for the siphon, if used, shall not be less than NPS 1/4 (DN 8). Where steel or wrought iron pipe or tubing is used, it shall not be less than 1/2 in. (13 mm) inside diameter. The minimum size of a siphon, if used, shall be 1/4 in. (6 mm) inside diameter.

2.8.3 TEMPERATURE

Each high-temperature water boiler shall have a temperature gage or other reporting device located to provide an accurate representation of the temperature at or near the boiler outlet.

2.8.4 PRESSURE CONTROL

Each automatically fired steam boiler shall be protected from overpressure by two pressure operated controls.

- a) Each individual steam boiler or each system of commonly connected steam boilers shall have a control that will cut off the fuel supply when the steam pressure reaches an operating limit, which shall be less than the maximum allowable working pressure.
- b) Each individual automatically fired steam boiler shall have a safety limit control, with a manual reset, that will cut off the fuel supply to prevent steam pressure from exceeding the maximum allowable working pressure of the boiler. Each control shall be constructed to prevent a pressure setting above the maximum allowable working pressure of the boiler.
- c) Shutoff valves of any type shall not be placed in the steam pressure connection between the boiler and the controls described in a) and b) above. These controls shall be protected with a siphon or equivalent means of maintaining a water seal that will prevent steam from entering the control. The connections to the boiler shall not be less than NPS 1/4 (DN 8) for lengths up to and including 5 ft (1.5 m) and not less than NPS 1/2 (DN 15) for lengths over 5 ft (1.5 m), but where steel or wrought iron pipe or tubing is used, they shall not be less than NPS 1/2 (DN 15) for lengths up to and including 5 ft (1.5 m) and not less than NPS 1 (DN 25) for lengths over 5 ft (1.5 m). The minimum size of an external siphon shall be NPS 1/4 (DN 8) or 3/8 in. (10 mm) outside diameter nonferrous tubing.
- d) Pressure controls should have separate connections, however manifolding is permitted. When multiple pressure controls are connected to the boiler with a common manifold, the connection at the boiler up to and including the entire manifold, for pipe of nonferrous material, shall not be less than NPS 1/2 (DN 15) for lengths up to and including 5 ft (1.5 m) and not less than NPS 3/4 (DN 20) for lengths over 5 ft (1.5 m). For manifolds using ferrous material, the connection at the boiler up to and including the entire manifold shall not be less than NPS 3/4 (DN 20) for lengths up to and including 5 ft (1.5 m) and not less than NPS 1 1/4 (DN 32) for lengths over 5 ft (1.5 m). Individual controls are to be piped from the manifold according to the provisions of c) above.

2.8.5 AUTOMATIC LOW-WATER FUEL CUTOFF AND/OR WATER FEEDING DEVICE FOR STEAM OR VAPOR SYSTEM BOILERS

- a) Each automatically fired steam-or vapor-system boiler shall have an automatic low-water fuel cutoff so located as to automatically cut off the fuel supply when the surface of the water falls to the lowest visible part of the water-gage glass. If a water feeding device is installed, it shall be so constructed that the water inlet valve cannot feed water into the boiler through the float chamber and so located as to supply requisite feedwater.
- b) Such a fuel cutoff or water feeding device may be attached directly to a boiler. A fuel cutoff or water feeding device may also be installed in the tapped openings available for attaching a water glass directly to a boiler, provided the connections are made to the boiler with nonferrous tees or Y's not less than NPS 1/2 (DN 15) between the boiler and water glass so that the water glass is attached directly and as close as possible to the boiler; the run of the tee or Y shall take the water glass fittings, and the

side outlet or branch of the tee or Y shall take the fuel cutoff or water feeding device. The ends of all nipples shall be reamed to full-size diameter.

- c) In addition to the requirements in a) and b) above, a secondary low-water fuel cutoff with manual reset shall be provided on each automatically fired steam or vapor system boiler.
- d) Fuel cutoffs and water feeding devices embodying a separate chamber shall have a vertical drain pipe, extended to a safe point of discharge, and a blowoff valve not less than NPS 3/4 (DN 20), located at the lowest point in the water equalizing pipe connections so that the chamber and the equalizing pipe can be flushed and the device tested.
- e) Each electric steam boiler of the resistance element type shall be equipped with an automatic low-water cutoff so located as to automatically cut off the power supply to the heating elements before the surface of the water falls below the visible part of the glass. No low-water cutoff is required for electrode-type boilers.

2.9 PRESSURE RELIEF VALVES

2.9.1 VALVE REQUIREMENTS – GENERAL

- a) Only direct spring loaded, pilot operated, or power actuated pressure relief valves designed to relieve steam shall be used for steam service.
- b) Pressure relief valves shall be manufactured in accordance with a national or international standard and be certified for capacity by the National Board.
- c) Deadweight or weighted-lever pressure relief valves shall not be used.
- d) For high-temperature water boilers, safety relief valves shall have a closed bonnet, and valve bodies shall not be constructed of cast iron.
- e) Pressure relief valves with an inlet connection greater than NPS 3 (DN 80) used for pressure greater than 15 psig (103 kPa), shall have a flange or a welded inlet connection. The dimensions of flanges subjected to boiler pressure shall conform to the applicable standards.
- f) When a pressure relief valve is exposed to outdoor elements that may affect operation of the valve, the valve may be shielded with a cover. The cover shall be vented and arranged to permit servicing and normal operation of the valve.
- g) All covers, caps, and/or plugs utilized for shipping or transport shall be removed prior to installation or being placed in service.
- h) Any wire or restraining device on lifting lever utilized for shipping or transport shall be removed prior to being placed in service.

2.9.1.1 NUMBER

At least one National Board capacity certified pressure relief valve shall be installed on the boiler. If the boiler has more than 500 ft² (47 m²) of bare tube water heating surface, or if an electric boiler has a power input of more than 3.76 million Btu/hr (1,100 kW), two or more National Board capacity certified pressure relief valves shall be installed. For a boiler with combined bare tube and extended water-heating surface exceeding 500 ft² (47 m²), two or more pressure relief valves are required only if the maximum designed steaming capacity of the boiler exceeds 4,000 lb/hr (1,800 kg/hr).

2.9.1.2 LOCATION

- a) Pressure relief valves shall be placed on, or as close as physically possible to, the boiler proper.
- b) Pressure relief valves shall not be placed on the feedline.
- c) Pressure relief valves shall be connected to the boiler independent of any other connection without any unnecessary intervening pipe or fittings. Such intervening pipe or fittings shall not be longer than the face-to-face dimension of the corresponding tee fitting of the same diameter and pressure rating as listed in the applicable standards.

2.9.1.3 CAPACITY

- a) The pressure relief valve capacity for each boiler shall be such that the valve or valves will discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 6% above the highest pressure at which any valve is set and in no case to more than 6% above the maximum allowable working pressure of the boiler.
- b) The minimum relieving capacity for other than electric boilers and forced-flow steam generators with no fixed steam line and waterline shall be estimated for the boiler and waterwall heating surfaces as given in NBIC Part 1, Table 2.9.1.3, but in no case shall the minimum relieving capacity be less than the maximum designed steaming capacity as determined by the manufacturer.
- c) The required relieving capacity, C, of the pressure relief valves on a high temperature water boiler shall be determined as follows:

$$C = Q/L$$

where,

C = required relieving capacity in lbs/hr (kg/hr)

Q = maximum output in BTU/hr (W) at the boiler nozzle obtained by the firing of any fuel for which the unit is designed

L = 1000 BTU/lb (646 W•hr/kg)

- d) The minimum pressure relief valve relieving capacity for electric boilers shall not be less than 3.5 lbs/hr/kW (1.6 kg/hr/kW) input.
- e) If the pressure relief valve capacity cannot be computed, or if it is desirable to prove the computations, it should be checked by any one of the following methods; and if found insufficient, additional relieving capacity shall be provided:
 - 1) By performing an accumulation test, that is, by shutting off all other steam discharge outlets from the boiler and forcing the fires to the maximum. This method should not be used on a boiler with a superheater or reheater, or on a high-temperature water boiler;
 - 2) By measuring the maximum amount of fuel that can be burned and computing the corresponding evaporative capacity upon the basis of the heating value of the fuel;
 - 3) By determining the maximum evaporative capacity by measuring the feedwater. The sum of the pressure relief valve capacities marked on the valves shall be equal to or greater than the maximum evaporative capacity of the boiler. This method should not be used on high-temperature water boilers.

TABLE 2.9.1.3

MINIMUM POUNDS OF STEAM PER HOUR PER SQUARE FOOT OF HEATING SURFACE
lb steam/hr ft² (kg steam/hr m²)

	Firetube Boiler	Watertube Boiler
Boiler Heating Surface		
Hand-fired	5 (24)	6 (29)
Stoker-fired	7 (34)	8 (39)
Oil, gas, or pulverized coal	8 (39)	10 (49)
Waterwall Heating Surface		
Hand-fired	8 (39)	8 (39)
Stoker-fired	10 (49)	12 (59)
Oil, gas, or pulverized coal	14 (68)	16 (78)
Copper-finned Watertubes		
Hand-fired		4 (20)
Stoker-fired		5 (24)
Oil, gas, or pulverized coal		6 (29)

Notes:

- When a boiler is fired only by a gas having a heat value not in excess of 200 Btu/ft.³(7.5MJ/m³), the minimum relieving capacity should be based on the values given for hand-fired boilers above.
- The heating surface shall be computed for that side of the boiler surface exposed to the products of combustion, exclusive of the superheating surface. In computing the heating surface for this purpose only the tubes, fireboxes, shells, tubesheets, and the projected area of headers need to be considered, except that for vertical firetube steam boilers, only that portion of the tube surface up to the middle gage cock is to be computed.
- For firetube boiler units exceeding 8,000 Btu/ft.² (9,085 J/cm.²) (total fuel Btu (J) Input divided by total heating surface), the factor from the table will be increased by 1 (4.88) for every 1,000 Btu/ft.² (1,136 J/cm.²) above 8,000 Btu/ft.² (9,085 J/cm.²) For units less than 7,000 Btu/ft.² (7,950 J/cm.²), the factor from the table will be decreased by 1 (4.88).
- For watertube boiler units exceeding 16,000 Btu/ft.² (18,170 J/cm.²)(total fuel Btu input divided by the total heating surface) the factor from the table will be increased by 1 (4.88) for every 1,000 Btu/ft.² (1,136 J/cm.²) above 16,000 Btu/ft.² (18,170 J/cm.²). For units with less than 15,000 Btu/ft.² (17,034 J/cm.²), the factor in the table will be decreased by 1 (4.88) for every 1,000 Btu/ft.² (1,136 J/cm.²) below 15,000 Btu/ft.² (17,034 J/cm.²).

2.9.1.4 SET PRESSURE

One or more pressure relief valves on the boiler proper shall be set at or below the maximum allowable working pressure. If additional valves are used, the highest pressure setting shall not exceed the maximum allowable working pressure by more than 3%. The complete range of pressure settings of all the pressure relief valves on a boiler shall not exceed 10% of the highest pressure to which any valve is set. The pressure setting of pressure relief valves on high temperature water boilers may exceed this 10% range.

2.9.2 FORCED-FLOW STEAM GENERATOR

For a forced-flow steam generator with no fixed steamline and waterline, equipped with automatic controls and protective interlocks responsive to steam pressure, pressure relief valves may be provided in accordance with the above paragraphs identified in NBIC Part 1, 2.9.1 or the following protection against overpressure shall be provided:

- a) One or more power-actuated pressure relief valves shall be provided in direct communication with the boiler when the boiler is under pressure and shall receive a control impulse to open when the maximum allowable working pressure at the superheater outlet is exceeded. The total combined relieving capacity of the power-actuated pressure relief valves shall be not less than 10% of the maximum design steaming capacity of the boiler under any operating condition as determined by the manufacturer. The valves shall be located in the pressure part system where they will relieve the overpressure. An isolating stop valve of the outside-screw-and-yoke type should be installed between the power-actuating pressure relief valve and the boiler to permit repairs provided an alternate power-actuated pressure relief valve of the same capacity is so installed as to be in direct communication with the boiler.
- b) Pressure relief valves shall be provided having a total combined relieving capacity, including that of the power-actuated pressure relief valve, of not less than 100% of the maximum designed steaming capacity of the boiler, as determined by the manufacturer. In this total, credit in excess of 30% of the total relieving capacity shall not be allowed for the power-actuated pressure relief valves actually installed. Any or all of the pressure relief valves may be set above the maximum allowable working pressure of the parts to which they are connected, but the set pressures shall be such that when all these valves (together with the power-actuated pressure relief valves) are in operation the pressure will not rise more than 20% above the maximum allowable working pressure of any part of the boiler, except for the steam piping between the boiler and the prime mover.
- c) When stop valves are installed in the water-steam flow path between any two sections of a forced-flow steam generator with no fixed steamline and waterline:
 - 1) The power-actuated pressure relief valve shall also receive a control impulse to open when the maximum allowable working pressure of the component, having the lowest pressure level upstream to the stop valve, is exceeded;
 - 2) The pressure relief valve shall be located to provide overpressure protection for the component having the lowest working pressure; and
 - 3) A reliable pressure-recording device shall always be in service and records kept to provide evidence of conformity to the above requirements.

2.9.3 SUPERHEATERS

- a) Every attached superheater shall have one or more pressure relief valves. The location shall be suitable for the service intended and shall provide the overpressure protection required. The pressure drop upstream of each pressure relief valve shall be considered in determining the set pressure and relieving capacity of that valve. If the superheater outlet header has a full, free steam passage from end to end and is so constructed that steam is supplied to it at practically equal intervals throughout its length so that there is a uniform flow of steam through the superheater tubes and the header, the pressure relief valve or valves may be located anywhere in the length of header.
- b) The pressure-relieving capacity of the pressure relief valve or valves on an attached superheater shall be included in determining the number and size of the pressure relief valves for the boiler provided there are no intervening valves between the superheater pressure relief valve and the boiler and the discharge capacity of the pressure relief valve or valves, on the boiler, as distinct from the superheater, is at least 75% of the aggregate capacity required.

- c) Every independently fired superheater that may be shut off from the boiler and permit the superheater to become a fired pressure vessel shall have one or more pressure relief valves having a discharge capacity equal to 6 pounds of steam per hr/ft.² (29 kg per hr per sq. m) of superheater surface measured on the side exposed to the hot gases.
- d) Every pressure relief valve used on a superheater discharging superheated steam at a temperature over 450°F (230°C) shall have a casing, including the base, body, bonnet, and spindle constructed of steel, steel alloy, or equivalent heat-resistant material. The valve shall have a flanged inlet connection or a welded-end inlet connection. The seat and disk shall be constructed of suitable heat-erosive and corrosive-resistant material, and the spring fully exposed outside of the valve casing so that it is protected from contact with the escaping steam.

2.9.4 ECONOMIZERS

An economizer that can not be isolated from a boiler does not require a pressure relief valve. Economizers that can be isolated from a boiler or other heat transfer device, allowing the economizer to become a fired pressure vessel, shall have a minimum of one pressure relief valve. Discharge capacity, rated in lbs/hr (kg/hr), of the pressure relief valve or valves shall be calculated from the maximum expected heat absorption rate in Btu/hr (W) of the economizer, and will be determined from manufacturer data, divided by 1,000 Btu/lb (2,326kJ/kg). The pressure relief valve shall be installed in a location recommended by the manufacturer when no recommendation exists the location shall be as close as practical to the economizer outlet.

2.9.5 PRESSURE-REDUCING VALVES

- a) Where pressure-reducing valves are used, one or more pressure relief valves shall be installed on the low pressure side of the reducing valve in those installations where the piping or equipment on the low pressure side does not meet the requirements for the steam supply piping.
- b) The pressure relief valves shall be located as close as possible to the pressure-reducing valve.
- c) The capacity of the pressure relief valves shall not be less than the total amount of steam that can pass from the high pressure side to the low pressure side and be such that the pressure rating of the lower pressure piping or equipment shall not be exceeded.
- d) The use of hand-controlled bypasses around reducing valves is permissible. The bypass around a reducing valve may not be greater in capacity than the reducing valve unless the piping or equipment is adequately protected by pressure relief valves or meets the requirements of the high pressure system.
- e) See Supplement 2 for additional information on the calculation of the required capacity of pressure relief valves installed after pressure-reducing valves.

2.9.6 INSTALLATION AND DISCHARGE REQUIREMENTS

- a) Every boiler shall have outlet connections for the pressure relief valve, or valves, independent of any other outside steam connection, the area of opening shall be at least equal to the aggregate areas of inlet connections of all of the attached pressure relief valves. An internal collecting pipe, splash plate, or pan should be used, provided the total area for inlet of steam is not less than twice the aggregate areas of the inlet connections of the attached pressure relief valves. The holes in such collecting pipes shall be at least 1/4 in. (6 mm) in diameter, and the least dimension in any other form of opening for inlet of steam shall be 1/4 in. (6 mm). If pressure relief valves are attached to a separate steam drum or dome, the opening between the boiler proper and the steam drum or dome shall be not less than 10 times the total area of the pressure relief valve inlet.
- b) Every pressure relief valve shall be connected so as to stand in an upright position with spindle vertical.

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- c) The opening or connection between the boiler and the pressure relief valve shall have at least the area of the valve inlet and the inlet pipe to the pressure relief valve shall be as short and straight as possible, no longer than twice the center-to-end (face) dimension of a corresponding tee fitting of the same diameter, pressure class, and connection type. When a discharge pipe is used, the cross-sectional area shall not be less than the full area of the valve outlet or of the total of the areas of the valve outlets. It shall be as short and straight as possible and arranged to avoid undue stresses on the valve or valves.
 - d) No valves of any type, except a changeover valve, shall be placed between the pressure relief valves and the boiler, nor on the discharge pipe between the pressure relief valves and the atmosphere.

A changeover valve, may be used provided the changeover valve is in accordance with the original code of construction. It is recommended that the Jurisdiction be contacted to determine the acceptability of changeover valves on boiler applications.

- e) When two or more pressure relief valves are used on a boiler, they shall be installed either separately, as twin valves made by placing individual valves on a Y-base, or duplex valves having two valves in the same body casing. If twin or duplex valves are used, they shall be of equal size.
- f) When two valves of different sizes are installed singly, the relieving capacity of the smaller valve shall not be less than 50% of that of the larger valve.
- g) When a boiler is fitted with two or more pressure relief valves on one connection, this connection to the boiler shall have a cross-sectional area not less than the combined areas of inlet connections of all the pressure relief valves with which it connects.
- h) All pressure relief valves shall be piped to a safe point of discharge. Provision for an ample gravity drain shall be made in the discharge pipe at or near each pressure relief valve, and where water or condensation may collect. Each valve shall have an open gravity drain through the casing below the level of the valve seat. For iron- and steel-bodied valves exceeding NPS 2 (DN 50), the drain hole shall be tapped not less than NPS 3/8 (DN 10).
- i) Discharge piping from pressure relief valves on high-temperature water boilers shall have adequate provisions for water drainage as well as steam venting.
- j) If a muffler is used on a pressure relief valve, it shall have sufficient outlet area to prevent back pressure from interfering with the proper operation and discharge capacity of the valve. The muffler plates or other devices shall be so constructed as to avoid a possibility of restriction of the steam passages due to deposits. Mufflers shall not be used on high-temperature water boiler pressure relief valves.

2.10 TESTING AND ACCEPTANCE

2.10.1 GENERAL

- a) Care shall be exercised during installation to prevent loose weld material, welding rods, small tools, and miscellaneous scrap metal from getting into the boiler. Where possible, an inspection of the interior of the boiler and its appurtenances shall be made for the presence of foreign debris prior to making the final closure.
- b) Safe operation should be verified by a person familiar with boiler system operations for all boilers and connected appurtenances and all pressure piping connecting them to the appurtenances and all piping up to and including the first stop valve, or the second stop valve when two are required.
- c) The wall thickness of all pipe connections shall comply with the requirements of the code of construction for the boiler.
- d) All threaded pipe connections shall engage at least five full threads of the pipe or fitting.

- e) In bolted connections, the bolts, studs, and nuts shall be marked as required by the original code of construction and be fully engaged (e.g., the end of the bolt or stud shall protrude through the nut).
- f) Washers shall only be used when specified by the manufacturer of the part being installed.

2.10.2 PRESSURE TEST

See NBIC Part 1, Section 1.6.10, *Testing And Final Acceptance*.

2.10.3 NONDESTRUCTIVE EXAMINATION

Boiler components and subcomponents shall be nondestructively examined as required by the governing code of construction.

2.10.4 SYSTEM TESTING

See NBIC Part 1, Section 1.6.10, *Testing And Final Acceptance*.

2.10.5 FINAL ACCEPTANCE

See NBIC Part 1, Section 1.6.10, *Testing And Final Acceptance*.

2.10.6 BOILER INSTALLATION REPORT

- a) Upon completion, inspection, and acceptance of the installation, the installer shall complete and certify the *Boiler Installation Report* I-1. See NBIC Part 1, 1.4.5.1.
- b) The *Boiler Installation Report* I-1 shall be submitted as follows:
 - 1) One copy to the owner; and
 - 2) One copy to the Jurisdiction, if required.

2.11 TABLES AND FIGURES

- a) NBIC Part 1, Table 2.5.1.3 - Guide for Feedwater Pump Differential
- b) NBIC Part 1, Table 2.9.1.3 - Minimum Pounds of Steam per Hour Per Square Foot of Heating Surface

PART 1, SECTION 3

INSTALLATION — STEAM HEATING BOILERS, HOT-WATER HEATING BOILERS, HOT-WATER SUPPLY BOILERS, AND POTABLE WATER HEATERS

3.1 SCOPE

This section provides requirements and guidelines for the installation of steam heating boilers, hot-water heating boilers, hot-water supply boilers, and potable water heaters.

3.2 DEFINITIONS

See in NBIC Part 1, Section 9, *Glossary*.

3.3 GENERAL REQUIREMENTS

3.3.1 SUPPORTS

See NBIC Part 1, Section 1.6.1, *Supports, Foundations and Settings*.

3.3.1.1 METHODS OF SUPPORT FOR STEAM HEATING, HOT-WATER HEATING, AND HOT-WATER SUPPLY BOILERS

a) Loadings

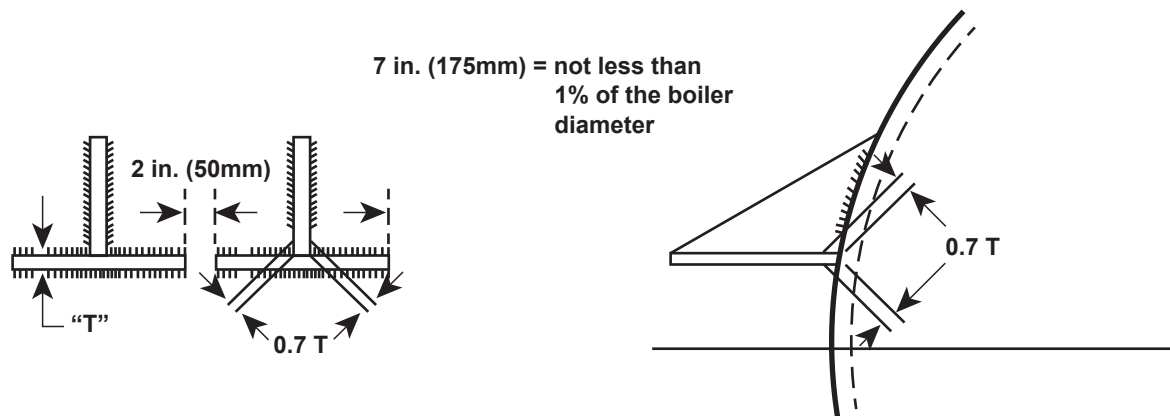
- 1) The design and attachment of lugs, hangers, saddles, and other supports shall take into account the stresses due to hydrostatic head of fully flooded equipment in determining the minimum thicknesses required. Additional stresses imposed by effects other than working pressure or static head that increase the average stress by more than 10% of the allowable working stress shall also be taken into account. These effects include the weight of the component and its contents and the method of support.
- 2) In applying the requirements of 1) above, provision shall be made for localized stresses due to concentrated support loads, temperature changes, and restraint against movement of the boiler due to pressure. Lugs, hangers, brackets, saddles, and pads shall conform satisfactorily to the shape of the shell or surface to which they are attached or are in contact.

b) Horizontal Return Firetube Boilers

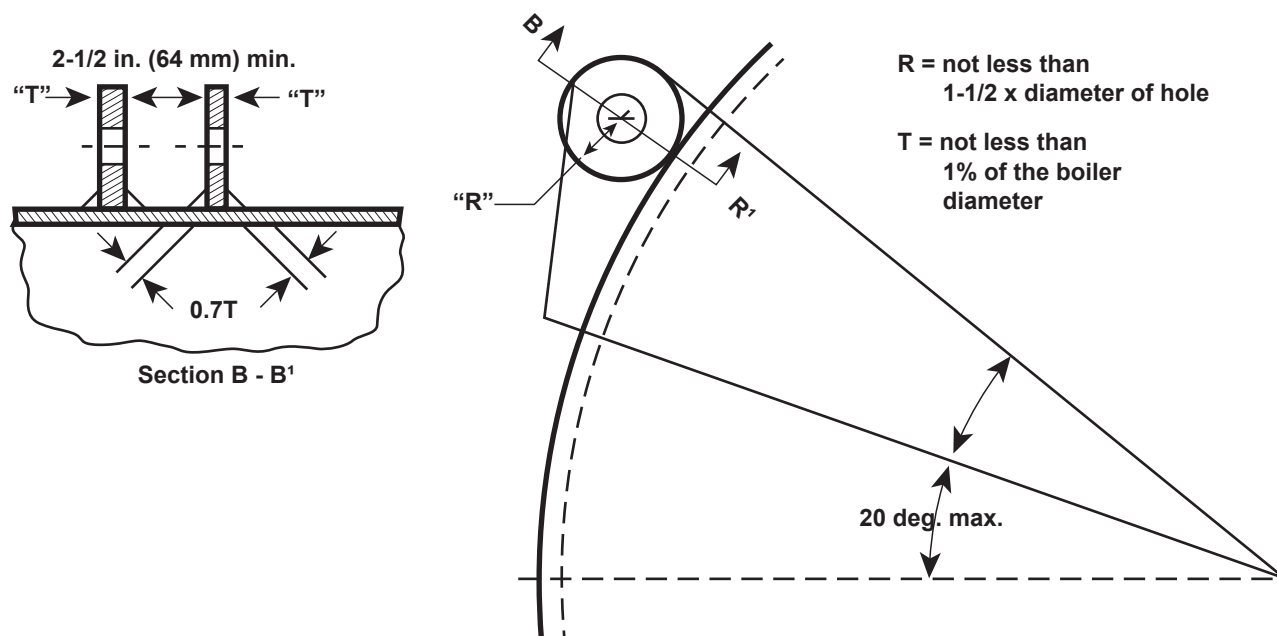
- 1) Boilers over 72 in. (1,830 mm) in diameter. A horizontal-return tubular boiler over 72 in. (1,830 mm) in diameter shall be supported from steel hangers by the outside-suspension type of setting, independent of the furnace wall. The hangers shall be so designed that the load is properly distributed.
- 2) Boilers 14 ft. (4.3 m) or over in length, or over 54 in. (1,370 mm) up to 72 in. (1,830 mm) in diameter: A horizontal-return tubular boiler over 54 in. (1,370 mm) and up to and including 72 in. (1,830 mm) in diameter shall be supported by the outside-suspension type of setting, or at four points by not less than eight steel brackets set in pairs, the brackets of each pair to be spaced not over 2 in. (50 mm) apart and the load to be equalized between them. See NBIC Part 1, Figure 3.3.1.1-a.
- 3) Boilers up to 54 in. (1,370 mm) in diameter
A horizontal-return boiler up to and including 54 in. (1,370 mm) in diameter shall be supported by the outside-suspension type of setting, or by not less than two steel brackets on each side. See NBIC Part 1, Figures 3.3.1.1-b.

FIGURE 3.3.1.1-a

SPACING AND WELD DETAILS FOR SUPPORTING LUGS IN PAIRS ON HORIZONTAL-RETURN TUBULAR BOILERS

**FIGURE 3.3.1.1-b**

WELDED BRACKET CONNECTION FOR HORIZONTAL-RETURN TUBULAR BOILERS



c) Supporting Members

If the boiler is supported by structural steel work, the steel supporting members shall be so located or insulated that the heat from the furnace will not impair their strength.

d) Lugs, Hangers, or Brackets

Lugs, hangers, or brackets made of materials in accordance with the requirements of the code of construction may be attached by fusion welding provided they are attached by fillet welds along the entire periphery or contact edges. NBIC Part 1, Figure 3.3.1.1-b illustrates an acceptable design of hanger bracket with the additional requirement that the center pin be located at the vertical center line over the center of the welded contact surface. The bracket plates shall be spaced at least 2-1/2 in. (64 mm) apart, but this dimension shall be increased if necessary to permit access for the welding operation. The stresses computed by dividing the total load on each lug, hanger, or bracket, by the minimum cross-sectional area of the weld shall not exceed 2,800 psig (19 MPa). Where it is impractical to attach lugs, hangers, or brackets by welding, studs with not less than 10 threads/in. (approximately 4 threads/cm) may be used. In computing the shearing stresses, the root area at the bottom of the thread shall be used. The shearing and crushing stresses on studs shall not exceed that permitted by the code of construction.

3.3.2 SETTINGS

See NBIC Part 1, Section 1.6.1, *Supports, Foundations and Settings*

3.3.3 STRUCTURAL STEEL

See NBIC Part 1, Section 1.6.2, *Structural Steel*

3.3.4 CLEARANCES

- a) Heating boilers shall have a minimum distance of at least 36 in. (914 mm) between the top of the heating boiler and any overhead structure and at least 36 in. (914 mm) between all sides of the heating boiler and adjacent walls, structures, or other equipment. Heating boilers having manholes shall have at least 84 in. (2,135 mm) of clearance between the manhole opening and any wall, ceiling, piping, or other equipment that may prevent a person from entering the heating boiler. Alternative clearances in accordance with the manufacturer's recommendations are subject to acceptance by the Jurisdiction.
- b) Modular heating boilers that require individual units to be set side by side, front to back, or by stacking shall provide clearances in accordance with the manufacturer's recommendations, subject to acceptance by the Jurisdiction.
- c) Heating boilers shall be located so that adequate space is provided for proper operation, maintenance, and inspection of equipment and appurtenances, which shall include the removal of tubes if applicable.

3.4 EQUIPMENT ROOM REQUIREMENTS**3.4.1 EXIT**

See NBIC Part 1, Section 1.6.3, *Exit*

3.4.2 LADDERS AND RUNWAYS

See NBIC Part 1, Section 1.6.4, *Ladders and Runways*

3.5 SOURCE REQUIREMENTS

3.5.1 WATER

- a) A means to add water to or fill the boiler, while not under pressure, shall be provided. A valve or threaded plug may be used to shut off the fill connection when the boiler is in service.
- b) Water fill connections shall be installed. A means shall be provided at or near the boiler to prevent back-feeding. Such means shall be rated for the boiler design pressure and temperature.
- c) Provision should also be made in every equipment room for a convenient water supply that can be used to flush out the boiler and to clean the equipment room floor.

3.5.2 FUEL

See NBIC Part 1, Section 1.6.5, *Fuel*.

3.5.3 ELECTRICAL

3.5.3.1 STEAM HEATING, HOT WATER HEATING, AND HOT WATER SUPPLY BOILERS

- a) All wiring for controls, heat generating apparatus, and other appurtenances necessary for the operation of the boiler or boilers shall be installed in accordance with the provisions of national or international standards and comply with the applicable local electrical codes.
- b) A disconnecting means capable of being locked in the open position shall be installed at an accessible location at the boiler so that the boiler can be disconnected from all sources of potential. This disconnecting means shall be an integral part of the boiler or adjacent to it.
- c) A manually operated remote shutdown switch or circuit breaker shall be located just outside the equipment room door and marked for easy identification. Consideration should also be given to the type and location of the switch to safeguard against tampering.
- d) If the equipment room door is on the building exterior, the switch should be located just inside the door. If there is more than one door to the equipment room, there should be a switch located at each door of egress.
 - 1) For atmospheric-gas burners, and oil burners where a fan is on a common shaft with the oil pump, the complete burner and controls should be shut off.
 - 2) For power burners with detached auxiliaries, only the fuel input supply to the firebox need to be shut off.

3.5.3.2 POTABLE WATER HEATERS

- a) All wiring for controls, heat generating apparatus, and other appurtenances necessary for the operation of the potable water heaters shall be installed in accordance with the provisions of national or international standards and comply with the applicable local electrical codes.
- b) A manually operated remote shutdown switch or circuit breaker shall be located just outside the equipment room door and marked for easy identification. Consideration should also be given to the type and location of the switch to safeguard against tampering.

- c) A disconnecting means capable of being locked in the open position shall be installed at an accessible location at the heater so that the heater can be disconnected from all sources of potential. This disconnecting means shall be an integral part of the heater or adjacent to it.
- d) If the equipment room door is on the building exterior, the switch should be located just inside the door. If there is more than one door to the equipment room, there should be a switch located at each door of egress.
 - 1) For atmospheric-gas burners, and oil burners where a fan is on a common shaft with the oil pump, the complete burner and controls should be shut off.
 - 2) For power burners with detached auxiliaries, only the fuel input supply needs be shut off.

3.5.3.3 CONTROLS AND HEAT GENERATING APPARATUS

- a) Oil- and gas-fired and electrically heated boilers and water heaters shall be equipped with suitable primary (flame safeguard) safety controls, safety limit controls, and burners or electric elements as required by a nationally or internationally recognized standard.
- b) The symbol of the certifying organization that has investigated such equipment as having complied with a nationally recognized standard shall be affixed to the equipment and shall be considered as evidence that the unit was manufactured in accordance with that standard.
- c) These devices shall be installed in accordance with jurisdictional and environmental requirements, manufacturer's recommendations, and/or industry standards, as applicable.

3.5.4 VENTILATION AND COMBUSTION AIR

See NBIC Part 1, Section 1.6.6, *Ventilation and Combustion Air*.

3.5.5 LIGHTING

See NBIC Part 1, Section 1.6.7, *Lighting*.

3.5.6 EMERGENCY VALVES AND CONTROLS

All emergency shut-off valves and controls shall be accessible from a floor, platform, walkway or runway. Accessibility shall mean within a 6 ft. (1.8 m) elevation of the standing space and not more than 12 in. (305 mm) horizontally from the standing space edge.

3.6 DISCHARGE REQUIREMENTS

3.6.1 CHIMNEY OR STACK

See NBIC Part 1, Section 1.6.8, *Chimney or Stack*.

3.6.2 ASH REMOVAL

Ash removal systems shall be installed in accordance with jurisdictional and environmental requirements, manufacturer's recommendations, and/or industry standards, as applicable.

3.6.3 DRAINS

Unobstructed floor drains, properly located in the equipment room, will facilitate proper cleaning of the equipment room. Floor drains that are used infrequently should have water poured into them periodically to prevent the entrance of sewer gasses and odors. If there is a possibility of freezing, an environmentally safe antifreeze mixture should be used in the drain traps. Drains receiving blowdown water should be connected to the sanitary sewer by way of an acceptable blowdown tank or separator or an air gap that will allow the blowdown water to cool to at least 140°F (60°C) and reduce the pressure to 5 psig (34 kPa) or less.

3.7 OPERATING SYSTEMS

3.7.1 OIL HEATERS

- a) A heater for oil or other liquid harmful to boiler operation shall not be installed directly in the steam or water space within a boiler.
- b) Where an external-type heater for such service is used, means shall be provided to prevent the introduction into the boiler of oil or other liquid harmful to boiler operation.

3.7.2 BREECHING AND DAMPERS

Breeching and dampers shall be installed in accordance with jurisdictional and environmental requirements, manufacturer's recommendations, and/or industry standards, as applicable.

3.7.3 BURNERS AND STOKERS

Burners and stokers shall be installed in accordance with jurisdictional and environmental requirements, manufacturer's recommendations, and/or industry standards, as applicable.

3.7.4 FEEDWATER, MAKEUP WATER, AND WATER SUPPLY

a) Steam Boilers

Feedwater or water treatment shall be introduced into a boiler through the return piping system. Alternatively, feedwater or water treatment shall be introduced through an independent connection. The water flow from the independent connection shall not discharge directly against parts of the boiler exposed to direct radiant heat from the fire. Feedwater or water treatment shall not be introduced through openings or connections provided for inspection or cleaning, safety valve, water column, water-gage glass, or pressure gage. The feedwater pipe shall be provided with a check valve, or a backflow preventer containing a check valve, near the boiler and a stop valve or cock between the check valve and the boiler, or between the check valve and the return pipe system.

b) Hot-Water Boilers

Makeup water may be introduced into a boiler through the piping system or through an independent connection. The water flow from the independent connection shall not discharge directly against parts of the boiler exposed to direct radiant heat from the fire. Makeup water shall not be introduced through openings or connections provided exclusively for inspection or cleaning, safety relief valve, pressure gage, or temperature gage. The makeup water pipe shall be provided with a check valve, or a backflow preventer containing a check valve, near the boiler and a stop valve or cock between the check valve and the boiler, or between the check valve and the piping system.

c) Potable Water Heaters

- 1) Water supply shall be introduced into a water heater through an independent water supply connection. Feedwater shall not be introduced through openings or connections provided for cleaning, safety relief valves, drain, pressure gage, or temperature gage.
- 2) If the water supply pressure to a water heater exceeds 75% of the set pressure of the safety relief valve, a pressure reducing valve is required.

3.7.5 STOP VALVES**(23) 3.7.5.1 STEAM HEATING, HOT WATER HEATING, AND HOT WATER SUPPLY BOILERS**

a) For Single Steam Heating Boilers

When a stop valve is used in the supply pipe connection of a single steam boiler, there shall be one installed in the return pipe connection.

b) For Single Hot Water Heating & Hot Water Supply Boilers

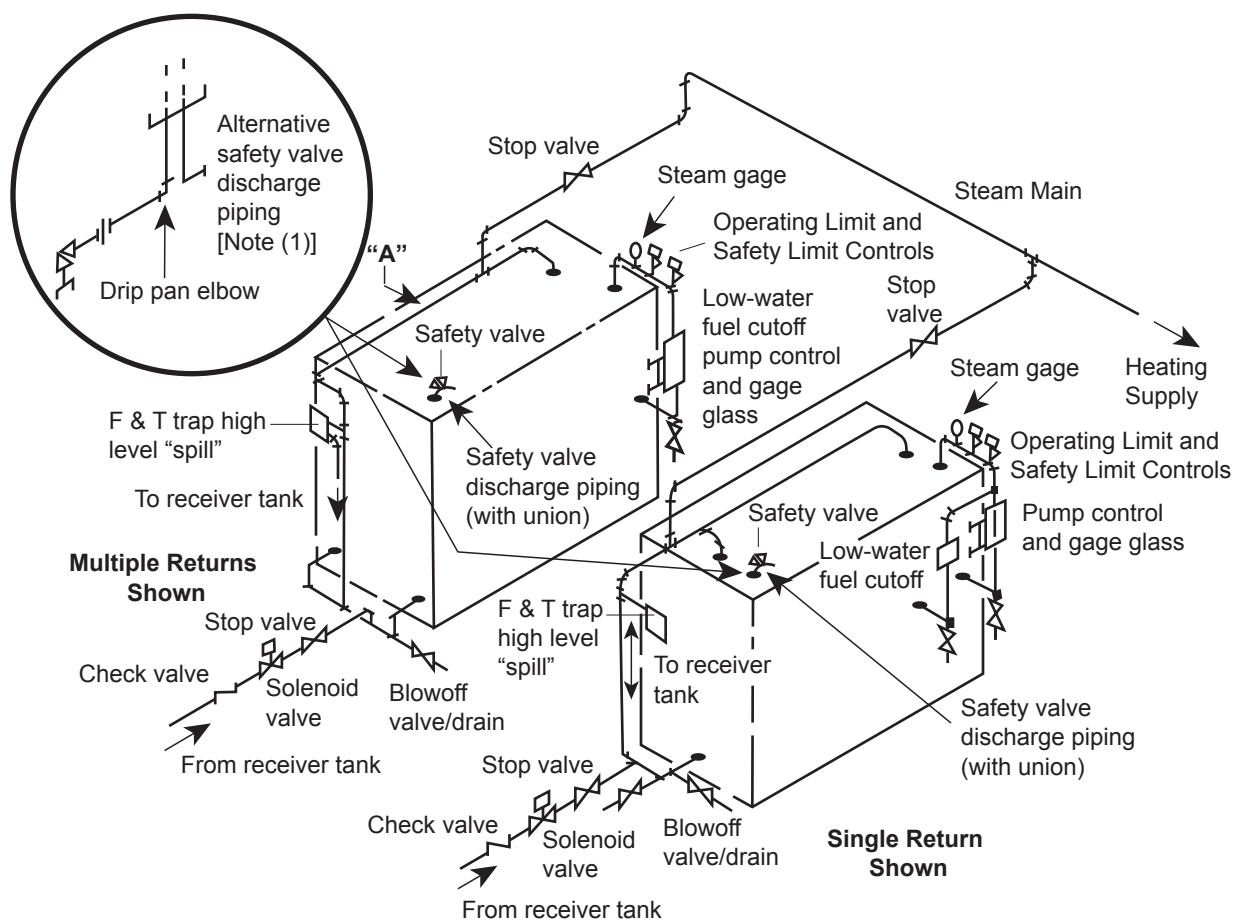
- 1) Stop valves shall be located at an accessible point in the supply and return pipe connections as near the boiler as is convenient and practicable, of a single hot water boiler installation to permit draining the boiler without emptying the system.
- 2) The stop valves required in NBIC Part 1, 3.7.5.1 b) 1) may be eliminated when the boiler can be drained without draining the system. Means to allow draining the boiler without emptying the system may include installation of the boiler above the system or isolation of the boiler from the system by equipment.

c) For Multiple Boiler Installations

A stop valve shall be used in each supply- and-return pipe connection of two or more boilers connected to a common system. See NBIC Part 1, Figures 3.7.5.1-a, 3.7.5.1-b, and 3.7.5.1-c.

d) Types of Stop Valve(s)

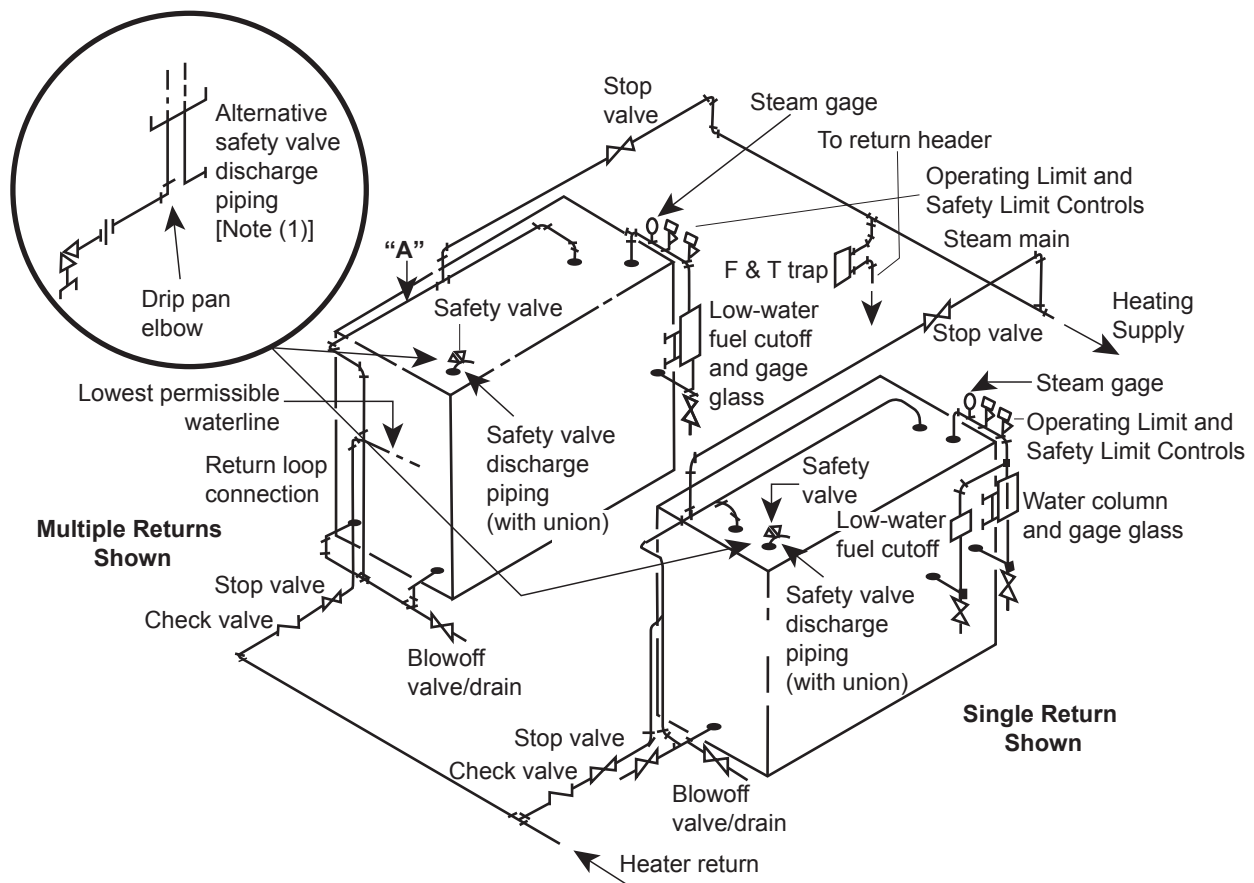
- 1) All valves or cocks shall conform with the applicable portions of an acceptable code of construction and may be ferrous or nonferrous.
- 2) The minimum pressure rating of all valves or cocks shall be at least equal to the pressure stamped upon the boiler, and the temperature rating of such valves or cocks, including all internal components, shall be not less than 250°F (121°C).
- 3) Valves or cocks shall be flanged, threaded or have ends suitable for welding or brazing.
- 4) All valves or cocks with stems or spindles shall have adjustable pressure-type packing glands or alternate design to prevent leakage around the stem and, in addition, all plug-type cocks shall be equipped with a guard or gland. The plug or other operating mechanism shall be distinctly marked in line with the passage to indicate whether it is opened or closed.
- 5) All valves or cocks shall have tight closure when under boiler hydrostatic test pressure.

FIGURE 3.7.5.1-a**STEAM BOILERS IN BATTERY — PUMPED RETURN — ACCEPTABLE PIPING INSTALLATION****General Note:**

Return connections shown for multiple boiler installation may not always ensure that the system will operate properly. In order to maintain proper water levels in multiple boiler installations, it may be necessary to install supplementary controls or suitable devices.

Note:

(1) Recommended for 1 in. (25mm) and larger safety valve discharge.

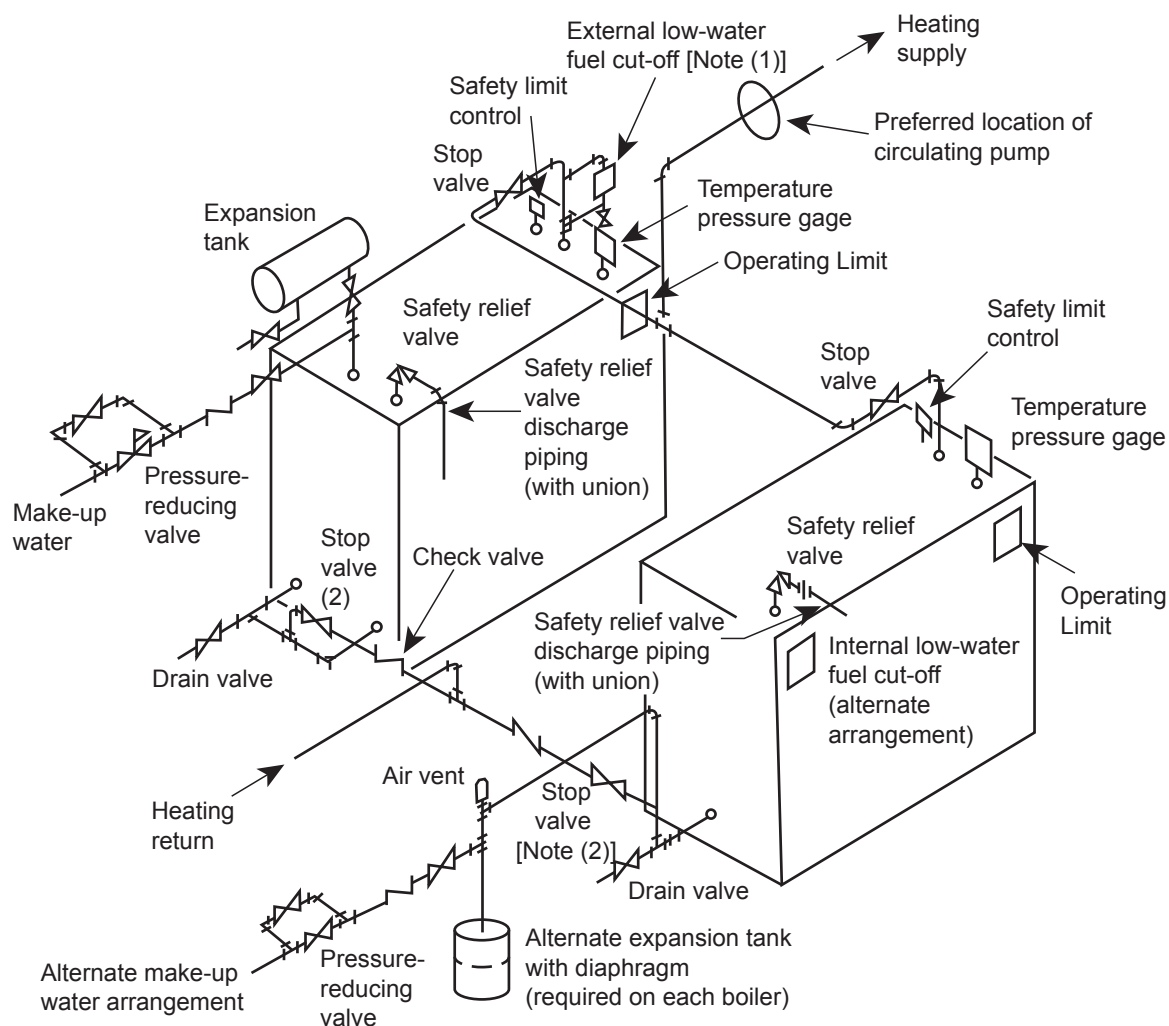
FIGURE 3.7.5.1-b**STEAM BOILERS IN BATTERY — GRAVITY RETURN — ACCEPTABLE PIPING INSTALLATION****General Note:**

Return connections shown for multiple boiler installation may not always ensure that the system will operate properly. In order to maintain proper water levels in multiple boiler installations, it may be necessary to install supplementary controls or suitable devices.

Note:

(1) Recommended for 1 in. (25mm) and larger safety valve discharge.

FIGURE 3.7.5.1-c
HOT-WATER BOILERS IN BATTERY — ACCEPTABLE PIPING INSTALLATION



General Notes:

(1) Recommended control. See ASME Section IV, HG-614. Acceptable shutoff valve or cocks in the connecting piping may be installed for convenience or control testing and/or service.

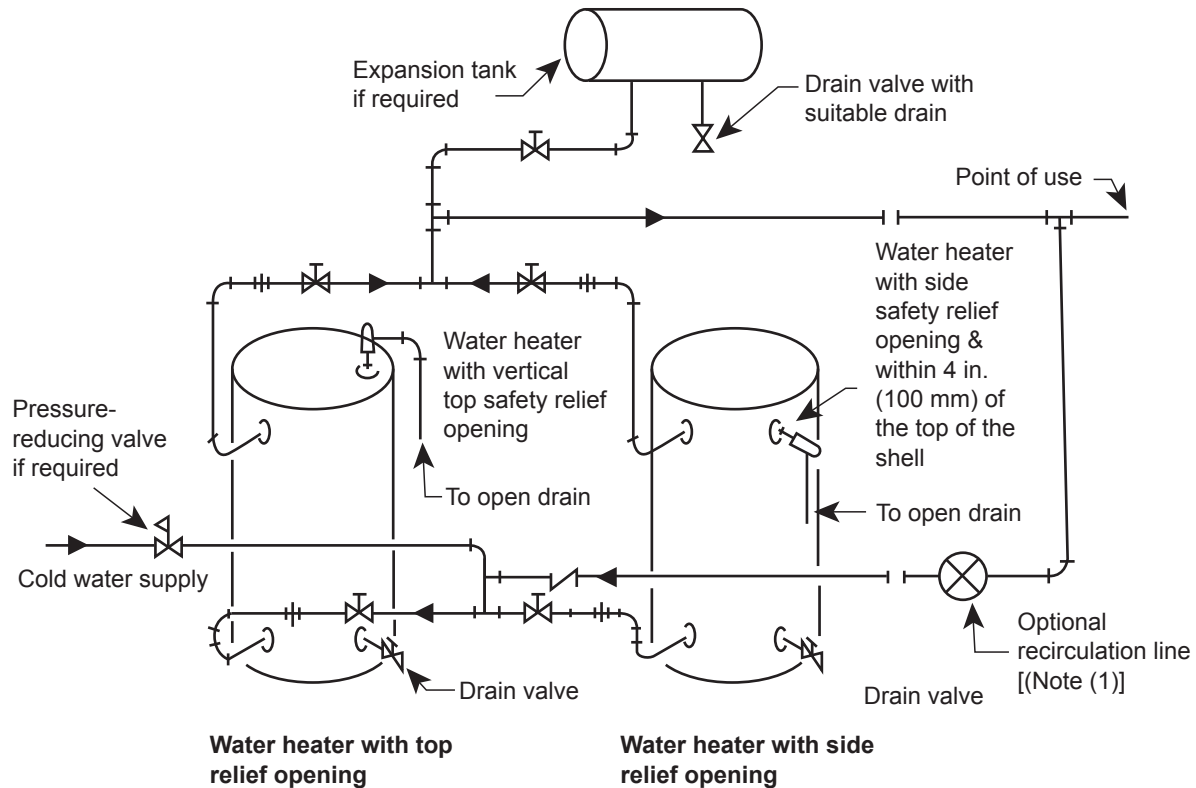
(2) The common return header stop valves may be located on either side of the check valves.

3.7.5.2 POTABLE WATER HEATERS

Stop valves shall be installed in the supply and discharge pipe connections of a water heater installation to permit draining the water heater without emptying the system. See NBIC Part 1, Figures 3.7.5.2-a and 3.7.5.2-b.

FIGURE 3.7.5.2-a

STORAGE POTABLE WATER HEATERS IN BATTERY – ACCEPTABLE PIPING INSTALLATION

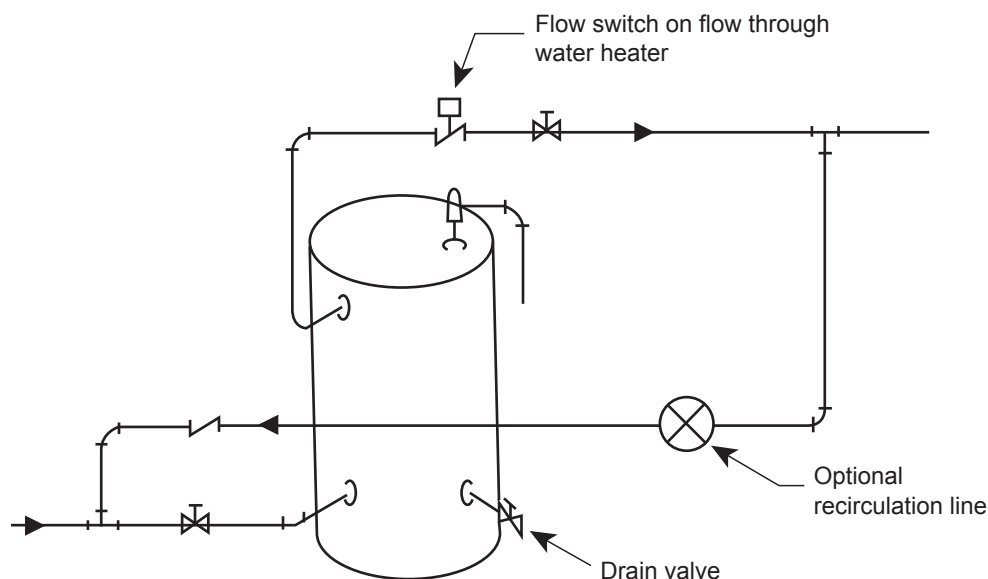


Note:

(1) Recirculation system may be gravity or pump activated.

FIGURE 3.7.5.2-b

FLOW THROUGH POTABLE WATER HEATER WITHOUT PROVISION FOR PIPING EXPANSION—ACCEPTABLE PIPING INSTALLATION.



3.7.6 RETURN PIPE CONNECTIONS

- a) The return pipe connections of each boiler supplying a gravity return steam heating system shall be so arranged as to form a loop substantially as shown in NBIC Part 1, Figure 3.7.5.1-b so that the water in each boiler cannot be forced out below the safe water level.
- b) For hand-fired boilers with a normal grate line, the recommended pipe sizes detailed as “A” in Figures 3.7.5.1-a and 3.7.5.1-b are NPS 1-1/2 (DN 40) for 4 ft² (0.37 m²) or less firebox area at the normal grate line, NPS 2-1/2 (DN 65) for areas more than 4 ft² (0.37 m²) up to 14.9 ft² (1.38 m²), and NPS 4 (DN 100) for 15 ft² (1.39 m²) or more.
- c) For automatically-fired boilers that do not have a normal grate line, the recommended pipe sizes detailed as “A” in Figures 3.7.5.1-a and 3.7.5.1-b are NPS 1-1/2 (DN 40) for boilers with minimum safety valve relieving capacity 250 lb/hr (113 kg/hr) or less, NPS 2-1/2 (DN 65) for boilers with minimum safety valve relieving capacity from 251 lb/hr (114 kg/hr) to 2000 lb/hr (907 kg/hr), inclusive, and NPS 4 (DN 100) for boilers with more than 2,000 lb/hr (907 kg/hr) minimum safety valve relieving capacity.
- d) Provision shall be made for cleaning the interior of the return piping at or close to the boiler. Washout openings should be used for return pipe connections and the washout plug placed in a tee or a cross so that the plug is directly opposite and as close as possible to the opening in the boiler.

3.7.7 BOTTOM BLOWOFF AND DRAIN VALVES

3.7.7.1 STEAM HEATING, HOT-WATER HEATING, AND HOT-WATER SUPPLY BOILERS

- a) Bottom Blowoffs

- 1) Each steam boiler shall have a bottom blowoff connection fitted with a valve or cock connected to the lowest water space practicable with a minimum size as shown in NBIC Part 1, Table 3.7.7.1. The discharge piping shall be full size to the point of discharge.
 - 2) Boilers having a capacity of 25 gallons (95 l) or less are exempt from the above requirements, except that they shall have a NPS 3/4 (DN 20) minimum drain valve.
- b) Drains
- 1) Each steam or hot-water boiler shall have one or more drain connections, fitted with valves or cocks connecting to the lowest water containing spaces. All parts of the boiler must be capable of being drained (the boiler design will dictate the number and size of drains). The minimum size of the drain piping, valves, and cocks shall be NPS 3/4 (DN 20). The discharge piping shall be full size to the point of discharge.
 - 2) When the blowoff connection is located at the lowest water containing space, a separate drain connection is not required.
- c) Minimum Pressure Rating

The minimum pressure rating of valves and cocks used for blowoff or drain purposes shall be at least equal to the pressure stamped on the boiler but in no case less than 30 psig (200 kPa). The temperature rating of such valves and cocks shall not be less than 250°F (121°C).

TABLE 3.7.7.1

SIZE OF BOTTOM BLOWOFF PIPING, VALVES, AND COCKS

Minimum Required Safety Valve Capacity, lbs. of steam/hr (kg steam/hr)	Blowoff Piping, Valve, and Cock Sizes, NPS (DN)
Up to 500 (227)	3/4 (20)
501 to 1,250 (over 227 to 567)	1 (25)
1,251 to 2,500 (567 to 1,134)	1-1/4 (32)
2,501 to 6,000 (1,134 to 2,722)	1-1/2 (40)
6,001 and larger (2,722)	2 (50)

Note:

To determine the discharge capacity of the safety relief valves in terms of total energy absorbed, use 1 lb steam per hour per 1,000 Btu (1 kg steam per hour per 2,326 kJ).

3.7.7.2 POTABLE WATER HEATERS

Drain Valve

- a) Each water heater shall have a bottom drain pipe connection fitted with a valve or cock connected with the lowest water space practicable. The minimum size bottom valve shall be NPS 3/4 (DN 20).
- b) Any discharge piping connected to the bottom drain connection shall be full size to the point of discharge.

3.7.8 MODULAR STEAM HEATING AND HOT-WATER HEATING BOILERS

3.7.8.1 INDIVIDUAL MODULES

- a) The individual modules shall comply with all the requirements of the code of construction and this paragraph.
- b) Each module of a modular steam heating boiler shall be equipped with:
 - 1) Safety valve, see NBIC Part 1, 3.9.2;
 - 2) Blowoff valve, see NBIC Part 1, 3.7.7.1 a); and
 - 3) Drain valve, see NBIC Part 1, 3.7.7.1 b).
- c) Each module of a modular hot-water heating boiler shall be equipped with:
 - 1) Safety relief valve, see NBIC Part 1, 3.9.3; and
 - 2) Drain valve, see NBIC Part 1, 3.7.7.1 b).

3.7.8.2 ASSEMBLED MODULAR BOILERS

- a) The individual modules shall be manifolded together at the job site without any intervening valves.
- b) The assembled modular steam heating boiler shall also be equipped with:
 - 1) Feedwater connection, see NBIC Part 1, Figures 3.7.5.1-a and 3.7.5.1-b; and
 - 2) Return pipe connection, see NBIC Part 1, Figures 3.7.5.1-a and 3.7.5.1-b.
- c) The assembled modular hot water boiler shall also be equipped with:
 - 1) Makeup water connection, see NBIC Part 1, Figure 3.7.5.1-c;
 - 2) Provision for thermal expansion, see NBIC Part 1, Figures 3.7.5.1-c and Table 3.7.9.1-a; and
 - 3) Stop valves, see NBIC Part 1, Figure 3.7.5.1-c (treating the assembled modular boiler as a single unit).

3.7.9 PROVISIONS FOR THERMAL EXPANSION

3.7.9.1 EXPANSION TANKS AND PIPING FOR STEAM HEATING, HOT-WATER HEATING AND HOT-WATER SUPPLY BOILERS

- a) Expansion Tanks for Hot-Water Heating and Hot-Water Supply Boilers

All hot-water heating systems incorporating hot-water tanks or fluid relief columns shall be so installed as to prevent freezing under normal operating conditions.

- 1) Heating Systems With Open Expansion Tank

An indoor overflow from the upper portion of the expansion tank shall be provided in addition to an open vent. The indoor overflow shall be carried within the building to a suitable plumbing fixture or drain.

2) Closed Heating Systems

An expansion tank shall be installed that will be consistent with the volume and capacity of the system. If the system is designed for a working pressure of 30 psig (200 kPa) or less, the tank shall be suitably designed for a minimum hydrostatic test pressure of 75 psig (520 kPa). Expansion tanks for systems designed to operate above 30 psig (200 kPa) shall be constructed in accordance with an acceptable code of construction. Provisions shall be made for draining the tank without emptying the system except for pressurized tanks. The minimum capacity of the closed-type expansion tank should be determined from NBIC Part 1, Tables 3.7.9.1-a and 3.7.9.1-b or from the following formula where the necessary information is available:

US Customary:

$$V_t = \frac{(0.00041T - 0.0466)V_s}{(P_a/P_f) - (P_a/P_o)}$$

where,

V_t	=	minimum volume of tanks, gallons
V_s	=	volume of system, not including tanks, gallons
T	=	average operating temperature, °F
t_1	=	lower temperature
t_2	=	higher temperature
P_a	=	atmospheric pressure, psia
P_f	=	fill pressure, psia
P_o	=	maximum operating pressure, psia

Metric:

$$V_t = \frac{(0.000738T - 0.3348)V_s}{(P_a/P_f) - (P_a/P_o)}$$

where,

V_t	=	minimum volume of tanks, liters
V_s	=	volume of system, not including tanks, liters
T	=	average operating temperature, °C
P_a	=	atmospheric pressure, kPa
P_f	=	fill pressure, kPa
P_o	=	maximum operating pressure, kPa

3) Hot-Water Supply Systems

If a system is equipped with a check valve or pressure-reducing valve in the cold water inlet line, consideration should be given to the installation of an airtight expansion tank or other suitable air cushion. Otherwise, due to the thermal expansion of the water, the safety relief valve may lift periodically. If an expansion tank is provided, it shall be constructed in accordance with an acceptable code of construction. Except for pre-pressurized tanks, which should be installed on the cold water side, provisions shall be made for draining the tank without emptying the system. See NBIC Part 1, Figure 3.7.5.1-c for a typical acceptable installation.

b) Piping for Steam Heating, Hot-Water Heating, and Hot-Water Supply Boilers

Provisions shall be made for the expansion and contraction of steam and hot water mains connected to boiler(s) so there will be no undue strain transmitted to the boiler(s). See NBIC Part 1, Figures 3.7.5.1-a, 3.7.5.1-b, and 3.7.5.1-c, for typical schematic arrangements of piping incorporating strain absorbing joints for steam and hot-water heating boilers.

TABLE 3.7.9.1-a**EXPANSION TANK CAPACITIES FOR GRAVITY HOT-WATER SYSTEMS**

Based on a two-pipe system with average operating water temperature 170°F (77°C), using cast-iron column radiation with heat emission rate 150 Btu/hr/ft ² (473 W/m ²) equivalent direct radiation.		
Installed Equivalent Direct Radiation, ft ² (m ²) (Note)	No.	Tank Capacity, gallon (l)
up to 350 (33)	1	18 (68)
up to 450 (42)	1	21 (79)
up to 650 (60)	1	24 (91)
up to 900 (84)	1	30 (114)
up to 1,100 (102)	1	35 (132)
up to 1,400 (130)	1	40 (151)
up to 1,600 (149)	2	60 (227)
up to 1,800 (167)	2	60 (227)
up to 2,000 (186)	2	70 (265)
up to 2,400 (223)	2	80 (303)

Note:

For systems with more than 2,400 ft² (223 m²) of installed equivalent direct water radiation, the required capacity of the cushion tank shall be increased on the basis of 1 gallon (3.79 l) tank capacity/33 ft² (3.1 m²) of additional equivalent direct radiation.

TABLE 3.7.9.1-b**EXPANSION TANK CAPACITIES FOR FORCED HOT-WATER SYSTEMS**

Based on average operating water temperature 195°F [91°C], fill pressure 12 psig [83 kPa], and maximum operating pressure 30 psig [200 kPa]		
Tank Capacities, gallon (l)		
System Volume	Pressurized Diaphragm Type	Nonpressurized Type
100 (379)	9 (34)	15 (57)
200 (757)	17 (64)	30 (114)
300 (1136)	25 (95)	45 (170)
400 (1514)	33 (125)	60 (227)
500 (1893)	42 (159)	75 (284)
1,000 (3785)	83 (314)	150 (568)
2,000 (7571)	165 (625)	300 (1 136)

Note:

System volume includes volume of water in boiler, radiation, and piping, not including the expansion tank. Expansion tank capacities are based on an acceptance factor of 0.4027 for pre-pressurized types and 0.222 for non-pressurized types.

For other cases or metric calculations see Chapter 12 of the 1996 HVAC Systems and Equipment Volume of the ASHRAE Handbook.

3.7.9.2 EXPANSION TANKS AND PIPING FOR POTABLE WATER HEATERS

a) Expansion Tanks

If a system is equipped with a check valve or pressure-reducing valve in the cold water inlet line, consideration should be given to the installation of an airtight expansion tank or other suitable air cushion. Otherwise, due to the thermal expansion of the water, the safety relief valve may lift periodically. If an expansion tank is provided, it shall be constructed in accordance with an acceptable code of construction. The minimum capacity of the expansion tank may be determined from NBIC Part 1, Table 3.7.9.2. (See NBIC Part 1, Figures 3.7.5.2-a and 3.7.5.2-b for a typical acceptable installation). Except for pre-pressurized diaphragm-type tanks, which should be installed on the cold water side, provisions shall be made for draining the tank without emptying the system.

b) Piping

Provisions shall be made for the expansion and contraction of hot water mains connected to potable water heater(s) so that there will be no undue stress transmitted to the potable water heater(s). (See NBIC Part 1, Figures 3.7.5.2-a and 3.7.5.2-b for typical schematic arrangements of piping incorporating strain absorbing joints.)

TABLE 3.7.9.2
EXPANSION TANK CAPACITIES FOR A POTABLE WATER HEATER

TANK CAPACITIES, GALLON (L)

System Volume	Pre-pressurized Diaphragm Type	Non-pressurized Type
50 (189)	1 (4)	3 (11)
100 (379)	2 (8)	6 (23)
200 (757)	3 (11)	12 (45)
300 (1140)	4 (15)	18 (68)
400 (1514)	5 (19)	24 (91)
500 (1893)	6 (23)	30 (114)
1,000 (3785)	12 (45)	60 (227)
2,000 (7571)	24 (91)	120 (454)

Notes:

Capacities in this table are given as a guide to reduce or eliminate relief valve weeping under conditions of partial water system demands or occasional water draw during recovery.

System volume includes water heater capacity plus all piping capacity for a recirculation system or potable water heater capacity only for a nonrecirculation system.

The capacities are based upon a water temperature rise from 40°F to 180°F (4°C to 82°C), 60 psig (414 kPa) fill pressure, maximum operating pressure of 125 psig (862 kPa), 20% water recovery, and

an acceptance factor of 0.465 for pressurized types, and 0.09156 for nonpressurized types. For other cases or metric calculations see Chapter 12 of the 1996 HVAC Systems and Equipment Volume of the ASHRAE Handbook.

3.8 INSTRUMENTS, FITTINGS, AND CONTROLS

3.8.1 STEAM HEATING BOILERS

3.8.1.1 STEAM GAGES

- a) Each steam boiler shall have a steam gage or a compound steam gage connected to its steam space or to its water column or to its steam connection. The gage or connection shall contain a siphon or equivalent device that will develop and maintain a water seal that will prevent steam from entering the gage tube. The connection shall be so arranged that the gage cannot be shut off from the boiler except by a cock placed in the pipe at the gage and provided with a tee-handle or lever-handle arranged to be parallel to the pipe in which it is located when the cock is open. The connections to the boiler shall be not less than NPS 1/4 (DN 8). Where steel or wrought iron pipe or tubing is used, the connection and external siphon shall be not less than NPS 1/2 (DN 15). The minimum size of a siphon, if used, shall be NPS 1/4 (DN 8). Ferrous and nonferrous tubing having inside diameters at least equal to that of standard pipe sizes listed above may be substituted for pipe.
- b) The scale on the dial of a steam boiler gage shall be graduated to not less than 30 psig (200 kPa) nor more than 60 psig (414 kPa). The travel of the pointer from 0 psig (0 kPa) to 30 psig (200 kPa) pressure shall be at least 3 in. (76 mm).

3.8.1.2 WATER-GAGE GLASSES

- a) Each steam boiler shall have one or more water-gage glasses attached to the water column or boiler by means of valved fittings not less than NPS 1/2 (DN 15), with the lower fitting provided with a drain valve of a type having an unrestricted drain opening not less than NPS 1/4 (DN 8) to facilitate cleaning. Gage glass replacement shall be possible under pressure. Water glass fittings may be attached directly to a boiler. Boilers having an internal vertical height of less than 10 in. (254 mm) should be equipped with a water level indicator of the glass bulls-eye type provided the indicator is of sufficient size to show the water at both normal operating and low-water cutoff levels.
- b) The lowest visible part of the water-gage glass shall be at least 1 in. (25 mm) above the lowest permissible water level recommended by the boiler manufacturer. With the boiler operating at this lowest permissible water level, there shall be no danger of overheating any part of the boiler.
- c) In electric boilers of the submerged electrode type, the water-gage glass shall be so located to indicate the water levels both at startup and under maximum steam load conditions as established by the manufacturer.
- d) In electric boilers of the resistance element type, the lowest visible part of the water gage shall be located at least 1 in. (25 mm) above the lowest permissible water level specified by the manufacturer. Each electric boiler of this type shall also be equipped with an automatic low-water cutoff on each boiler pressure vessel so located as to automatically cut off the power supply to the heating elements before the surface of the water falls below the visible part of the glass.
- e) Tubular water glasses on electric boilers having a normal water content not exceeding 100 gal. (380 l) shall be equipped with a protective shield.

Note:

Transparent material other than glass may be used for the water gage provided the material will remain transparent and has proved suitable for the pressure, temperature, and corrosive conditions expected in service.

3.8.1.3 WATER COLUMN AND WATER LEVEL CONTROL PIPES

- a) The minimum size of ferrous or nonferrous pipes connecting a water column to a steam boiler shall be NPS 1 (DN 25). No outlet connections, except for damper regulator, feedwater regulator, steam gages, or apparatus that does not permit the escape of any steam or water except for manually operated blowdown, shall be attached to a water column or the piping connecting a water column to a boiler (see NBIC Part 1, 3.7.4 a)) for introduction of feedwater into a boiler. If the water column, gage glass, low-water fuel cutoff, or other water level control device is connected to the boiler by pipe and fittings, no shutoff valves of any type shall be placed in such pipe and a cross or equivalent fitting to which a drain valve and piping may be attached shall be placed in the water piping connection at every right angle turn to facilitate cleaning. The water column drain pipe and valve shall be not less than NPS 3/4 (DN 20).
- b) The steam connections to the water column of a horizontal firetube wrought boiler shall be taken from the top of the shell or the upper part of the head, and the water connection shall be taken from a point not above the center line of the shell. For a cast-iron boiler, the steam connection to the water column shall be taken from the top of an end section or the top of the steam header, and the water connection shall be made on an end section not less than 6 in. (152 mm) below the bottom connection to the water-gage glass.

3.8.1.4 PRESSURE CONTROL

Each automatically fired steam boiler shall be protected from overpressure by two pressure-operated controls

- a) Each individual steam boiler or each system of commonly connected steam boilers shall have a control that will cut off the fuel supply when the steam pressure reaches an operating limit, which shall be less than the maximum allowable pressure.
- b) Each individual automatically fired steam boiler shall have a safety limit control, with a manual reset, that will cut off the fuel supply to prevent steam pressure from exceeding the 15 psig (100 kPa) maximum allowable working pressure of the boiler. Each control shall be constructed to prevent a pressure setting above 15 psig (100 kPa).
- c) Shutoff valves of any type shall not be placed in the steam pressure connection between the boiler and the controls described in a) and b) above. These controls shall be protected with a siphon or equivalent means of maintaining a water seal that will prevent steam from entering the control. The connections to the boiler shall not be less than NPS 1/4 (DN 8) for lengths up to and including 5 ft (1.5 m) and not less than NPS 1/2 (DN 15) for lengths over 5 ft (1.5 m), but where steel or wrought iron pipe or tubing is used, they shall not be less than NPS 1/2 (DN 15) for lengths up to and including 5 ft (1.5 m) and not less than NPS 1 (DN 25) for lengths over 5 ft (1.5 m). The minimum size of an external siphon shall be NPS 1/4 (DN 8) or 3/8 in. (10 mm) outside diameter nonferrous tubing.
- d) Pressure controls should have separate connections, however manifolding is permitted. When multiple pressure controls are connected to the boiler with a common manifold, the connection at the boiler up to and including the entire manifold, for pipe of nonferrous material, shall not be less than NPS 1/2 (DN 15) for lengths up to and including 5 ft (1.5 m) and not less than NPS 3/4 (DN 20) for lengths over 5 ft (1.5 m). For manifolds using ferrous material, the connection at the boiler up to and including the entire manifold shall not be less than NPS 3/4 (DN 20) for lengths up to and including 5 ft (1.5 m) and not less than NPS 1 1/4 (DN 32) for lengths over 5 ft (1.5 m). Individual controls are to be piped from the manifold according to the provisions of c) above.

3.8.1.5 AUTOMATIC LOW-WATER FUEL CUTOFF AND/OR WATER FEEDING DEVICE

- a) Each automatically fired steam boiler shall have an automatic low-water fuel cutoff. The low-water fuel cutoffs must be located to automatically cut off the fuel supply when the surface of the water falls to a level not lower than the lowest visible part of the water-gage glass. If a water feeding device is installed, it shall be so constructed that the water inlet valve cannot feed water into the boiler through the float chamber and so located as to supply requisite feedwater.
- b) Such a fuel cutoff or water feeding device may be attached directly to a boiler. A fuel cutoff or water feeding device may also be installed in the tapped openings available for attaching a water-gage glass directly to a boiler, provided the connections are made to the boiler with nonferrous tees or Y's not less than NPS 1/2 (DN 15) between the boiler and water glass so that the water glass is attached directly and as close as possible to the boiler; the run of the tee or Y shall take the water glass fittings, and the side outlet or branch of the tee or Y shall take the fuel cutoff or water feeding device. The ends of all nipples shall be reamed to full-size diameter.
- c) In addition to the requirements in a) and b) above, a secondary low-water fuel cutoff with manual reset shall be provided on each automatically fired steam boiler.
- d) Fuel cutoffs and water feeding devices embodying a separate chamber shall have a vertical drain pipe and a blowoff valve not less than NPS 3/4 (DN 20), located at the lowest point in the water equalizing pipe connections so that the chamber and the equalizing pipe can be flushed and the device tested.

3.8.1.6 MODULAR STEAM HEATING BOILERS

(23)

- a) Each module of a modular steam boiler shall be equipped with:
 - 1) Steam gage, see NBIC Part 1, 3.8.1.1;
 - 2) Water-gage glass, see NBIC Part 1, 3.8.1.2;
 - 3) Pressure control, see NBIC Part 1, 3.8.1.4 a); and
 - 4) Low-water fuel cutoff, see NBIC Part 1, 3.8.1.5 a).
- b) The assembled modular steam heating boiler shall also be equipped with:
 - 1) Pressure control, see NBIC Part 1, 3.8.1.4 b); and
 - 2) Low-water fuel cutoff, see NBIC Part 1, 3.8.1.5 c).

3.8.1.7 INSTRUMENTS, FITTINGS, AND CONTROLS MOUNTED INSIDE BOILER JACKETS

Any or all instruments, fittings, and controls required by these rules may be installed inside boiler jackets provided the water gage and pressure gage on a steam boiler are visible through an opening or openings at all times.

3.8.2 HOT-WATER HEATING OR HOT-WATER SUPPLY BOILERS

3.8.2.1 PRESSURE OR ALTITUDE GAGES

- a) Each hot-water heating or hot-water supply boiler shall have a pressure or altitude gage connected to it or to its flow connection in such a manner that it cannot be shut off from the boiler except by a cock with tee or lever handle, placed on the pipe near the gage. The handle of the cock shall be parallel to the pipe in which it is located when the cock is open.

- b) The scale on the dial of the pressure or altitude gage shall be graduated approximately to not less than 1-1/2 nor more than 3-1/2 times the pressure at which the safety relief valve is set.
- c) Piping or tubing for pressure or altitude gage connections shall be of nonferrous metal when smaller than NPS 1 (DN 25).

3.8.2.2 THERMOMETERS

Each hot-water heating or hot-water supply boiler shall have a thermometer so located and connected that it shall be easily readable. The thermometer shall be so located that it shall at all times indicate the temperature of the water in the boiler at or near the outlet.

3.8.2.3 TEMPERATURE CONTROL

Each automatically fired hot-water heating or hot-water supply boiler shall be protected from over-temperature by at least two temperature-operated controls.

- a) Each individual hot-water heating or hot-water supply boiler or each system of commonly connected boilers shall have at least one control that will cut off the fuel supply when the water temperature reaches an operating limit, which shall be less than the maximum allowable temperature.
- b) In addition to a) above, each individual automatically fired hot-water heating or hot-water supply boiler shall have at least one safety limit control with manual reset that will cut off the fuel supply at or below the maximum allowable temperature at the boiler outlet.
- c) Each operating and safety limit control shall have its own sensing element and operating switch.
- d) Alternatively, integrated controls with multiple sensors may be used to meet the requirements of a) and b).

3.8.2.4 LOW-WATER FUEL CUTOFF

- a) Each automatically fired hot-water boiler shall have an automatic low-water fuel cutoff with manual reset. The low-water fuel cutoff shall be designed for hot-water service, and it shall be so located as to automatically cut off the fuel supply when the surface of the water falls to the level established in b) below.
- b) As there is no normal waterline to be maintained in a hot-water boiler, any location of the low-water fuel cutoff above the lowest safe permissible water level established by the boiler manufacturer is satisfactory.
- c) In lieu of the requirements for low-water fuel cutoffs in paragraph a), boilers requiring forced circulation to prevent overheating of the tubes, coils, or vessel, shall have an accepted flow, and/or temperature-sensing device to prevent burner operation at a flow rate inadequate to protect the boiler unit against overheating at all allowable firing rates. This safety control(s) shall shut down the burner and prevent restarting until an adequate flow is restored and shall be independent of all other controls.
- d) A means shall be provided for testing the operation of the external low-water fuel cutoff without resorting to draining the entire system. Such means shall not render the device inoperable except as follows. If the means temporarily isolates the device from the boiler during this testing, it shall automatically return to its normal position. The connection may be so arranged that the device cannot be shut off from the boiler except by a cock placed at the device and provided with a tee or lever-handle arranged to be parallel to the pipe in which it is located when the cock is open.

3.8.2.5 MODULAR HOT-WATER HEATING BOILERS

- a) Each module of a modular hot-water heating boiler shall be equipped with:
 - 1) Pressure/altitude gage, see NBIC Part 1, 3.8.2.1;
 - 2) Thermometer, see NBIC Part 1, 3.8.2.2; and
 - 3) Temperature control, see NBIC Part 1, 3.8.2.3 a).
- b) The assembled modular hot-water heating boiler shall be equipped with:
 - 1) Temperature control, see NBIC Part 1, 3.8.2.3 b); and
 - 2) Low-water fuel cutoff, see NBIC Part 1, 3.8.2.4.

3.8.2.6 INSTRUMENTS, FITTINGS, AND CONTROLS MOUNTED INSIDE BOILER JACKETS

Any or all instruments, fittings, and controls required by these rules may be installed inside boiler jackets provided the thermometer and pressure gage are visible through an opening or openings at all times.

3.8.3 POTABLE WATER HEATERS

3.8.3.1 TEMPERATURE CONTROLS

Each individual automatically fired water heater, in addition to the operating control used for normal water heater operation, shall have a separate high limit temperature actuated combustion control that will automatically cut off the fuel supply. The temperature range of the high limit temperature actuated control shall not allow a setting over 210°F (99°C).

- a) On gas-fired water heaters, the high limit temperature control, when actuated, shall shut off the fuel supply with a shutoff means other than the operating control valve. Separate valves may have a common body.
- b) On electrically heated water heaters, the high limit temperature control when actuated shall cut off all power to the operating controls.
- c) On oil-fired water heaters, the high limit temperature control when actuated shall cut off all current flow to the burner mechanism.
- d) On indirect water heating systems, the high limit temperature control when activated shall cut off the source of heat.

3.8.3.2 THERMOMETER

Each installed water heater shall have a thermometer so located and connected that it shall be easily readable. The thermometer shall be so located that it shall at all times indicate the temperature of the water in the water heater at or near the outlet.

3.9 PRESSURE RELIEF VALVES

See NBIC Part 1, 3.1 for the scope of pressure retaining items covered by these requirements.

3.9.1 PRESSURE RELIEF VALVE REQUIREMENTS – GENERAL

The following general requirements pertain to installing, mounting, and connecting pressure relief valves on heating boilers.

- a) All covers, caps, and/or plugs utilized for shipping or transport shall be removed prior to installation or being placed in service.
- b) Any wire or restraining device on lifting lever utilized for shipping or transport shall be removed prior to being placed in service.

3.9.1.1 INSTALLATION OF PRESSURE RELIEF VALVES FOR STEAM HEATING, HOT-WATER HEATING, AND HOT-WATER SUPPLY BOILERS

3.9.1.1.1 PERMISSIBLE INSTALLATION

Pressure relief valves shall be located at the top side of the boiler. The top side of the boiler shall mean the highest practicable part of the boiler proper but in no case shall the safety valves be located below the normal operating level and in no case shall the pressure relief valve be located below the lowest permissible water level. They shall be connected directly to a tapped or flanged opening in the boiler, to a fitting connected to the boiler by a short nipple, to a Y-base, or to a valveless header connecting steam or water outlets on the same boiler. Coil or header type boilers shall have the pressure relief valve located on the steam or hot-water outlet end. Pressure relief valves shall be installed with their spindles vertical. The opening or connection between the boiler and any pressure relief valve shall have at least the area of the valve inlet.

3.9.1.1.2 REQUIREMENTS FOR COMMON CONNECTIONS FOR TWO OR MORE VALVES

- a) When a boiler is fitted with two or more pressure relief valves on one connection, this connection shall have a cross-sectional area not less than the combined areas of inlet connections of all the pressure relief valves with which it connects.
- b) When a Y-base is used, the inlet area shall be not less than the combined outlet areas. When the size of the boiler requires a pressure relief valve larger than NPS 4 (DN 100), two or more valves having the required combined capacity shall be used. When two or more valves are used on a boiler, they may be single, directly attached, or installed on a Y-base.

3.9.1.2 THREADED CONNECTIONS

A threaded connection may be used for attaching a valve.

3.9.1.3 PROHIBITED INSTALLATIONS

Pressure relief valves shall not be connected to an internal pipe in the boiler.

3.9.1.4 USE OF SHUTOFF VALVES PROHIBITED

No shutoff valve of any description shall be placed between the pressure relief valve and the boiler or on discharge pipes between such valves and the atmosphere.

3.9.1.5 PRESSURE RELIEF VALVE DISCHARGE PIPING

- a) A discharge pipe shall be used. Its internal cross-sectional area shall be not less than the full area of the valve outlet or of the total of the valve outlets discharging therein, and shall be as short and straight as possible and arranged as to avoid undue stress on the valve or valves. A union may be installed in the discharge piping close to the valve outlet. When an elbow is placed on a pressure relief valve discharge pipe, it shall be located close to the valve outlet downstream of the union to minimize reaction moment stress.
- b) The discharge from pressure relief valves shall be so arranged that there will be no danger of scalding attendants. The pressure relief valve discharge shall be piped away from the boiler to a safe point of discharge, and there shall be provisions made for properly draining the piping. The size and arrangement of discharge piping shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the relieving devices below that required to protect the boiler.
- c) Discharge piping shall be rated for the discharge fluid conditions of pressure and temperature including a minimum and maximum design temperature. Material selection for the discharge piping shall consider the reduction in material toughness at the low end of design temperature and the reduction in material strength at the high end of design temperature. Rigid pipe or tubing should be used for discharge lines that carry hot water or steam.
- d) Plastic discharge pipe and fittings are permitted (when compatible with the process fluid, system design temperatures, and other ambient conditions such as light and humidity) and shall conform to NSF/ANSI 14 Plastics Piping System Components and Related Materials.
- e) Discharge piping shall be rated for any static pressure present and the back pressure that may develop when the pressure relief device is at full capacity. Where multiple pressure relief devices or vents discharge into common piping, the back pressure that could develop due to simultaneous flow from all sources shall be considered.

3.9.1.6 TEMPERATURE AND PRESSURE RELIEF VALVES

Hot-water heating or supply boilers limited to a water temperature of 210°F (99°C) may have one or more National Board capacity certified temperature and pressure relief valve(s) installed. The requirements of NBIC Part 1, 3.9.1.1 through 3.9.1.5 shall be met, except as follows:

- a) A Y-type fitting shall not be used.
- b) If additional valves are used, they shall be temperature and pressure relief valves.
- c) When the temperature and pressure relief valve is installed directly on the boiler with no more than 4 in. (100 mm) maximum interconnecting piping, the valve may be installed in the horizontal position with the outlet pointed down.

3.9.2 PRESSURE RELIEF VALVE REQUIREMENTS FOR STEAM HEATING BOILERS (23)

- a) Pressure relief valves shall be manufactured in accordance with a national or international standard and be certified for capacity by the National Board.
- b) Each steam boiler shall have one or more National Board capacity certified pressure relief valves of the spring pop type adjusted and sealed to discharge at a pressure not to exceed 15 psig (100 kPa).
- c) No pressure relief valve for a steam boiler shall be smaller than NPS 1/2 (DN 15). No pressure relief valve shall be larger than NPS 4 (DN 100).
- d) The minimum valve capacity in lbs/hr (kg/hr) shall be the greater of that determined by dividing the

maximum Btu/hr (W) output at the boiler nozzle obtained by the firing of any fuel for which the unit is installed by 1,000 Btu/lb (2,326 kw/kg), or shall be determined on the basis of the lbs steam/hr/ft² (kg steam/hr/m²) of boiler heating surface as given in NBIC Part 1, Table 2.9.1.3. For cast-iron boilers, the minimum valve capacity shall be determined by the maximum output method. In many cases a greater relieving capacity of valves will have to be provided than the minimum specified by these rules. In every case, the requirement of NBIC Part 1, 3.9.2 e) shall be met.

- e) The pressure relief valve capacity for each steam boiler shall be such that with the fuel burning equipment installed, and operated at maximum capacity, the pressure cannot rise more than 5 psig (34 kPa) above the maximum allowable working pressure.
- f) When operating conditions are changed, or additional boiler heating surface is installed, the valve capacity shall be increased, if necessary, to meet the new conditions and be in accordance with NBIC Part 1, 3.9.2 e). The additional valves required, on account of changed conditions, may be installed on the outlet piping provided there is no intervening valve.

(23) 3.9.3 PRESSURE RELIEF VALVE REQUIREMENTS FOR HOT-WATER HEATING OR HOT-WATER SUPPLY BOILERS

- a) Pressure relief valves shall be manufactured in accordance with a national or international standard and be certified for capacity by the National Board.
- b) Each hot-water heating or hot-water supply boiler shall have at least one National Board capacity certified pressure relief valve, of the automatic reseating type set to relieve at or below the maximum allowable working pressure of the boiler.
- c) Hot-water heating or hot-water supply boilers limited to a water temperature not in excess of 210°F (99°C) may have, in lieu of the valve(s) specified in b) above, one or more National Board capacity certified temperature and pressure relief valves of the automatic reseating type set to relieve at or below the maximum allowable working pressure of the boiler.
- d) When more than one pressure relief valve is used on either hot-water heating or hot-water supply boilers, the additional valves shall be National Board capacity certified and may have a set pressure within a range not to exceed 6 psig (40 kPa) above the maximum allowable working pressure of the boiler up to and including 60 psig (414 kPa), and 5% for those having a maximum allowable working pressure exceeding 60 psig (414 kPa).
- e) No pressure relief valve shall be smaller than NPS 3/4 (DN 20) nor larger than NPS 4 (DN 100), except that boilers having a heat input not greater than 15,000 Btu/hr (4.4 kW) should be equipped with a rated pressure relief valve of NPS 1/2 (DN 15).
- f) The required relieving capacity, in lbs/hr (kg/hr), of the pressure relief device or devices on a boiler shall be the greater of that determined by dividing the maximum output in Btu/hr (Watts) at the boiler nozzle obtained by the firing of any fuel for which the unit is installed by 1,000 Btu/lb (645 W-hr/kg), or shall be determined on the basis of lbs steam/hr/ft² (kg steam/hr/m²) as given in NBIC Part 1, Table 2.9.1.3. For cast-iron boilers, the minimum valve capacity shall be determined by the maximum output method. In many cases a greater relieving capacity of valves will have to be provided than the minimum specified by these rules. In every case, the requirements of NBIC Part 1, 3.9.3 h) shall be met.
- g) When operating conditions are changed, or additional boiler heating surface is installed, the valve capacity shall be increased, if necessary, to meet the new conditions and shall be in accordance with NBIC Part 1, 3.9.3 h). The additional valves required, on account of changed conditions, may be installed on the outlet piping provided there is no intervening valve.

- h) Pressure relief valve capacity for each boiler with a single pressure relief valve shall be such that, with the fuel burning equipment installed and operated at maximum capacity, the pressure cannot rise more than 10% above the maximum allowable working pressure. When more than one pressure relief valve is used, the over pressure shall be limited to 10% above the set pressure of the highest set valve allowed by NBIC Part 1, 3.9.3 d).

3.9.4 PRESSURE RELIEF VALVE REQUIREMENTS FOR POTABLE WATER HEATERS

- a) Each water heater shall have at least one National Board capacity certified temperature and pressure relief valve. No temperature and pressure relief valve shall be smaller than NPS 3/4 (DN 20).
- b) The pressure setting shall be less than or equal to the maximum allowable working pressure of the water heater. However, if any of the other components in the hot-water supply system (such as valves, pumps, expansion or storage tanks, or piping) have a lesser working pressure rating than the water heater, the pressure setting for the temperature and pressure relief valve(s) shall be based upon the component with the lowest maximum allowable working pressure rating. If more than one temperature and pressure relief valve is used, the additional valve(s) may be set within a range not to exceed 10% over the set pressure of the first valve.
- c) The required relieving capacity in Btu/hr (W) of the temperature and pressure relief valve shall not be less than the maximum allowable input unless the water heater is marked with the rated burner input capacity of the water heater on the casing in a readily visible location, in which case the rated burner input capacity may be used as a basis for sizing the temperature pressure relief valves. The relieving capacity for electric water heaters shall be 3,500 Btu/hr (1.0 kW) per kW of input. In every case, the following requirements shall be met. Temperature and pressure relief valve capacity for each water heater shall be such that with the fuel burning equipment installed and operated at maximum capacity, the pressure cannot rise more than 10% above the maximum allowable working pressure.

Many temperature and pressure relief valves have a National Board capacity certified rating which was determined according to ASME Code requirements, and a lower Canadian Standards Association (CSA) rating value. Where the ASME Code is the only referenced code of construction the National Board capacity certified rating may be used. If the water heater is not an ASME vessel, or the CSA rating is required by another standard (such as a plumbing or building code) then that rating shall be used.

- d) If operating conditions are changed or additional heating surface is installed, the temperature and pressure relief valve capacity shall be increased, if necessary, to meet the new conditions and shall be in accordance with the above provisions. In no case shall the increased input capacity exceed the maximum allowable input capacity. The additional valves required, on account of changed conditions, may be installed on the outlet piping providing there is no intervening valve.

3.9.4.1 INSTALLATION

Temperature and pressure relief valves shall be installed by either the water heater manufacturer or installer before a water heater is placed in operation.

3.9.4.2 PERMISSIBLE INSTALLATIONS

Temperature and pressure relief valves shall be connected directly to a tapped or flanged opening in the top of the water heater or to a fitting connected to the water heater by a short nipple. Temperature and pressure relief valves shall be installed with their spindles upright and vertical with no horizontal connecting pipe, except when the temperature and pressure relief valve is installed directly on the water heater vessel with no more than 4 in. (100 mm) maximum interconnecting piping, the valve may be installed in the horizontal position with the outlet pointed down. The center line of the temperature and pressure relief valve connection shall be no lower than 4 in. (100 mm) from the top of the shell. No piping or fitting used to install the temperature and pressure relief valve shall be of nominal pipe size less than that of the valve inlet.

3.9.4.3 REQUIREMENTS FOR COMMON CONNECTION FOR TWO OR MORE VALVES

- a) When a potable water heater is fitted with two or more temperature and pressure relief valves on one connection, this connection shall have a cross-sectional area not less than the combined areas of inlet connections of all the temperature and pressure release valves with which it connects.
- b) When the size of the water heater requires a temperature and pressure relief valve larger than NPS 4 (DN 100) two or more valves having the required combined capacity shall be used.

3.9.4.4 THREADED CONNECTIONS

A threaded connection may be used for attaching a temperature and pressure relief valve.

3.9.4.5 PROHIBITED INSTALLATIONS

Temperature and pressure relief valves shall not be connected to an internal pipe in the water heater or a cold water feed line connected to the water heater.

3.9.4.6 USE OF SHUTOFF VALVES PROHIBITED

No shutoff valve of any description shall be placed between the temperature and pressure relief valve and the water heater or on discharge pipes between such valves and the atmosphere.

3.9.4.7 TEMPERATURE AND PRESSURE RELIEF VALVE DISCHARGE PIPING

- a) The discharge from temperature and pressure relief valves shall be so arranged that there will be no danger of scalding attendants. When the temperature and pressure relief valve discharge is piped away from the water heater to the point of discharge, there shall be provisions for properly draining the piping and valve body. The size and arrangement of discharge piping shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the relieving devices below that required to protect the water heater.
- b) When a discharge pipe is used, it shall be not less than the nominal size of the valve outlet, and shall be as short and straight as possible and so arranged as to avoid undue stress on the valve. When an elbow is placed on a temperature and pressure relief discharge pipe, it shall be located close to the valve outlet.
- c) Where multiple valves relieve into a common discharge pipe, the cross-sectional flow area of the common discharge pipe shall be equal to or greater than the sum of the individual temperature and pressure relief valve discharge pipe areas.
- d) Discharge piping shall be rated for the discharge fluid conditions of pressure and temperature including a minimum and maximum design temperature. Material selection for the discharge piping shall consider the reduction in material toughness at the low end of design temperature and the reduction in material strength at the high end of design temperature. Rigid pipe or tubing should be used for discharge lines that carry hot water or steam.
- e) Plastic discharge pipe and fittings are permitted (when compatible with the process fluid, system design temperatures, and other ambient conditions such as light and humidity) and shall conform to NSF/ANSI 14 Plastics Piping System Components and Related Materials.
- f) Discharge piping shall be rated for any static pressure present and the back pressure that may develop when the pressure relief device is at full capacity. Where multiple pressure relief devices or vents discharge into common piping, the back pressure that could develop due to simultaneous flow from all sources shall be considered.

3.9.5 PRESSURE RELIEF VALVES FOR TANKS AND HEAT EXCHANGERS

3.9.5.1 STEAM TO HOT-WATER SUPPLY

When a hot-water supply is heated indirectly by steam in a coil or pipe within the service limitations set forth in NBIC Part 1, 3.2, *Definitions*, the pressure of the steam used shall not exceed the safe working pressure of the hot water tank, and a pressure relief valve at least NPS 1 (DN 25), set to relieve at or below the maximum allowable working pressure of the tank, shall be applied on the tank.

3.9.5.2 HIGH-TEMPERATURE WATER TO WATER HEAT EXCHANGER

When high-temperature water is circulated through the coils or tubes of a heat exchanger to warm water for space heating or hot-water supply, within the service limitations set forth in NBIC Part 1, 3.2, *Definitions*, the heat exchanger shall be equipped with one or more National Board capacity certified pressure relief valves set to relieve at or below the maximum allowable working pressure of the heat exchanger, and of sufficient rated capacity to prevent the heat exchanger pressure from rising more than 10% above the maximum allowable working pressure of the vessel.

3.9.5.3 HIGH-TEMPERATURE WATER TO STEAM HEAT EXCHANGER

When high-temperature water is circulated through the coils or tubes of a heat exchanger to generate low pressure steam, within the service limitations set forth in NBIC Part 1, 3.2, *Definitions*, the heat exchanger shall be equipped with one or more National Board capacity certified pressure relief valves set to relieve at a pressure not to exceed 15 psig (100 kPa), and of sufficient rated capacity to prevent the heat exchanger pressure from rising more than 5 psig (34 kPa) above the maximum allowable working pressure of the vessel. For heat exchangers requiring steam pressures greater than 15 psig (100 kPa), refer to NBIC Part 1, Section 2 or Section 4.

3.10 TESTING AND ACCEPTANCE

3.10.1 PRESSURE TEST

See NBIC Part 1, Section 1.6.10, *Testing And Final Acceptance*.

3.10.2 FINAL ACCEPTANCE

See NBIC Part 1, Section 1.6.10, *Testing And Final Acceptance*.

3.10.3 BOILER INSTALLATION REPORT

- a) Upon completion, inspection, and acceptance of the installation, the installer shall complete and certify the *Boiler Installation Report* I-1. See NBIC Part 1, 1.4.5.1.
- b) The *Boiler Installation Report* I-1 shall be submitted as follows:
 - 1) One copy to the owner; and
 - 2) One copy to the Jurisdiction, if required.

3.11 TABLES AND FIGURES

- a) NBIC Part 1, Figure 3.3.1.1-a, *Spacing and Weld Details for Supporting Lugs in Pairs on Horizontal Return Tubular Boilers*
- b) NBIC Part 1, Figure 3.3.1.1-b, *Welded Bracket Connection for Horizontal-Return Tubular Boilers*
- c) NBIC Part 1, Figure 3.7.5.1-a, *Steam Boilers in Battery – Pumped Return – Acceptable Piping Installation*
- d) NBIC Part 1, Figure 3.7.5.1-b, *Steam Boilers in Battery – Gravity Return – Acceptable Piping Installation*
- e) NBIC Part 1, Figure 3.7.5.1-c, *Hot-Water Boilers in Battery – Acceptable Piping Installation*
- f) NBIC Part 1, Figure 3.7.5.2-a, *Storage Potable Water Heaters in Battery – Acceptable Piping Installation*
- g) NBIC Part 1, Figure 3.7.5.2-b, *Flow Through Potable Water Heater Without Provision for Piping Expansion – Acceptable Piping Installation*
- h) NBIC Part 1, Table 3.7.7.1, *Size of Bottom Blowoff Piping, Valves, and Cocks*
- i) NBIC Part 1, Table 3.7.9.1-a, *Expansion Tank Capacities for Gravity Hot-Water Systems*
- j) NBIC Part 1, Table 3.7.9.1-b, *Expansion Tank Capacities for Forced Hot-Water Systems*
- k) NBIC Part 1, Table 3.7.9.2, *Expansion Tank Capacities for a Potable Water Heater*

PART 1, SECTION 4 INSTALLATION — PRESSURE VESSELS

4.1 SCOPE

This section provides requirements and guidelines for the installation of pressure vessels.

4.2 DEFINITIONS

See NBIC Part 1, Section 9, *Glossary of Terms*.

4.3 GENERAL REQUIREMENTS

4.3.1 SUPPORTS

See NBIC Part 1, Section 1.6.1, *Supports, Foundations and Settings*

4.3.2 CLEARANCES

- a) All pressure vessel installations must allow sufficient clearance for normal operation, maintenance, and inspection (internal and external).
- b) Orientation of nozzles, manways, and attachments shall be such that sufficient clearance between the nozzles, manways and attachments, and the surrounding structure(s) is maintained during installation, the attachment of associated piping, and operation.

4.3.3 PIPING

Piping loads on the vessel nozzles shall be considered. Piping loads include weight of the pipe, weight of the contents of the pipe, expansion of the pipe from temperature and pressure changes (wind and seismic loads). The effects of piping vibration on the vessel nozzles shall also be considered.

4.3.4 BOLTING

All mechanical joints and connections shall conform to manufacturers' installation instructions and recognized standards acceptable to the jurisdiction having authority.

4.4 INSTRUMENTS AND CONTROLS

4.4.1 LEVEL INDICATING DEVICES

Steam drums of unfired steam boilers shall be provided with two level indicating devices. Direct level indicating devices should be connected to a single water column or connected directly to the drum, and the connections and pipe shall be not less than NPS 1/2 (DN 15). Indirect level indicating devices acceptable to the Jurisdiction may be used.

4.4.2 PRESSURE INDICATING DEVICES

The need for pressure indicating devices should be considered in the design of the pressure vessel, and when required, the scale on the dial of the pressure gage shall be at least 25% above the highest set pressure of the pressure relief device.

4.5 PRESSURE RELIEF DEVICES

See NBIC Part 1, 4.1 for the scope of pressure vessels covered by these requirements.

Pressure relief devices protecting pressure vessels shall meet the following requirements.

4.5.1 DEVICE REQUIREMENTS

- a) Pressure relief devices shall be manufactured in accordance with a national or international standard and be certified for capacity or flow resistance by the National Board.
- b) Dead weight or weighted lever pressure relief valves shall not be used.
- c) An unfired steam boiler shall be equipped with pressure relief valves as required in NBIC Part 1, 2.9.
- d) Pressure relief devices shall be selected (e.g., material, pressure, etc.) and installed such that their proper functioning will not be hindered by the nature of the vessel's contents.

4.5.2 NUMBER OF DEVICES

At least one device shall be provided for protection of a pressure vessel. Pressure vessels with multiple chambers with different maximum allowable working pressures shall have a pressure relief device to protect each chamber under the most severe coincident conditions.

(23) 4.5.3 LOCATION

- a) The pressure relief device shall be installed directly on the pressure vessel, unless the source of pressure is external to the vessel and is under such positive control that the pressure cannot exceed the maximum overpressure permitted by the original code of construction and the pressure relief device cannot be isolated from the vessel, except as permitted by NBIC Part 1, 4.5.6 e).
- b) Pressure relief devices intended for use in compressible fluid service shall be connected to the vessel in the vapor space above any contained liquid or in the piping system connected to the vapor space.
- c) Pressure relief devices intended for use in liquid service shall be connected below the normal liquid line. The liquid level during upset conditions shall be considered.

4.5.4 CAPACITY

- a) The pressure relief device(s) shall have sufficient capacity to ensure that the pressure vessel is not exposed to pressure greater than that specified in the original code of construction.
- b) Pressure vessels that can be exposed to fire or other sources of unexpected external heat may require supplemental pressure relief devices to provide additional relieving capacity.
 - 1) The combined relieving capacity of all installed pressure relief devices shall be adequate to prevent the pressure from rising more than 21% above maximum allowable working pressure.

- 2) The set point of any supplemental pressure relief device(s) shall not exceed 110% of the maximum allowable working pressure. If a single pressure relief device is utilized to protect the vessel during both operational and fire or other unexpected external heating conditions, the set point shall not exceed maximum allowable working pressure.
- c) Vessels connected together by a system of piping not containing valves that can isolate any pressure vessel may be considered as one unit when determining capacity requirements.
- d) Heat exchangers and similar vessels shall be protected with a pressure relief device of sufficient capacity to avoid overpressure in case of internal failure.
- e) When a non-reclosing device is installed between a pressure relief valve and the pressure vessel, the reduction in capacity due to installation of the nonreclosing device shall be determined in accordance with the code of construction by use of a National Board certified Combination Capacity Factor (CCF). For rupture disks, if a certified combination capacity factor is not available, the capacity of the pressure relief valve shall be multiplied by 0.9 and this value used as the capacity of the combination installation.
- f) The owner shall make information regarding the basis of pressure relief device selection, including required capacity, available to the Jurisdiction.

4.5.5 SET PRESSURE

- a) When a single pressure relief device is used, the set pressure marked on the device shall not exceed the maximum allowable working pressure.
- b) When more than one pressure relief device is provided to obtain the required capacity, only one pressure relief device set pressure needs to be at the maximum allowable working pressure. The set pressures of the additional pressure relief devices shall be such that the pressure cannot exceed the overpressure permitted by the code of construction.

4.5.6 INSTALLATION AND DISCHARGE PIPING REQUIREMENTS

- a) The opening through all pipe and fittings between a pressure vessel and its pressure relief device shall have at least the area of the pressure relief device inlet. The characteristics of this upstream system shall be such that the pressure drop will not reduce the relieving capacity below that required or adversely affect the proper operation of the pressure relief device. When a discharge pipe is used, the size shall be such that any pressure that may exist or develop will not reduce the relieving capacity below that required or adversely affect the proper operation of the pressure relief device. It shall be as short and straight as possible and arranged to avoid undue stress on the pressure relief device.
- b) A non-reclosing device installed between a pressure vessel and a pressure relief valve shall meet the requirements of 4.5.6 a).
- c) The opening in the pressure vessel wall shall be designed to provide unobstructed flow between the vessel and its pressure relief device.
- d) When two or more required pressure relief devices are placed on one connection, the inlet cross-sectional area of this connection shall be sized either to avoid restricting flow to the pressure relief devices or made at least equal to the combined inlet areas of the pressure relief devices connected to it. The flow characteristics of the upstream system shall satisfy the requirements of NBIC Part 1, 4.5.6 a).
- e) There shall be no intervening stop valves between the vessel and its pressure relief device(s), or between the pressure relief device(s) and the point of discharge, except under the following conditions:

- 1) When these stop valves are so constructed or positively controlled that the closing of the maximum number of block valves at one time will not reduce the pressure relieving capacity below the required relieving capacity.
 - 2) Upon specific acceptance of the Jurisdiction, when necessary for the continuous operation of processing equipment of such a complex nature that shutdown of any part is not feasible, a full area stop valve between a pressure vessel and its pressure relief device may be provided for inspection and repair purposes only. This stop valve shall be arranged so that it can be locked or sealed open, and it shall not be closed except by an authorized person who shall remain stationed there during that period of operation while the valve remains closed. The valve shall be locked or sealed in the open position before the authorized person leaves the station.
 - 3) A full area stop valve may also be placed on the discharge side of a pressure relief device when its discharge is connected to a common header for pressure relief devices to prevent discharges from these other devices from flowing back to the first device during inspection and repair. This stop valve shall be arranged so that it can be locked or sealed open, and it shall not be closed except by an authorized person who shall remain stationed there during that period of operation while the valve remains closed. The valve shall be locked and sealed in the open position before the authorized person leaves the station. This valve shall only be used when a stop valve on the inlet side of the pressure relief device is first closed.
 - 4) A pressure vessel in a system where the pressure originates from an outside source may have a stop valve between the vessel and the pressure relief device, and this valve need not be sealed open, provided it also closes off that vessel from the source of the pressure.
 - 5) Pressure vessels designed for human occupancy (such as decompression or hyperbaric chambers) shall be provided with a quick opening stop valve between the pressure vessel and its pressure relief valve. The stop valve shall be normally sealed open with a frangible seal and be readily accessible to the pressure relief attendant.
- f) All pressure relief devices shall relieve to a safe point of discharge.
 - g) Discharge lines from pressure relief devices shall be designed to facilitate drainage or be fitted with drains to prevent liquid from collecting in the discharge side of a pressure relief device. The size of discharge lines shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the pressure relief device or adversely affect the operation of the pressure relief device. It shall be as short and straight as possible and arranged to avoid undue stress on the pressure relief device.
 - h) Pressure relief devices shall be installed so they are readily accessible for inspection, repair, or replacement.
 - i) Pressure vessel pressure relief devices and discharge piping shall be safely supported. The reaction forces due to discharge of pressure relief devices shall be considered in the design of the inlet and discharge piping. Design of supports, foundations, and settings shall consider vibration (including seismic when necessary), movement (including thermal movement), and loadings (including reaction forces during device operation) in accordance with jurisdictional requirements, manufacturer's recommendations, and/or other industry standards, as applicable.

4.6 TESTING AND ACCEPTANCE

See NBIC Part 1, 1.6.10, *Testing And Final Acceptance*.

4.7 REQUIREMENTS FOR HOT WATER STORAGE TANKS/POTABLE HOT WATER STORAGE TANKS

4.7.1 SUPPORTS

Each hot water storage tank shall be supported in accordance with NBIC Part 1, 1.6.1.

4.7.2 CLEARANCE AND ACCESSIBILITY

- a) The required nameplate (marking or stamping) should be exposed and accessible.
- b) The openings when required should be accessible to allow for entry for inspection and maintenance.
- c) Each hot water storage tank shall meet the requirements of NBIC Part 1, 4.3.2.

4.7.3 TEMPERATURE AND PRESSURE RELIEF DEVICES

- a) Each potable hot water storage tank shall be equipped with an ASME/NB certified temperature and pressure relief valve set at a pressure not to exceed the maximum allowable working pressure and 210°F (99°C).
- b) Potable hot water storage tanks exceeding the pressure limit of ASME Code Section IV shall meet the original code of construction and shall be protected by a pressure relief valve set not to exceed the vessel's maximum allowable working pressure. A temperature limiting device shall be installed so that the water inside the storage tank does not exceed 210°F (99°C).
- c) Each hot water storage tank shall be equipped with an ASME/NB certified pressure relief valve set at a pressure not to exceed the maximum allowable working pressure.
- d) The temperature and pressure relief valve shall meet the requirements of NBIC Part 1, 4.5.

4.7.4 THERMOMETERS

- a) Each hot water storage/potable hot water storage tank shall be equipped with a thermometer.
- b) Each hot water storage/potable hot water storage tank shall have a thermometer so located that it shall be easily readable at or near the outlet. The thermometer shall be so located that it shall at all times indicate the temperature of the water in the storage tank.

4.7.5 SHUT OFF VALVES

- a) Each hot water storage/potable hot water storage tank shall be equipped with stop valves in the water inlet piping and the outlet piping in order for the hot water storage tank to be removed from service without having to drain the complete system.
- b) Each hot water storage/potable hot water storage tank shall be equipped with a bottom drain valve to provide for flushing and draining of the vessel.

4.7.6 TESTING AND ACCEPTANCE

See NBIC Part 1, 1.6.10, *Testing And Final Acceptance*.

PART 1, SECTION 5 INSTALLATION — PIPING

5.1 SCOPE

This section provides requirements and guidelines for the installation of piping.

5.2 GENERAL REQUIREMENTS

For piping, the basic considerations are: the design temperature, the pressure retained by the pipe, the fluid in the pipe, the load resulting from the thermal expansion or contraction, and impact or shock loads imparted (such as water hammer, external loads, wind loads and vibration from equipment).

5.2.1 ADDITIONS TO EXISTING PIPING

Additions to existing piping systems shall conform to this section. That portion of the existing piping system that is not part of the addition need not comply with this section provided the addition does not result in a change in piping system operation or function that would exceed the design conditions of the existing piping system or result in unsafe conditions.

5.2.2 PROXIMITY TO OTHER EQUIPMENT AND STRUCTURES

The arrangement of the piping and its appurtenances shall take into consideration the location of other structures and equipment adjacent to the piping, which may result in freezing, interference and/or damage as a result of expansion, contraction, vibration, or other movements.

5.2.3 FLANGES AND OTHER NON-WELDED JOINTS

The layout of the piping shall take into consideration the need for required access to maintain and inspect piping joints.

5.2.4 VALVES

- a) Valves are used in piping systems to stop and start the flow of fluids, to regulate the flow, to prevent the back-flow, and to relieve excessive pressure buildup in piping.
- b) Consideration should be given to the appropriate location and orientation of valves necessary for safe operation and isolation of the piping. To reduce the effects of downstream disturbances, if possible, install the valve at least the distance of eight pipe diameters downstream from the closest elbow or pump.
- c) Verify the pressure and temperature information on the valve conforms to the piping design requirements.
- d) Clean the piping of all debris which could cause damage to the valve seat, disc, or bearings. Failure to lift the valve properly may cause damage. Lift the valve assembly with slings, chains, or cables fastened around the valve body. Lifting devices may be fastened to rods running through bolt holes in the flanges. Do not fasten lifting devices to the actuator or the disc and never put any lifting devices through the seat opening.

5.2.5 MATERIALS

All materials for piping and its appurtenances shall comply with the requirements of the code of construction.

5.2.6 HANGERS AND SUPPORTS

Support of piping shall consider loads (including wind and seismic loads) imposed on equipment or existing piping to which it is attached. Non-piping attachments such as ladders and walkways, equipment supports, temporary supports, structural supports, etc., shall not be connected to the piping unless such loads have been considered in the design of the piping and its supports. Design of hangers and supports for piping shall consider loads imposed by hydrostatic pressure testing. The installer shall remove pins from non-rigid hangers and seal plugs from hydraulic snubbers and temporary supports used for installation prior to placing the piping in service.

5.2.7 PROTECTION AND CLEANING

The installer shall exercise care during installation to prevent loose weld material, welding rods, small tools, and miscellaneous scrap metal from getting into the piping. The installer shall inspect and, where necessary, clean the interior of the piping and its appurtenances where possible, prior to making the final closures for the presence of foreign debris.

5.2.8 WELDING AND BRAZING

The installer should consider the impact of performing any preheating, welding, brazing, or postweld heat treatment on valves, instrumentation, or other heat sensitive equipment and, where appropriate, review the equipment manufacturer's recommended installation procedures prior to performing the work.

5.2.9 BOLTING

All mechanical joints and connections shall conform to manufacturers' installation instructions and recognized standards acceptable to the Jurisdiction having authority.

5.3 PRESSURE RELIEF DEVICES

When required by the original code of construction, piping shall be protected by pressure relief devices in accordance with the following requirements.

5.3.1 DEVICE REQUIREMENTS

- a) Pressure relief devices shall be manufactured in accordance with a national or international standard and be certified for capacity or flow resistance by the National Board.
 - 1) In certain cases piping codes of construction permit the use of regulators, which may include integral pressure relief valves to limit the pressure in a piping system. In this case, capacity certification of the pressure relief valve is not required.
 - 2) Some piping codes of construction permit the use of pressure relief devices without capacity certification. In this case, capacity certification of the pressure relief device by the National Board is not required.
- b) Dead weight or weighted lever pressure relief devices shall not be used.

- c) Pressure relief devices shall be selected (i.e., material, pressure, etc.) and installed such that their proper functioning will not be hindered by the nature of the piping system's contents.

5.3.2 NUMBER OF DEVICES

At least one pressure relief device shall be provided for protection of a piping system. A pressure relief device installed on a pressure vessel or other component connected to the piping system may be used to meet this requirement. Portions of piping systems with different maximum allowable working pressures shall have a pressure relief device to protect each portion separately.

5.3.3 LOCATION

Pressure relief devices, except those covered by NBIC Part 1, Sections 2 and 3, may be installed at any location in the system provided the pressure in any portion of the system cannot exceed the maximum overpressure permitted by the original code of construction. Pressure drop to the pressure relief device under flowing conditions shall be considered when determining pressure relief device location. The pressure-relief device shall not be isolated from the piping system except as permitted by NBIC Part 1, 5.3.6 e).

5.3.4 CAPACITY

- a) The pressure relief device(s) shall have sufficient capacity to ensure that the piping is not exposed to pressures greater than that specified in the original code of construction.
- b) When a non-reclosing device is installed between a pressure relief valve and the pipe, the reduction in capacity due to installation of the non-reclosing device shall be determined in accordance with the code of construction by use of a National Board certified Combination Capacity Factor (CCF). For rupture disks, if a certified combination capacity factor is not available, the capacity of the pressure relief valve shall be multiplied by 0.9 and this value used as the capacity of the combination installation.
- c) The owner shall document the basis for selection of the pressure relief devices used, including capacity, and have such calculations available for review by the Jurisdiction, when required.

5.3.5 SET PRESSURE

- a) When a single pressure relief device is used, the set pressure marked on the device shall not exceed the maximum allowable working pressure, except when allowed by the original code of construction.
- b) When more than one pressure relief device is provided to obtain the required capacity, only one pressure relief device set pressure need be at or below the maximum allowable working pressure. The set pressures of the additional pressure relief devices shall be such that the pressure cannot exceed the overpressure permitted by the code of construction.

5.3.6 INLET AND DISCHARGE PIPING REQUIREMENTS

- a) The opening through all pipes and fittings between a piping system and its pressure relief device shall have at least the area of the pressure relief device inlet. The characteristics of this upstream system shall be such that the pressure drop will not reduce the relieving capacity below that required or adversely affect the operation of the pressure relief device.
- b) A non-reclosing device installed between a piping system and a pressure relief valve shall meet the requirements of NBIC Part 1, 5.3.6 a).
- c) The opening in the pipe shall be designed to provide unobstructed flow between the pipe and its pressure relief device.

- d) When two or more required pressure relief devices are placed on the connection, the inlet cross-sectional area of this connection shall be sized either to avoid restricting flow to the pressure relief devices or made at least equal to the combined inlet areas of the pressure relief devices connected to it. The flow characteristics of the upstream system shall satisfy the requirements of NBIC Part 1, 5.3.6 a).
- e) There shall be no intervening stop valves between the piping system and its pressure relief device(s), or between the pressure relief device(s) and the point of discharge except under the following conditions:
 - 1) These stop valves shall be so constructed or positively controlled that the closing of the maximum number of block valves at one time will not reduce the pressure relieving capacity below the required relieving capacity;
 - 2) Upon specific acceptance of the Jurisdiction, when necessary for the continuous operation of processing equipment of such a complex nature that shutdown of any part is not feasible, a full area stop valve between a piping system and its pressure relief device may be provided for inspection and repair purposes only. This stop valve shall be arranged so that it can be locked or sealed open and it shall not be closed except by an authorized person who shall remain stationed there during that period of operation while the valve remains closed. The valve shall be locked or sealed in the open position before the authorized person leaves the station;
 - 3) A full area stop valve may be placed on the discharge side of a pressure relief device when its discharge is connected to a common header for pressure relief devices to prevent discharges from these other devices from flowing back to the first device during inspection and repair. This stop valve shall be arranged so that it can be locked or sealed open, and it shall not be closed except by an authorized person who shall remain stationed there during that period of operation while the valve remains closed. The valve shall be locked or sealed in the open position before the authorized person leaves the station. This valve shall only be used when a stop valve on the inlet side of the pressure relief device is first closed; or
 - 4) A piping system where the pressure originates from an outside source may have a stop valve between the system and the pressure relief device, and this valve need not be sealed open, provided it also closes off that vessel from the source of pressure.
- f) Pressure relief device discharges shall be arranged such that they are not a hazard to personnel or other equipment and, when necessary, lead to a safe location for disposal of fluids being relieved.
- g) Discharge lines from pressure relief devices shall be designed to facilitate drainage or be fitted with drains to prevent liquid from collecting in the discharge side of a pressure relief device. The size of discharge lines shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the pressure relief device or adversely affect the operation of the pressure relief device. It shall be as short and straight as possible and arranged to avoid undue stress on the pressure relief device.
- h) The reaction forces due to discharge of pressure relief devices shall be considered in the design of the inlet and discharge piping.
- i) Pressure relief devices shall be installed so they are accessible for inspection, repair, or replacement. These stop valves shall be so constructed or positively controlled that the closing of the maximum number of block valves at one time will not reduce the pressure relieving capacity below the required relieving capacity.

5.4 EXAMINATION, INSPECTION, AND TESTING

The owner shall ensure that all examinations, inspections, and tests required by the code of construction have been performed prior to operation.

PART 1, SECTION 6 INSTALLATION SUPPLEMENTS

(23) SUPPLEMENT 1 INSTALLATION OF YANKEE DRYERS

(23) S1.1 SCOPE

This supplement provides guidelines for the installation of a yankee dryer. Additional guidelines are found in Part 2 for Inspection, and Part 3 for Repairs and Alterations.

- a) A yankee dryer is a rotating steam-pressurized cylindrical vessel commonly used in the paper industry. It is characterized by a center shaft connecting the heads. While traditionally made of cast iron, bolted or welded steel vessels are in use.
- b) Yankee dryers are primarily used in the production of tissue-type paper products. When used to produce machine-glazed (MG) paper, the dryer is termed an MG cylinder. A wet paper web is pressed onto the finished dryer surface using one or two pressure (pressing) rolls. Paper is dried through a combination of mechanical dewatering by the pressure roll(s); thermal drying by the pressurized yankee dryer; and a steam-heated or fuel-fired hood. After drying, the paper web is removed from the dryer.
- c) The dryer is typically manufactured in a range of outside diameters from 8 ft. to 23 ft. (2.4 m to 7 m), widths from 8 ft. to 28 ft. (2.4 m to 8.5 m), pressurized and heated with steam up to 160 psi (1,100 kPa), and rotated at speeds up to 7,000 ft/min (2,135 m/min). Typical pressure roll loads against the yankee dryer are up to 600 pounds per linear inch (105 kN/m). A thermal load results from the drying process due to difference in temperature between internal and external shell surfaces. The dryer has an internal system to remove steam and condensate. These vessels can weigh up to 220 tons (200 tonnes).
- d) The typical yankee dryer is an assembly of several large components. The cylindrical shell is commonly ASME SA-278 gray cast iron, or SA-516 steel. Internally, shells may be smoothbore or ribbed. Heads, center shafts, and journals may be gray cast iron, ductile cast iron, or steel.

(23) S1.2 INSTALLATION ASSESSMENT

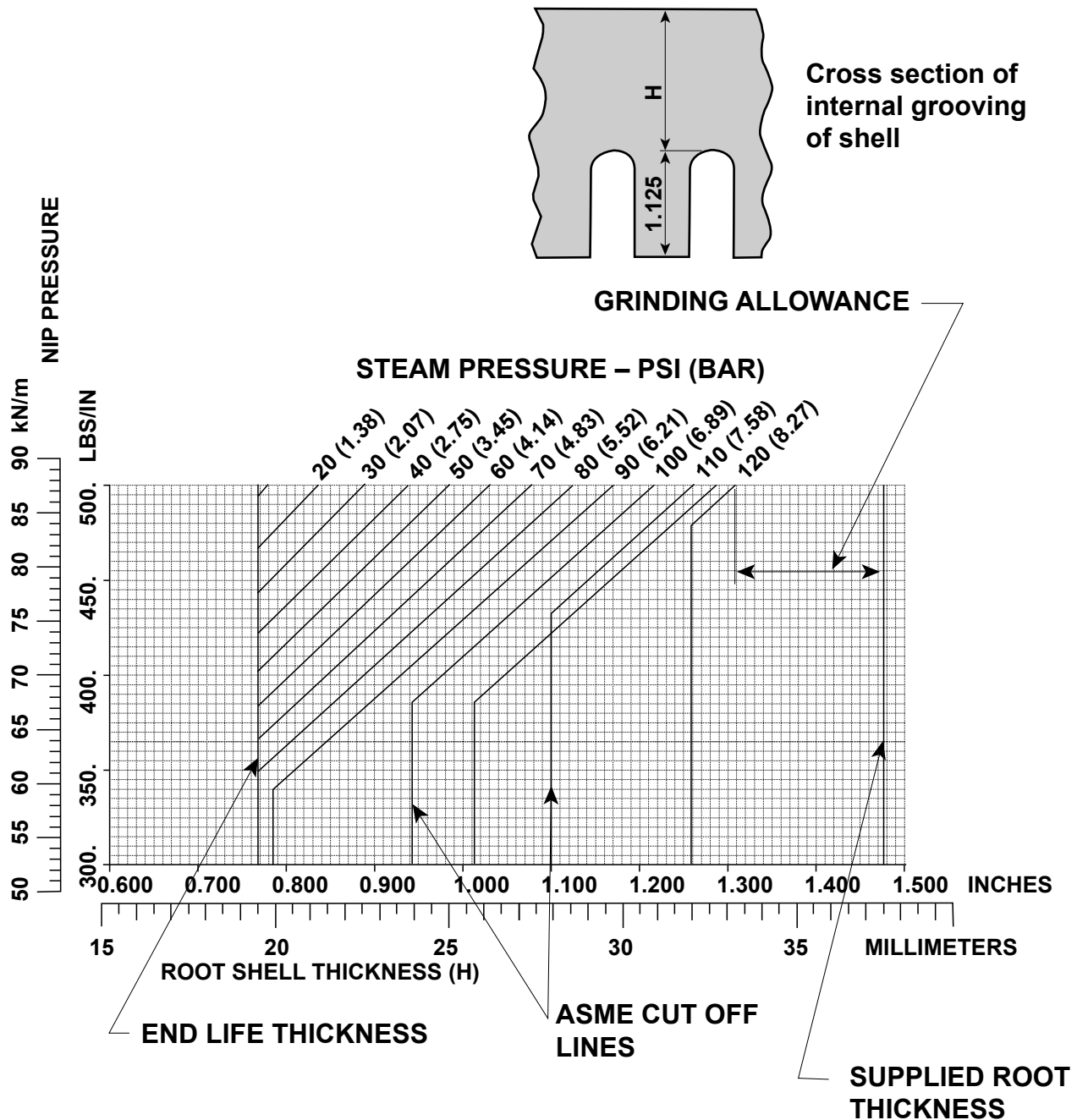
- a) The Inspector verifies that the owner or user is prepared to properly control the operation of the dryer such that maximum operating conditions are not exceeded. The maximum operating conditions are provided by the dryer manufacturer or a source acceptable to the Inspector and can be in the form of a de-rate curve or drawing with listed parameters.
- b) The dryer is subjected to a variety of loads over its life. Some of the loads exist individually, while others are combined. Considerations of all the loads that can exist on a yankee dryer are required to determine the maximum allowable operating parameters. There are four loads that combine during normal operation to create the maximum operating stresses, usually on the outside surface of the shell at the axial center line. These loads and the associated protection devices provided to limit these loads are:
 - 1) Pressure load due to internal steam pressure. Overpressure protection is provided by a safety relief valve;
 - 2) Inertial load due to dryer rotation. Over-speed protection is usually provided by an alarm that indicates higher-than-allowable machine speed;
 - 3) Thermal gradient load due to the drying of the web. Protection against unusual drying loads is usually provided by logic controls on the machine, primarily to detect a "sheet-off" condition that

changes the thermal load on the shell exterior from being cooled by the tissue sheet to being heated by the hot air from the hood; and

- 4) Pressure roll load (line or nip load) due to pressing the wet web onto the dryer. Overload protection is usually provided by a control valve that limits the pneumatic or hydraulic forces on the roll loading arms such that the resultant nip load does not exceed the allowable operating nip load.
- c) Steam pressure, inertial, and thermal gradient loads impose steady-state stresses. These stresses typically change when the dryer shell thickness (effective thickness for ribbed dryers) is reduced to restore a paper-making surface, the grade of tissue is changed or speed of the dryer is changed.
- d) The pressure roll(s) load imposes an alternating stress on the shell face. The resulting maximum stress is dependent on the magnitude of the alternating and steady-state stresses.
- e) ASME Section VIII, Division 1, only provides specific requirements for the analysis of pressure loads. Although the Code requires analysis of other loads, no specific guidance for thermal, inertial, or pressure roll loads is provided. Hence, additional criteria must be applied by the manufacturer to account for all the steady-state and alternating stresses.
- f) To maintain product quality, the dryer surface is periodically refurbished by grinding. This results in shell thickness reduction. Therefore, the manufacturer does not provide a single set of maximum allowable operating parameters relating steam pressure, rotational speed, and pressure roll load for a single design shell thickness. The manufacturer, or another qualified source acceptable to the Inspector, instead provides a series of curves that graphically defines these maximum allowable operating parameters across a range of shell thicknesses. This document is known as the “De-rate Curve.” See NBIC Part 1, Figure S1.2. In cases where no de-rate curve is provided, the manufacturer or another qualified source shall provide operating conditions that include a minimum shell thickness.
- g) Thermal spray (metallizing) materials may be applied to extend and improve dryer operations and provide a more wear-resistant surface. Thermal spray coatings are often applied to the exterior of steel shells and may be applied to cast iron shells. Once applied, the metallization may be ground periodically before it is removed or replaced. Thermal spray coatings do not add strength to the component and are not included in shell thickness calculation. Shell thickness shall be verified prior to metallizing. Grinding that reduces thickness of the pressure containing shell material to which metallization has been applied must be evaluated for any necessary pressure and safety device re-settings.
- h) In addition to the loads on the yankee dryer due to operation, other nonstandard load events can occur during shipment and installation into the paper machine. These nonstandard load events should be recorded in an incident log. Examples of nonstandard load events include:
 - 1) Damage to the protective packaging of the yankee dryer during transport and installation;
 - 2) Scratches, gouges, or dents of the yankee dryer during packaging removal or installation into the paper machine, or undesirable mechanical contact between the yankee dryer and other surfaces;
 - 3) Excessive heating of the yankee dryer during the installation and testing of the hot air hood. If the hot air hood will be generating air that is hotter than the yankee dryer shell material’s maximum allowable working temperature (MAWT), then temperature sensors should be installed to monitor and record the yankee dryer shell temperature during the hood testing; and
 - 4) Impact load from improperly installed rolls, wires, nuts, dropped wrenches, etc., that may travel through the pressure roll nip causing external impact loads on the yankee dryer shell.
- i) If nonstandard events (incidents) have occurred during installation, then the Inspector should ensure that an appropriate assessment of the structural integrity of the yankee dryer has been performed. For additional details see NBIC Part 2, Supplement 5 and NBIC Part 3, Supplement 5.

FIGURE S1.2
A TYPICAL MANUFACTURER'S "DE-RATE CURVE"

NOTE: There are several safe operating pressures for a given shell thickness.



(23) S1.3 DETERMINATION OF ALLOWABLE OPERATING PARAMETERS

- a) A yankee dryer is designed and intended to have its shell thickness reduced over the life of the vessel through routine wear and grinding. The yankee dryer shell is ground on the outside surface to restore the quality or shape of the papermaking surface essential to the manufacturing of tissue or other paper products.

- b) Design documentation that dictates the maximum allowable operating parameters as shell thickness is reduced is required. Calculations used to determine those parameters are in accordance with ASME Code requirements for primary membrane stress and design criteria based upon other relevant stress categories (e.g., fatigue and maximum principal stress). Calculation of these parameters requires that the respective stresses, resulting from the imposed loads, be compared to the appropriate material strength properties. Hence, knowledge of the applied stresses in the shell and the tensile and fatigue properties of the material is essential.
- c) Yankee dryers are subjected to a variety of loads that create several categories of stress. Yankee dryers are designed such that the stress of greatest concern typically occurs on the outside surface at the axial centerline of the shell.
 - 1) Steam Pressure Load — The internal steam pressure is one of the principal design loads applied to the yankee dryer. The steam pressure expands the shell radially, causing a predominately circumferential membrane tensile stress. Because the shell is constrained radially by the heads at either end of the shell, the steam pressure also causes a primary bending stress in the vicinity of the head-to-shell joint. The ends of the shell are in tension on the inside and compression on the outside due to the steam pressure. The steam pressure also causes a bending stress in the heads.
 - 2) Inertia Load — The rotation of the yankee dryer causes a circumferential membrane stress in the shell similar to that caused by the steam pressure load. This stress is included in the design of the shell and increases with dryer diameter and speed.
 - 3) Thermal Gradient Load — The wet sheet, applied to the shell, causes the outside surface to cool and creates a thermal gradient through the shell wall. This thermal gradient results in the outside surface being in tension and the inside surface in compression. With this cooling, the average shell temperature is less than the head temperature, which creates bending stresses on the ends of the shell and in the heads. The ends of the shell are in tension on the outside and compression on the inside.
 - a. Other thermal loading also occurs on a yankee dryer. The use of full-width showers for a variety of papermaking purposes affects the shell similar to a wet sheet. The use of edge sprays produces high bending stress in the ends of the shell due to the mechanical restraint of the heads.
 - b. Warm-up, cool-down, hot air impingement from the hood, moisture profiling devices, firefighting, and wash-up can all produce non-uniform thermal stresses in the pressure-containing parts of the yankee dryer. Heating or cooling different portions of the yankee dryer at different rates causes these non-uniform stresses.
 - 4) Line Load — The line load from the contacting pressure roll(s) results in an alternating, high cycle, bending stress in the shell. This stress is greatest at the centerline of the shell. The load of the pressure roll deflects the shell radially inward causing a circumferential compressive stress on the outside surface and a tensile stress on the inside. Because the shell has been deflected inward at the pressure roll nip, it bulges outward about 30 degrees on each side of the nip. The outward bulge causes a tensile stress on the outside shell surface at that location and a corresponding compressive stress on the inside. Since the shell is passing under the pressure roll, its surface is subjected to an alternating load at every revolution.

S1.4 ASME CODE PRIMARY MEMBRANE STRESS CRITERIA

(23)

- a) Yankee dryers are typically designed and fabricated in accordance with ASME Section VIII, Division 1.
- b) ASME Section VIII, Division 1, requires design stresses to be calculated such that any combination of loading expected to occur simultaneously during normal operation of the yankee dryer will not result in a general primary stress exceeding the maximum allowable stress value of the material. In the ASME Code, the combination of loading resulting in the primary membrane stress in the shell is interpreted to

be only composed of the circumferential stress from steam pressure. Sometimes, the stress from the inertial loading is included in this consideration.

- c) In ASME Section VIII, Division 1, it is very important to note that no formulas are given for determining the stresses from thermal operating loads and pressure roll nip load(s). Hence, additional criteria need to be incorporated to establish the maximum allowable operating parameters of the yankee dryer. Two such additional criteria are based upon the maximum principal and fatigue stress.

1) Maximum Principal Stress Criteria

The maximum principal stress in a yankee dryer shell is the sum of the stresses that are simultaneously applied to the shell and is always aligned in the circumferential direction. The purpose of these criteria is to recognize the paper making application of the yankee dryer and to prevent catastrophic failure by including all stresses. The ASME Code does not provide specific formulas for the full array of yankee dryer shell stresses encountered in tissue making.

2) Fatigue Stress Criteria

Under normal operation, the stresses due to the steam pressure, inertial and thermal operating loads are considered to be steady-state stresses. When acting simultaneously, the sum of these stresses must be judged against the cyclic, or alternating, stress due to the pressure roll nip load. Fatigue stress criteria limit the alternating stress at a given mean stress using fatigue failure criteria. The purpose of this limitation is to prevent crack initiation in the outside wall due to the combination of stresses. As the thickness of the shell is reduced, one or more of these criteria will control the various operating parameters.

(23) S1.5 PRESSURE TESTING

- a) Water pressure testing in the field is not recommended because of the large size of yankee dryers and the resulting combined weight of the yankee dryer and the water used in the testing. This combined weight can lead to support structure overload. Several failures of yankee dryers have occurred during field pressure testing using water. If this test must occur, the following review is recommended:
- 1) The testing area should be evaluated for maximum allowable loading, assuming the weight of the yankee dryer, the weight of the water filling the yankee dryer, and the weight of the support structure used to hold the yankee dryer during the test; and
 - 2) The manufacturer should be contacted to provide information on building the yankee dryer support structure for the water pressure test. Typically, the yankee dryer is supported on saddles that contact the yankee dryer shell at each end near the head-to-shell joint. The manufacturer can provide information on saddle sizing and location so that the yankee dryer is properly supported for the test.
- b) When pressure testing is desired to evaluate the yankee dryer for fitness for service, an alternative to water pressure testing is Acoustic Emission Testing using steam or air pressure. Typically, the test pressure used is the operating pressure. Caution needs to be exercised to ensure personnel safety. Entry to the test area needs to be controlled and all personnel need to maintain a safe distance from the yankee dryer during the test. The steam or air test pressure should never exceed the maximum allowable working pressure (MAWP) of the yankee dryer.

(23) S1.6 NONDESTRUCTIVE EXAMINATION

- a) Nondestructive examination (NDE) methods should be implemented using written NDE procedures by individuals qualified and experienced with the material to be tested.
- b) Typical NDE methods should be employed to determine indication length, depth, and orientation (sizing) of discontinuities in yankee dryers. Magnetic Particle, specifically the wet fluorescent method, and Dye

Penetrant methods are applicable in the evaluation of surface-breaking indications. Ultrasound testing is the standard method for evaluation of surface-breaking and embedded indications. Radiographic methods are useful in the evaluation of embedded indications. Acoustic Emission Testing can be used to locate and determine if a linear indication is active (e.g., propagating crack). Metallographic Analysis is useful in differentiating between original casting discontinuities and cracks.

- c) When NDE produces an indication, the indication is subject to interpretation as false, relevant, or non-relevant. If it has been interpreted as relevant, the necessary subsequent evaluation will result in a decision to accept, repair, replace, monitor, or adjust the maximum allowable operating parameters.

SUPPLEMENT 2**PRESSURE RELIEF VALVES ON THE LOW-PRESSURE SIDE OF STEAM
PRESSURE REDUCING VALVES****S2.1 SCOPE**

This supplement provides requirements and guidelines for the installation of safety valves on the low-pressure side of steam pressure reducing valves.

- a) The subject of protection of vessels in steam service connected to the low-pressure side of a steam-pressure reducing valve is of considerable importance to proper operation of auxiliary equipment such as pressure cookers, hot-water heating systems, etc., operating at pressures below that which the primary boiler generating unit is operating.
- b) To automatically reduce the primary boiler pressure for such processing equipment, pressure reducing valves are used. The manufacturers of such equipment have data available listing the volume of flow through reducing valves manufactured by them, but such data are not compiled in a form that the results can be deduced readily. To protect the equipment operating on the low-pressure side of a pressure reducing valve, pressure relief valves of a relieving capacity sufficient to prevent an unsafe pressure rise in case of failure of the pressure reducing valve, should be installed.
- c) The pressure reducing valve is a throttling device, the design of which is based on certain diaphragm pressures opposed by spring pressure which, in turn, controls the opening through the valve. If the spring, the diaphragm, or any part of the pressure reducing valve fails, steam will flow directly through the valve and the low pressure equipment will be subjected to the boiler pressure. To protect the equipment operating on the low pressure side of the pressure reducing valve, pressure relief valve(s) should be installed on the low pressure side of the pressure reducing valve, which will provide a relieving capacity sufficient to prevent the pressure from rising above the system design pressure.
- d) In most cases pressure reducing valves used for the reduction of steam pressures have the same pipe size on the inlet and outlet. In case of failure of a pressure reducing valve, the pressure relief valve on the low-pressure side must have a capacity to take care of the volume of steam determined by the high pressure side and the area of the pipe.

S2.2 PRESSURE RELIEF VALVE CAPACITY

- a) The capacity of the pressure relief valve(s) on the low-pressure side of the pressure reducing valve should be based on the capacity of the pressure reducing valve when wide open or under maximum flow conditions or the flow capacity through the bypass valve.
- b) By using the formula in NBIC Part 1, S2.3, Inspectors may calculate the required relieving capacities of the pressure relief valve(s) installed on the low-pressure side of the pressure reducing valve.
- c) Usually a pressure reducing valve has a bypass arrangement so that in case of failure of the pressure reducing valve the boiler pressure may be short circuited into the low-pressure line without passing through the pressure reducing valve. When determining the required relieving capacity of pressure relief valves for the low-pressure side of the pressure reducing valve, the steam flow through the bypass must be taken into consideration.

S2.3 CALCULATION OF PRESSURE RELIEF VALVE RELIEVING CAPACITY

- a) When a pressure reducing valve is installed, there are two possibilities of introducing boiler pressure into the low-pressure system:
 - 1) The failure of the pressure reducing valve so that it remains wide open; and

2) The possibility of the bypass valve being open.

- b) It is necessary therefore, to determine the flow under both circumstances in paragraph a) above and check that the size of the pressure relief valve under either condition will be adequate. The following formulas should be used:

- 1) W = steam flow in lbs/hr (kg/hr) through the pressure reducing valve

$$W = AKC$$

where,

A = internal area in sq. in. (sq. mm) of the inlet pipe size of the pressure reducing valve (see NBIC Part 1, Table S2.5)

K = flow coefficient for the pressure reducing valve (see NBIC Part 1, S2.4)

C = flow capacity of saturated steam through a pipe in lbs/hr/in² (kg/hr/mm²) at various pressure differentials from NBIC Part 1, Tables S2.3-a, S2.3-b, or S2.3-c (for U.S. Customary units) or NBIC Part 1, Tables S2.3M-a, S2.3M-b, or S2.3M-c (for metric units).

- 2) W = steam flow in lbs/hr (kg/hr) through the by-pass valve

$$W = A_1 K_1 C_1$$

where,

A_1 = internal area in sq. in. (sq. mm) of the pipe size of the bypass around the pressure reducing valve

K_1 = flow coefficient for the bypass valves (see NBIC Part 1, S2.4)

C_1 = flow capacity of saturated steam through a pipe in lbs/hr/in² (kg/hr/mm²) at various pressure differentials from Tables S2.3-a, S2.3-b, or S2.3-c (for U.S. Customary units) or Tables NBIC Part 1, S2.3M-a, S2.3M-b, or S2.3M-c (for metric units).

TABLE S2.3-a

CAPACITY OF SATURATED STEAM, IN LBS/HR, PER IN.² OF PIPE AREA

Outlet Pressure, psi	pressure reducing valve inlet pressure, psi												
	1,500	1,450	1,400	1,350	1,300	1,250	1,200	1,150	1,100	1,050	1,000	950	900
1,000	76,560	72,970	69,170	64,950	60,540	55,570	49,930	43,930	35,230	25,500	.....	.....	.....
950	77,430	74,180	70,760	63,100	63,100	58,770	53,920	48,610	42,380	34,890	24,910	.....	.....
900	77,750	74,810	71,720	68,340	64,870	61,040	56,820	52,260	47,050	41,050	33,490	23,960	.....
850	77,830	74,950	72,160	69,130	66,020	62,610	58,900	54,930	50,480	45,470	39,660	29,080	23,190
800		75,070	72,330	69,490	66,700	63,680	60,390	56,910	53,060	48,800	43,980	38,340	31,610
750				69,610	66,880	64,270	61,260	58,200	54,840	51,170	47,080	42,420	37,110
700					66,900	64,270	61,520	58,820	55,870	52,670	49,170	45,230	40,860
650							61,550	58,860	56,260	53,480	50,440	47,070	43,400
600								58,980	56,270	53,660	51,020	48,470	45,010
550										53,810	51,040	48,470	45,800
500													45,850
450													45,870
400													
350													
300													
250													
200													
175													
150													
110													
100													
85													
75													
60													
50													
40													
30													
25													
15													
10													
5													
Where capacities are not shown for inlet and outlet conditions, use the highest capacity shown under the applicable inlet pressure column.													

Where capacities are not shown for inlet and outlet conditions, use the highest capacity shown under the applicable inlet pressure column.

TABLE S2.3M-a

CAPACITY OF SATURATED STEAM, IN KG/HR, PER MM² OF PIPE AREA

Outlet Pressure, MPa	pressure reducing valve inlet pressure, MPa														
	10.25	10.00	9.75	9.5	9.25	9.00	8.75	8.5	8.25	8.00	7.75	7.50	7.25	7.00	6.75
6.75	53.44	51.68	49.82	47.85	45.77	43.63	41.28	38.73	36.01	33.09	29.47	25.37	20.89	.....	.....
6.50	53.87	52.23	50.52	48.69	46.79	44.83	42.69	40.40	37.95	35.30	32.33	29.02	25.31	20.46	.....
6.25	54.07	52.55	50.96	49.27	47.51	45.71	43.75	41.67	39.46	37.08	34.46	31.59	28.43	24.45	19.36
6.00	54.15	52.67	51.19	49.62	47.99	46.33	44.53	42.63	40.62	38.74	36.12	33.59	30.83	27.53	23.13
5.75	54.19	52.74	51.32	49.85	48.33	45.80	45.14	43.40	41.56	39.62	37.51	35.25	32.82	30.04	26.20
5.50	54.20	52.78	49.97	49.610	48.53	47.11	45.60	44.00	42.32	40.55	38.56	36.63	34.48	32.05	29.37
5.25	.....	.....	.....	50.00	48.60	47.20	45.82	44.35	42.78	41.17	39.44	37.62	35.68	33.52	31.16
5.00	.....	.....	.....	50.01	48.62	47.23	45.89	44.49	43.02	41.55	39.98	38.33	36.57	34.64	32.56
4.75	.....	.....	.....	.....	.....	47.24	.....	44.52	43.13	41.75	40.31	38.81	37.22	35.50	33.64
4.50	.....	.....	.....	.....	.....	.....	.....	44.53	43.14	41.77	40.43	39.08	37.63	36.07	34.41
4.25	.....	.....	.....	.....	.....	.....	.....	.....	43.15	41.82	40.46	39.10	37.74	36.33	34.90
4.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	41.84	40.48	39.12	37.82	36.45	35.12
3.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	39.14	37.88	36.48	35.13
3.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Where capacities are not shown for inlet and outlet conditions, use the highest capacity shown under the applicable inlet pressure column.

TABLE S2.3-b

CAPACITY OF SATURATED STEAM, IN LBS/HR, PER IN.² OF PIPE AREA

Outlet Pressure, psi	pressure reducing valve inlet pressure, psi												
	850	800	750	700	650	600	550	500	450	400	350	300	250
1,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
950	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
900	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
850	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
800	22,550	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
750	30,600	21,800	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
700	35,730	29,420	21,020	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
650	39,200	34,250	28,260	20,190	.....	.....	.....	.....	.....	.....	.....	.....	.....
600	41,500	37,470	32,800	27,090	19,480	.....	.....	.....	.....	.....	.....	.....	.....
550	42,480	39,850	35,730	31,310	25,940	18,620	.....	.....	.....	.....	.....	.....	.....
500	43,330	40,530	37,610	33,880	29,760	24,630	17,720	.....	.....	.....	.....	.....	.....
450	43,330	40,730	38,150	35,260	31,980	28,080	23,290	16,680	.....	.....	.....	.....	.....
400	.....	40,760	38,220	35,680	33,050	29,980	26,380	21,870	15,760	.....	.....	.....	.....
350	.....	.....	.....	.....	33,120	30,690	27,910	24,570	20,460	14,790	.....	.....	.....
300	.....	.....	.....	.....	33,240	.....	28,140	25,610	22,620	18,860	13,630	.....	.....
250	.....	.....	.....	.....	.....	.....	28,150	25,650	23,200	21,000	17,100	10,800	.....
200	.....	.....	.....	.....	.....	.....	.....	.....	.....	21,350	18,250	15,350	10,900
175	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18,250	16,000	12,600
150	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18,250	16,200	13,400
110	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18,780	.....	13,600
100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13,600
85	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13,600
75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13,600
60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13,600
50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13,630
40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Where capacities are not shown for inlet and outlet conditions, use the highest capacity shown under the applicable inlet pressure column.

Where capacities are not shown for inlet and outlet conditions, use the highest capacity shown under the applicable inlet pressure column.

TABLE S2.3M-b

CAPACITY OF SATURATED STEAM, IN KG/HR, PER MM² OF PIPE AREA

Outlet Pressure, MPa	pressure reducing valve inlet pressure, MPa															
	6.00	5.75	5.50	5.25	5.00	4.75	4.50	4.25	4.00	3.75	3.50	3.25	3.00	2.75	2.50	2.25
5.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5.50	18.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5.25	22.24	17.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5.00	24.96	21.60	17.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4.75	27.06	24.31	21.18	17.17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4.50	28.64	26.30	23.70	20.58	16.54	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4.25	29.71	27.67	25.44	22.83	19.75	15.63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4.00	30.49	28.74	26.86	24.59	22.06	19.18	15.75	.....	.....	.....	.....	.....	.....	.....	.....	.....
3.75	30.99	29.49	27.95	25.92	23.77	21.42	18.76	15.23	.....	.....	.....	.....	.....	.....	.....	.....
3.50	31.15	29.77	28.32	26.74	24.90	22.87	20.68	17.93	14.24	.....	.....	.....	.....	.....	.....	.....
3.25	31.18	29.86	28.49	27.10	25.53	23.81	21.95	19.73	17.12	13.72	.....	.....	.....	.....	.....	.....
3.00	31.19	29.88	28.56	27.25	25.86	24.40	22.82	20.98	18.90	16.51	13.46	.....	.....	.....	.....	.....
2.75	.....	.....	28.58	27.28	25.98	24.68	23.34	21.79	20.09	18.19	15.90	12.98	.....	.....	.....	.....
2.50	.....	.....	.....	.....	.....	.....	23.37	22.05	20.62	19.04	17.19	14.94	11.83	.....	.....	.....
2.25	.....	.....	.....	.....	.....	.....	23.42	22.15	20.83	19.45	17.94	16.18	14.11	11.59	.....	.....
2.00	.....	.....	.....	.....	.....	.....	23.46	22.17	20.87	19.57	18.28	16.85	15.26	13.48	10.95	.....
1.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.58	18.30	17.03	15.79	14.59	12.54	9.55
1.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17.05	15.90	14.84	12.12	10.46
1.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15.92	14.95	12.98	11.75
1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14.96	13.44	12.19
0.90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14.97	13.60	12.30
0.80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13.66	12.35
0.70	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Where capacities are not shown for inlet and outlet conditions, use the highest capacity shown under the applicable inlet pressure column.

TABLE S2.3-c

CAPACITY OF SATURATED STEAM, IN LBS/HR, PER IN² OF PIPE AREA

Outlet pres., psi	pressure reducing Valve Inlet Pressure											
	200	175	150	125	100	85	75	60	50	40	30	25
1,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
950	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
900	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
850	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
800	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
750	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
700	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
650	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
600	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
550	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
500	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
450	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
400	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
350	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
300	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
250	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
200	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
175	7,250	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
150	9,540	6,750	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
125	10,800	8,780	6,220	.....	.....	.....	.....	.....	.....	.....	.....	.....
110	11,000	9,460	7,420	4,550	.....	.....	.....	.....	.....	.....	.....	.....
100	11,000	9,760	7,970	5,630	.....	.....	.....	.....	.....	.....	.....	.....
85	11,000	.....	8,480	6,640	4,070	.....	.....	.....	.....	.....	.....	.....
75	11,000	.....	.....	7,050	4,980	3,150	.....	.....	.....	.....	.....	.....
60	11,000	.....	.....	7,200	5,750	4,540	3,520	.....	.....	.....	.....	.....
50	11,000	.....	.....	.....	5,920	5,000	4,230	2,680	.....	.....	.....	.....
40	11,000	.....	.....	.....	.....	5,140	4,630	3,480	2,470	.....	.....	.....
30	11,050	.....	.....	.....	.....	.....	.....	3,860	3,140	2,210	.....	.....
25	.....	.....	.....	.....	.....	.....	.....	.....	3,340	2,580	1,485	.....
15	.....	.....	.....	.....	.....	.....	.....	.....	.....	2,830	2,320	1,800
10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2,060
5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Where capacities are not shown for inlet and outlet conditions, use the highest capacity shown under the applicable inlet pressure column.												

TABLE S2.3M-c

CAPACITY OF SATURATED STEAM, IN KG/HR, PER MM² OF PIPE AREA

Outlet Pressure, kPa	pressure reducing valve inlet pressure, kPa										
	1,500.00	1,250.00	1,000.00	900.00	800.00	700.00	600.00	500.00	400.00	300.00	200.00
1,250.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1,000.00	7.78	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
900.00	8.15	6.25	.....	.....	.....	.....	.....	.....	.....	.....	.....
800.00	8.34	6.77	4.29	.....	.....	.....	.....	.....	.....	.....	.....
700.00	8.38	7.06	5.21	4.22	.....	.....	.....	.....	.....	.....	.....
600.00	8.38	7.08	5.65	4.87	3.82	.....	.....	.....	.....	.....	.....
500.00	8.38	.....	5.77	5.19	4.48	3.68	.....	.....	.....	.....	.....
400.00	8.38	.....	5.78	5.26	4.71	4.13	3.37	.....	.....	.....	.....
300.00	8.38	.....	.....	.....	4.74	4.22	3.66	3.01	.....	.....	.....
200.00	8.41	.....	.....	.....	.....	.....	3.69	3.71	2.62	1.83	.....
100.00	.....	.....	.....	.....	.....	.....	.....	.....	2.64	2.12	1.56
80.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.58
60.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.60
40.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Where capacities are not shown for inlet and outlet conditions, use the highest capacity shown under the applicable inlet pressure column.											

Where capacities are not shown for inlet and outlet conditions, use the highest capacity shown under the applicable inlet pressure column.

S2.4 STEAM FLOW WHEN FLOW COEFFICIENTS ARE NOT KNOWN

- a) It is possible that the flow coefficients K and K_1 may not be known and in such instances for approximating the flow, a factor of $1/3$ may be substituted for K and $1/2$ for K_1 .

The formulas in S2.3 then become:

$W = 1/3 AC$ for the capacity through the pressure reducing valve; and

$W = 1/2 A_1 C_1$ for the capacity through the bypass valve.

- b) Caution should be exercised when substituting these factors for the actual coefficients since this method will provide approximate values only and the capacities so obtained may in fact be lower than actual. It is recommended that the actual flow coefficient be obtained from the pressure reducing valve manufacturer and reference books be consulted for the flow coefficient of the bypass valve.

S2.5 TWO-STAGE PRESSURE REDUCING VALVE STATIONS

The pressure relief valve for two-stage pressure reducing valve stations shall be sized on the basis of the high-side pressure and the inlet size of the first pressure reducing valve in the line. If an intermediate pressure line is taken off between the pressure reducing valves, then this line and the final low side shall be protected by pressure relief valves sized on the basis of the high-side pressure and the inlet size of the first pressure reducing valve. See NBIC Part 1, Table S2.5.

TABLE S2.5
PIPE DATA

Nominal Pipe Size, Unitless (US Customary)	Nominal Pipe Size, Unitless (SI Metric)	Average Outside Diameter (D)		Nominal Wall Thickness Standard Weight Pipe (t)		Approximate Internal Area (Note 1)	
ASME B36.10M							
Unitless	Unitless	in.	mm	in.	mm	in ²	mm ²
NPS 3/8	DN 10	0.675	17.1	0.091	2.31	0.191	122
NPS 1/2	DN 15	0.840	21.3	0.109	2.77	0.304	195
NPS 3/4	DN 20	1.050	26.7	0.113	2.87	0.533	345
NPS 1	DN 25	1.315	33.4	0.133	3.38	0.864	557
NPS 1-1/4	DN 32	1.660	42.2	0.140	3.56	1.496	967
NPS 1-1/2	DN 40	1.900	48.3	0.145	3.68	2.036	1,316
NPS 2	DN 50	2.375	60.3	0.154	3.91	3.356	2,163
NPS 2-1/2	DN 65	2.875	73.0	0.203	5.16	4.788	3,086
NPS 3	DN 80	3.500	88.9	0.216	5.49	7.393	4,769
NPS 3-1/2	DN 90	4.000	101.6	0.226	5.74	9.887	6,379
NPS 4	DN 100	4.500	114.3	0.237	6.02	12.73	8,213
NPS 5	DN 125	5.563	141.3	0.258	6.55	20.00	12,908
NPS 6	DN 150	6.625	168.3	0.280	7.11	28.89	18,646
NPS 8	DN 200	8.625	219.1	0.332	8.18	49.78	32,283
NPS 10	DN 250	10.750	273.0	0.365	9.27	78.85	50,854
NPS 12	DN 300	12.750	323.8	0.375	9.53	113.1	72,937

Note:

In applying these rules, the area of the pipe is always based upon standard weight pipe and the inlet size of the pressure reducing valve.

Where: D = outside diameter of the pipe and t = nominal wall of the pipe

$$Area = \frac{\pi(D - 2t)^2}{4}$$

SUPPLEMENT 3

INSTALLATION OF LIQUID CARBON DIOXIDE STORAGE VESSELS

S3.1 SCOPE

This supplement provides requirements and guidelines for the installation of Liquid Carbon Dioxide Storage Vessels (LCDSVs), fill boxes, fill lines, and pressure relief discharge/vent circuits used for carbonated beverage systems, swimming pool pH control systems, and other fill in place systems storing 1,000 lbs (454 kg) or less of liquid CO₂.

S3.2 GENERAL REQUIREMENTS STORAGE TANK LOCATION

LCDSVs should be installed in an unenclosed area whenever possible. LCDSVs that do not meet all criteria for an unenclosed area shall be considered an enclosed area installation. An unenclosed area:

- a) Shall be outdoors;
- b) Shall be above grade; and
- c) Shall not obstruct more than three sides of the perimeter with supports and walls. At least 25% of the perimeter area as calculated from the maximum height of the storage container shall be open to atmosphere and openings shall be in direct conveyance with ground level.

S3.2.1 GENERAL REQUIREMENTS (ENCLOSED AND UNENCLOSED AREAS)

- a) LCDSVs shall not be located within 10 feet (3,050 mm) of elevators, unprotected platform ledges, or other areas where falling would result in dropping distances exceeding half the container height.
- b) LCDSVs shall be installed with sufficient clearance for filling, operation, maintenance, inspection, and replacement.
- c) Orientation of nozzles and attachments shall be such that sufficient clearance between the nozzles, attachments, and the surrounding structures is maintained during the installation, the attachment of associated piping, and operation.
- d) LCDSVs shall not be installed on roofs.
- e) LCDSVs shall be safely supported. Vessel supports, foundations, and settings shall be in accordance with jurisdictional requirements, manufacturer recommendations and/or other industry standards as applicable. The weight of the vessel when full of liquid carbon dioxide shall be considered when designing vessel supports. Design of supports, foundations, and settings shall consider vibration (including seismic and wind loads where necessary), movement (including thermal movement), and loadings. Vessel foundations or floors in multistory buildings must be capable of supporting the full system weight and in accordance with building codes.
- f) LCDSVs shall not be installed within 36 in. (915 mm) of electrical panels.
- g) LCDSVs installed outdoors in areas in the vicinity of vehicular traffic shall be guarded to prevent accidental impact by vehicles. The guards or bollards shall be installed in accordance with local building codes or to a national recognized standard when no local building code exists.
- h) LCDSVs shall be equipped with isolation valves in accordance with paragraph NBIC Part 1, S3.6.

S3.2.2 UNENCLOSED AREA LCDSV INSTALLATIONS

If LCDSVs are installed outdoors and exposed to the elements, appropriate additional protection may be provided as necessary based on the general weather conditions and temperatures that the tank may be exposed to. Some possible issues include:

- a) Exposure to high solar heating loads will increase the net evaporation rate and will decrease hold times in low CO₂ usage applications. The vessel may be covered or shade provided to help reduce the solar load and increase the time needed to reach the relief valve setting in low use applications.
- b) If supply line is not UV resistant then the supply line should be protected via conduit or appropriate covering.

S3.2.3 ENCLOSED AREA LCDSV INSTALLATIONS

- a) Permanent LCDSV installations with remote fill connections:
 - 1) Shall be equipped with a gas detection system installed in accordance with NBIC Part 1, S3.4;
 - 2) Shall have signage posted in accordance with NBIC Part 1, S3.5; and
 - 3) Shall be equipped with fill boxes, fill lines and safety relief/vent valve circuits installed in accordance with NBIC Part 1, S3.6.
- b) Portable LCDSV installations with no permanent remote fill connection:

Warning: LCDSVs shall not be filled indoors or in enclosed areas under any circumstances. Tanks must always be moved to the outside to an unenclosed, free airflow area for filling.

- 1) Shall be equipped with a gas detection system installed in accordance with NBIC Part 1, S3.4;
- 2) Shall have signage posted in accordance with NBIC Part 1, S3.5;
- 3) Shall have a safety relief/vent valve circuit connected at all times except when the tank is being removed for filling. Connects may be fitted with quick disconnect fittings meeting the requirements of NBIC Part 1, S3.6; and
- 4) Shall be provided with a pathway that provides a smooth rolling surface to the outdoor, unenclosed fill area. There shall not be any stairs or other than minimal inclines in the pathway.

S3.3 FILLBOX LOCATION / SAFETY RELIEF/VENT VALVE CIRCUIT TERMINATION

Fill boxes and/or vent valve terminations shall be installed above grade, outdoors in an unenclosed, free airflow area. The fill connection shall be located so not to impede means of egress or the operation of side-walk cellar entrance doors, including during the delivery process and shall be:

- a) At least 36 in. (915 mm) from any door or operable windows;
- b) At least 36 in. (915 mm) above grade;
- c) Shall not be located within 10 ft. (31 m) from side to side at the same level or below, from any air intakes; and
- d) Shall not be located within 10 ft. (31 m) from stairwells that go below grade.

S3.4 GAS DETECTION SYSTEMS

A continuous gas detection system shall be provided in the room or area where container systems are filled/used, and in areas where the heavier-than-air gas can accumulate, including below grade, enclosed, or confined space outdoor locations. Small outdoor, at-grade enclosures which are not large enough for a person to enter are not required to have gas detection. Carbon dioxide (CO₂) sensors shall be provided within 12 inches (305mm) of the floor in the area where the gas is most likely to accumulate or leaks are most likely to occur, or as specified by the gas detection manufacturer. The system shall be designed to detect and alert at a low and high level alarm.

- a) The threshold for activation of the low level alarm shall not exceed a carbon dioxide concentration of 5,000 ppm (9,000 mg/m³) Time Weighted Average (TWA) over 8 hours. When carbon dioxide is detected at the low level alarm, the system shall activate a signal at a normally attended location within the building.
- b) The threshold for activation of the high level alarm shall not exceed a carbon dioxide concentration 30,000 ppm (54,000 mg/m³). When carbon dioxide is detected at the high level alarm, the system shall activate an audible and visual alarm at a location approved by the jurisdiction having authority.

S3.5 SIGNAGE

Hazard identification signs shall be posted at the entrance to the room and / or the confined enclosed area where the LCDSV is located. The warning sign shall be at least 8 in. (200 mm) wide and 6 in. (150 mm) high and indicate:

FIGURE S3.5

CO₂ WARNING SIGN

CAUTION - CARBON DIOXIDE GAS

Ventilate the area before entering.
A high carbon dioxide (CO₂) gas concentration
in this area can cause asphyxiation.

S3.6 VALVES, PIPING, TUBING, AND FITTINGS

- a) Materials – Materials selected for valves, piping, tubing, hoses, and fittings used in the LCDSV system shall meet following requirements:
 - 1) Components must be compatible for use with CO₂ in the phase (gas, or liquid in the applicable circuit) it encounters in the system.
 - 2) Components shall be rated for the operational temperatures and pressures encountered in the applicable circuit of the system.
 - 3) Shall be stainless steel, copper, brass, or plastic/polymer materials rated for CO₂.
 - 4) Only fittings and connections recommended by the manufacturer shall be used for all hoses, tubes, and piping.

- 5) All valves and fittings used on the LCDSV shall be rated for the maximum allowable working pressure stamped on the tank.
 - 6) All piping, hoses, and tubing used in the LCDSV system shall be rated for the working pressure of the applicable circuit in the system and have a burst pressure rating of at least four times the maximum allowable working pressure of the piping, hose, or tubing.
- b) Relief Valves – Each LCDSV shall have at least one ASME/NB stamped & certified relief valve with a pressure setting at or below the MAWP of the tank. The relief valve shall be suitable for the temperatures and flows experienced during relief valve operation. The minimum relief valve capacity shall be designated by the manufacturer. Additional relief valves that do not require ASME stamps may be added per recommendations in Compressed Gas Association pamphlet, CGA S-1.3 Pressure Relief Device Standards Part 3, Stationary Storage Containers for Compressed Gases. Discharge lines from the relief valves shall be sized in accordance with tables NBIC Part 1, S3.6-a and S3.6-b.

Note:

Due to the design of the LCDSV, the discharge line may be smaller in diameter than the relief valve outlet size.

Caution:

Companies and/or individuals filling or refilling LCDSVs shall be responsible for utilizing fill equipment that is acceptable to the manufacturer to prevent over pressurization of the vessel.

- c) Isolation Valves – Each LCDSV shall have an isolation valve installed on the fill line and tank discharge, or gas supply line in accordance with the following requirements:
- 1) Isolation valves shall be located on the tank or at an accessible point as near to the storage tank as possible.
 - 2) All valves shall be designed or marked to indicate clearly whether they are open or closed.
 - 3) All valves shall be capable of being locked or tagged in the closed position for servicing.
 - 4) Gas Supply and Liquid CO₂ Fill Valves shall be clearly marked for easy identification.
- d) Safety Relief/Vent Lines – Safety relief/vent lines shall be as short and straight as possible with a continuous routing to an unenclosed area outside the building and installed in accordance with the manufacturer's instructions. The vent line(s) shall be a continuous run from the vessel pressure relief device vent piping to the outside vent line discharge fitting. Mechanical joints in metallic piping and tubing shall be visible and inspectable. Any splices in plastic or polymeric tubing shall be done within three feet of the vessel and must be visible and inspectable. These lines shall be free of physical defects such as cracking or kinking and all connections shall be securely fastened to the LCDSV and the fill box. All safety relief/vent lines shall be protected to prevent penetration by nail, projectile, or other foreign object when routed through a wall, floor, or ceiling. The minimum size and length of the lines shall be in accordance with NBIC Part 1, Tables S3.6-a and S3.6-b. Fittings or other connections may result in a localized reduction in diameter have been factored into the lengths given by the NBIC Part 1, Tables S3.6-a and S3.6-b.

Note:

Due to the design of the LCDSV, the discharge line may be smaller in diameter than the relief valve outlet size but shall not be smaller than that shown in NBIC Part 1, Tables S3.6-a and S3.6-b.

TABLE S3.6-a

MINIMUM LCDSV SYSTEM RELIEF / VENT LINE REQUIREMENTS (METALLIC)

Tank Size (Pounds)	Fire Flow Rate Requirements (Pounds per Minute)	Maximum length of 3/8 inch ID Metallic Tube Allowed	Maximum length of 1/2 inch ID Metallic Tube Allowed
Less than 500	2.60 maximum	80 feet	100 feet
500 - 750	3.85 maximum	55 feet	100 feet
Over 750 – 1,000	5.51 maximum	18 feet	100 feet

TABLE S3.6-b

MINIMUM LCDSV SYSTEM RELIEF / VENT LINE REQUIREMENTS (PLASTIC/POLYMER)

Tank Size (Pounds)	Fire Flow Rate Requirements (Pounds per Minute)	Maximum length of 3/8 inch ID plastic/polymer Tube Allowed	Maximum length of 1/2 inch ID plastic/polymer Tube Allowed
Less than 500	2.60 maximum	100 feet	100 feet
500 - 750	3.85 maximum	100 feet	100 feet
Over 750 – 1,000	5.51 maximum	N/A see 1/2 inch	100 feet

TABLE S3.6M-a

METRIC MINIMUM LCDSV SYSTEM RELIEF / VENT LINE REQUIREMENTS (METALLIC)

Tank Size (kg)	Fire Flow Rate Requirements (kg per Minute)	Maximum length of 10 mm ID Metallic Tube Allowed	Maximum length of 13 mm ID Metallic Tube Allowed
Less than 227	1.18 maximum	24 m	30.5 m
227 - 340	1.75 maximum	17 m	30.5 m
Over 340 - 454	2.5 maximum	5.5 m	30.5 m

TABLE S3.6M-b

METRIC MINIMUM LCDSV SYSTEM RELIEF / VENT LINE REQUIREMENTS (PLASTIC/POLYMER)

Tank Size (kg)	Fire Flow Rate Requirements (kg per Minute)	Maximum length of 10 mm ID plastic/polymer Tube Allowed	Maximum length of 13 mm ID plastic/polymer Tube Allowed
Less than 227	1.80 maximum	30.5 m	30.5 m
227 - 340	1.75 maximum	30.5 m	30.5 m
Over 340 - 454	2.50 maximum	N/A see 13 mm	30.5 m

Note:

Due to the design of the LCDSV, the discharge line may be smaller in diameter than the relief valve outlet size but shall not be smaller than that shown in tables NBIC Part 1, S3.6-a and -b.

S3.6.1 SYSTEM DESCRIPTION

The Liquid Carbon Dioxide Beverage systems include the Liquid Carbon Dioxide Storage Vessel or LCDSV (tank) and associated sub-system circuits - Liquid CO₂ fill circuit, and associated sub-system circuits and pressure relief / vent line circuit. The LCDSVs are vacuum insulated pressure vessels, constructed of stainless steel, with Super Insulation wrapping between the inner pressure vessel and the outer vacuum jacket. (See Figure S3.6.1-a) These pressure vessels are typically designed for a maximum allowable working pressure (MAWP) of either 300 psig (2,068 kPa) or 283 psig (1,951 kPa). The LCDSV come equipped with an ASME/NB certified "UV" Primary Relief Valve (PRV) set at or below the MAWP of the vessel. Additionally, as recommended by the Compressed Gas Association pamphlet CGA S-1.3, (PRESSURE RELIEF DEVICE STANDARDS PART 3 - STATIONARY STORAGE CONTAINERS FOR COMPRESSED GASSES) a secondary relief valve may be installed. This secondary relief valve is beyond the scope of ASME Section VIII, Division 1 and is not required to be ASME/NB stamped and certified. This additional PRV is typically rated no higher than 1.5 times the vessel MAWP.

Operating conditions of the system, components, and inner pressure vessel can vary causing temperatures and pressures to range from 90 psig (-56°F) to 300 psig (+2°F) {620 kPa (-49°C) to 2,068 kPa (-16°C)}. Below about 60 psig (413 kPa) in the tank, liquid CO₂ begins changing to solid phase (dry ice). If the tank becomes completely depressurized to 0 psig, temperatures inside the tank could reach -109°F (-78°C), (solid dry ice). When liquid CO₂ turns to solid dry ice in a completely depressurized tank, all CO₂ gas flow in the system ceases and the tank becomes nonfunctional.

See the attached CO₂ Phase Diagram NBIC Part 1; Figure S3.6.1-b, showing the typical operating range of these systems. Components external to the LCDSV inner tank pressure vessel may encounter pressures and temperatures between 90 psig, and -56°F to 300 psig and +2°F, respectively {between 620 kPa, and -49°C to 2,068 kPa and -16°C, respectively}. Typical operating pressures and temperatures vary in each of the associated sub-system circuits. (See NBIC Part 1, Table S3.6.1-b)

TABLE S3.6.1

TYPICAL OPERATING PRESSURES & TEMPERATURES OF LCDSV SYSTEMS

System Component	Operating Pressure	Operating Temperature
Storage Vessel (tank internal conditions)	90 – 300 psig	-56°F to +2°F
Liquid CO ₂ Fill Line	150 – 300 psig	-34°F to +2°F
Pressure Relief Gas Vent Line	0 – 120 psig	Ambient to -50°F

FIGURE S3.6.1-a

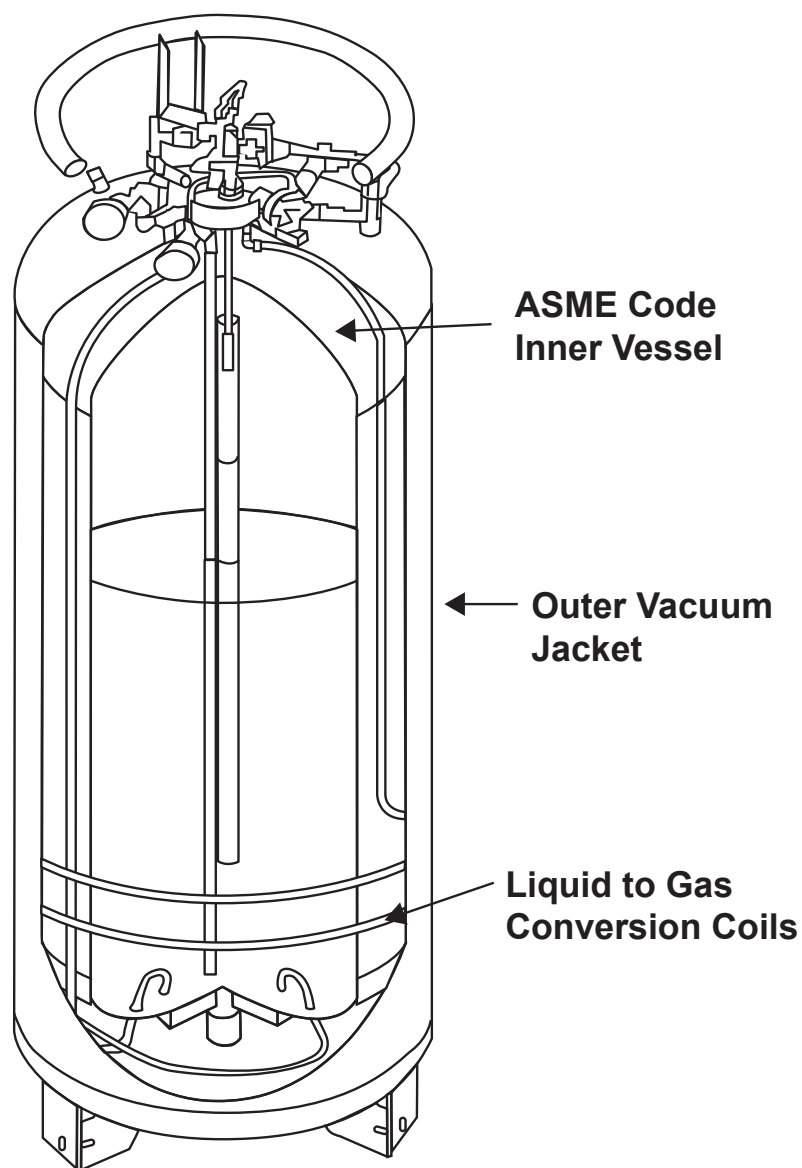
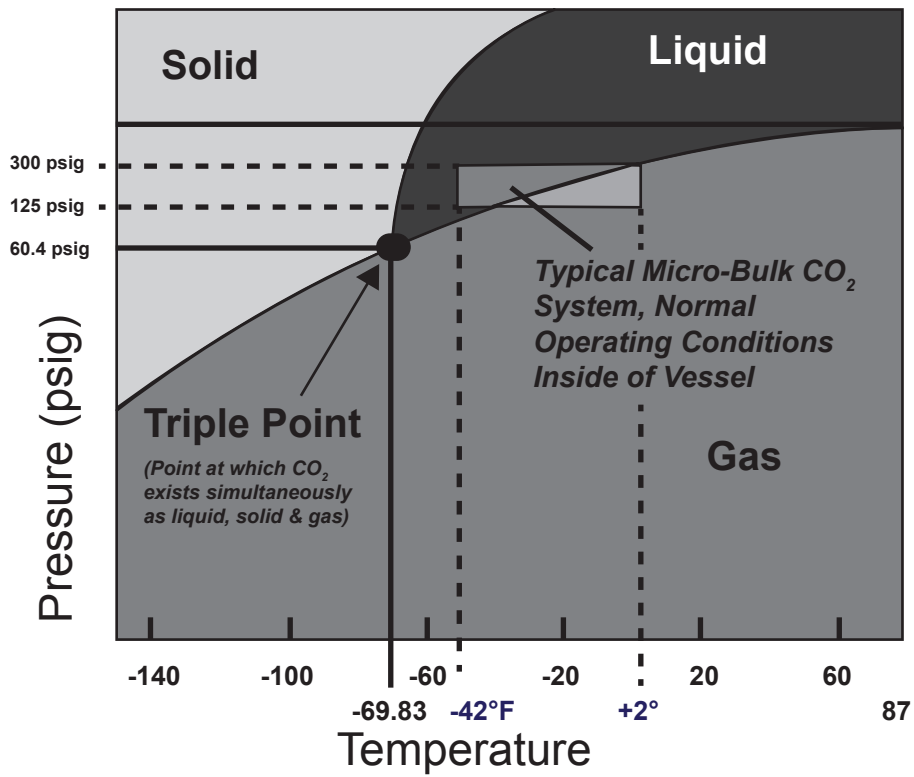


FIGURE S3.6.1-b
CO₂ PHASE DIAGRAM



SUPPLEMENT 4

INSTALLATION OF BIOMASS (WOOD/SOLID FUEL) FIRED BOILERS

S4.1 SCOPE

This supplement provides requirements and guidelines for the installation of biomass (wood/solid fuel) fired boilers as defined in NBIC Part 1, Section 9.

S4.2 PURPOSE

- a) The purpose of these rules is to establish minimum requirements for the installation of biomass boilers.
- b) It should be recognized that many of the requirements included in these rules must be considered in the design of the boiler by the manufacturer. However, the owner-user is responsible for ensuring that the installation complies with all the applicable requirements contained herein. Further, the installer is responsible for complying with the applicable sections when performing work on the behalf of the owner-user.
- c) This supplement provides requirements for the installation and control of boilers which use biomass as a major fuel component and will address the differences that occur when solid fuels, such as biomass, are being used. Thus the primary thrust of this section will be directed toward the control of the fuel handling and distribution systems.
- d) Fuels will vary widely depending upon source, moisture content, particle size, and distribution; however, once the fuel has been established, the owner-user should adhere to the original specification as closely as possible in order to minimize handling, combustion, and emissions problems.
- e) Additionally, the emissions control equipment is designed around the initial fuel specification. Any changes in fuel fired will impact on the performance of the various elements of the emissions control system.
- f) Biomass boilers and boiler rooms require additional considerations than traditionally fueled boilers that may include:
 - 1) Transportation of the fuel from a storage facility to a metering device within the equipment room;
 - 2) Transportation of the metered fuel to the boiler for distribution to a combustion system whether it be a grate upon which the combustion takes place, a bubbling fluidized bed, circulating fluidized bed or suspension burner;
 - 3) In grate based combustion systems combustion air is typically divided into an underfire air system and an overfire air system, each of which must be closely controlled in order to produce clean, efficient combustion;
 - 4) Induced draft fans to overcome the pressure drop of the emissions control equipment;
 - 5) A fly ash or carbon recycle system, to return unburned carbon to the combustion zone; and
 - 6) An ash removal system, to move ash from the boiler and emissions control equipment to suitable cooling and storage area.

S4.3 DETERMINATION OF ALLOWABLE OPERATING PARAMETERS

The allowable operating parameters of the combustion side shall be installed in accordance with jurisdictional and environments requirements, manufacturer's recommendations, and/or industrial standards, as applicable.

S4.4 GENERAL REQUIREMENTS

- a) Power boilers utilizing biomass as the primary fuel source shall meet the requirements of NBIC Part 1, Section 2 and this supplement.
- b) Steam heating, hot water heating, and hot water supply boilers utilizing biomass as the primary fuel source shall meet the requirements of NBIC Part 1, Section 3 and this supplement.

S4.5 FUEL SYSTEM REQUIREMENTS AND CONTROLS

- a) Fuel Transport Systems shall address preserving fuel particle size distribution, fire prevention, and the suppression of fires or explosions. In a single installation, various types of fuel transportation systems may co-exist. The most common systems are:
 - 1) Conveyor systems – In these systems fuel is dropped onto a moving belt, bucket elevator, drag link conveyor, or a screw or auger mechanism. Speed of the conveyor may be varied to meet fuel demand.
 - 2) Lean phase pneumatic systems – In these systems fuel is dropped into a moving airstream, mixes with the air, and travels through a pipe at a velocity of approximately 5,000 ft/min (1,525 m/min). Air pressures are in the region of 25 inches (635 mm) water column.
 - 3) Dense phase pneumatic systems – An intermittent or batch feed system, in which fuel is dropped through a valve (dome valve) into a pressure vessel. When the vessel is filled, the valve is closed, air at a pressure between 30 to 100 psig (200 to 700 kPa) is admitted and the fuel leaves the vessel in the form of a “slug”. The sequence then repeats. (Note that these systems are also used for ash handling.)
- b) Fuel Transport Solid Fuel Metering Systems vary depending upon the fuel used and the particle size distribution. These metering systems include but are not limited to:
 - 1) Variable Speed Augers

Variable speed, helically flighted, augers can be located in the bottom of a fuel metering bin. Alternatively, they could be a part of a retort type stoker. The auger dimensions, flighting, and speed range are selected on the basis of fuel being burned, its size range, heating value, and required boiler turndown range. The metered fuel typically is then dropped into the throat of a venturi (or in some cases a plain pipe) through which the fuel transport air flows to carry the fuel into the boiler combustion zone, for distribution on a grate, upon which the burning of the fuel takes place.

- 2) Variable Speed Air-lock Valves

This valve is basically a rotating slotted cylinder, operating within an outer cylinder, suitably sealed to prevent leakage. Rotational speed and slot dimensions can be varied to accommodate changes in fuel flow rate. The fuel passing through the valve, typically, is deposited onto a moving grate type stoker.

- 3) Variable Stroke Rams

This is another device that can be located on the bottom of a metering bin, is typically used on smaller units, and is essentially a batch feed mechanism. The stroke of the ram is adjusted to set fuel flow rate.

S4.6 COMBUSTION REQUIREMENTS

a) Overfire Air/Underfire Air Distribution

When solid fuels are burned on a grate, rather than in fluidized bed units or in suspension, it is normal practice to introduce some of the combustion air under the grate, or bed, and the remainder over the bed. In many cases fuel transport air becomes a part of the over-the-bed combustion air. The proportioning of the overfire to underfire airflow rates is dependent upon several factors, such as fuel particle size, fuel density, burn rate and volatiles. In general the objective is to get as complete a burn on the grate as possible, without creating large quantities of particulate emissions, and then using the overfire air to complete burning of the volatile and small particulate matter, leaving the fuel bed.

- b) Loss of combustion air from either the underfire or overfire source shall cause shutoff of the fuel supply and a lockout condition. The control system shall be capable of maintaining the correct relationship between underfire air and overfire air, over the complete firing range of the boiler, while promoting complete burning with minimum particulate emissions.

c) Programming Controls

Programming controls may be relay based, or on more current units, programmable logic controller (PLC) based. Interactive graphics displays may also be incorporated into the system. Access to PLC based controls and interactive graphic displays shall be limited to qualified individuals and password protected. PLC functions shall be confined to the normal boiler operating logic, covering startup, interlocks, and normal shutdown sequences. PLC logic shall not interfere with, or over-ride safety controls, which cause boiler safety shutdown when activated. The PLC logic shall comply with the requirements of NFPA-85.

d) Pre-firing Checks/Interlocks

In addition to the Safety Controls defined in NBIC Part 2, Sections S4.5, S4.6 a), and S4.6 b), prove that the following air handling fans are operating properly shall be required.

- 1) Induced draft fans;
- 2) Fuel transport fans;
- 3) Underfire air and Overfire air fans; and
- 4) Carbon, or flyash, re-injection fans.

In cases where variable speed drives are used on fans, the combustion system manufacturer's instructions shall be followed in terms of the allowable upper and lower limits of the power supply frequency (Hz).

e) Pre-purging

Pre-purging the boiler and its venting system shall be required. Unless defined otherwise by the manufacturer of the fuel burning equipment, the pre-purge may be achieved by operating the induced draft fan prior to starting the remaining fans in the installation.

Purge air volume shall be set during commissioning by the combustion system manufacturer, or the manufacturer's representative, in accordance with applicable codes or standards and shall not be capable of being reset by operating personnel.

f) Ignition Systems

Solid fuel ignition systems and/or methods can vary from the placement of manually ignited, oil soaked rags on the fuel bed, to gas or oil fired pilot burners or lances but in all cases shall be in accordance the manufacturer's recommendations.

g) Firing Rate Control and Fuel/Air Ratio Control

The control system shall be capable of maintaining the desired air to fuel ratio over the entire firing range of the boiler, while promoting clean, stable combustion.

h) Re-injection Systems

In installations where fly ash is re-injected from a multi-cyclone collector into the combustion zone for carbon re-burn; precautions should be taken to ensure that plugging of the reinjection pipe work does not occur. Consideration should be given to installing cleanouts in the pipe work.

i) Shutdown and Post Purge

Unless the boiler manufacturer's instructions state otherwise, the fuel supply shall be terminated at shutdown, and the overfire air should remain on until the fuel bed is burned out, and the residue cooled.

SUPPLEMENT 5

INSTALLATION OF THERMAL FLUID HEATERS

S5.1 SCOPE

This supplement provides requirements and guidelines for the installation of a thermal fluid heater. A thermal fluid heater system consists of the heater, expansion tank, circulating pump, safe catchment with the proper piping and controls to heat jacketed kettles, presses, reactors, ovens, exchangers, etc. The scope does not include thermal fluid vaporizers.

S5.2 DEFINITIONS

- a) Thermal fluid: A fluid (other than water) that is chemically stable over a large temperature range and is specifically designed for use as a heat transfer medium.
- b) Thermal fluid heater: A closed loop liquid phase heater (flooded pressure vessel) in which the heat transfer media is heated but no vaporization takes place within the vessel. Depending on the fluid selection and operating parameters, systems may be open or closed to the atmosphere. Closed systems may be pressurized with an inert gas blanket.
- c) Thermal fluid vaporizer: A heater in which the thermal fluid is vaporized within the pressure vessel.

S5.3 GENERAL REQUIREMENTS

S5.3.1 SUPPORTS, FOUNDATIONS, AND SETTINGS

See NBIC Part 1, 1.6.1 *Supports, Foundations, and Settings*.

S5.3.2 STRUCTURAL STEEL

See NBIC Part 1, 1.6.2 *Structural Steel*.

S5.3.3 SETTINGS

The thermal fluid heater shall be installed on a flat, level, noncombustible surface preferably of concrete to protect against any fire hazard. A 4 in. (100 mm) containment curb or 2 in. (50 mm), seal welded drip lip around the thermal fluid heater equipment skid shall be provided.

S5.3.4 CLEARANCES

- a) Thermal fluid heater installations shall allow for normal operation, maintenance, and inspections. There shall be at least 18 in. (460 mm) of clearance on each side of the thermal fluid heater to enable access for maintenance and/or inspection activities. Thermal fluid heaters operated in battery shall not be installed closer than 18 in. (460 mm) from each other. The front or rear of any thermal fluid heater shall not be located nearer than 36 in. (915 mm) from any wall or structure.
- b) Vertical heaters shall have at least 60 in. (1,520 mm) clearance from the top of the heater or as recommended by the heater manufacturer.
- c) Heaters with a bottom opening used for inspection or maintenance shall have at least 18 in. (460 mm) of unobstructed clearance.

NOTE:

Alternative clearances in accordance with the manufacturer's recommendation are subject to acceptance by the Jurisdiction.

S5.4 THERMAL FLUID HEATER ROOM REQUIREMENTS**S5.4.1 EXIT**

See NBIC Part 1, 1.6.3 *Exit*.

S5.4.2 LADDERS AND RUNWAYS

See NBIC Part 1, 1.6.4 *Ladders and Runways*.

S5.5 SYSTEM REQUIREMENTS**S5.5.1 THERMAL LIQUIDS (HEAT TRANSFER FLUIDS)**

It is extremely important that the proper heat transfer fluid be selected by competent personnel knowledgeable of the system. Heat transfer fluids should meet the following basic requirements:

- a) Resist deterioration at the temperatures involved to ensure long, useful life and a clean system.
- b) Possess good heat transfer characteristics.
- c) Have low vapor pressures at operating temperatures to permit operation at moderate pressures. Note: processes requiring thermal fluid temperatures higher than 650°F (340°C) will require the use of specialty fluids with high vapor pressures [e.g. 150 psi (1,030 kPa)]. These fluids also tend to have special environmental, safety, and health considerations.
- d) Have low viscosities to decrease pumping losses (due to pipe friction) and the power required for circulation.
- e) Be suitable for outside temperatures involved to prevent freeze up unless a means of heat trace has been implemented.
- f) Meet environmental regulations.

The heat transfer fluid must be kept clean and in proper condition. Tests of the fluid shall be conducted per the fluid manufacturer's recommendations by approved laboratories. Any heat transfer fluid that is added must be clean and of the proper specification.

S5.5.2 EXPANSION

- a) The expansion tank shall have sufficient volume to handle the required expansion of the total system thermal liquid at the required operating temperature.
- b) The expansion tank should be sized so that when the thermal liquid in the system is cold, the tank will be one quarter full or as recommended by the manufacturer. When the system is up to operating temperature, the level of fluid in the expansion tank shall not exceed the manufacturer's recommendation. A high expansion tank liquid level alarm may be used for indication of high liquid level in the expansion tank(s). An expansion tank low level switch (or similar device) shall be used to ensure the appropriate minimum level of fluid in the tank per the manufacturer's recommendation. Tripping of this switch should shut down the pump and burner. The activation of this switch should activate an audible alarm and/or

light. All expansion tank vents and drains shall be piped to a safe catchment or per the manufacturer's recommendations.

- c) If the expansion tank is to be pressurized with an inert gas, pressure relief shall be provided in accordance with the code of construction used for the expansion vessel. When a safety relief valve is used, it shall be piped to a safe catchment.

S5.5.3 CONNECTION

The circulating pump shall be piped to the thermal fluid heater per the manufacturer's recommendations. The expansion tank should be installed at an elevation above all piping when possible. If the tank is not at the highest elevation, an inert gas blanket shall be used to pressurize the system to overcome the weight of the fluid above the tank.

- a) Vented – The expansion tank shall accommodate the Net Positive Suction Head (NPSH) requirements of the circulating pump to provide a NPSH for the circulating pump. For non-pressurized tanks, a vent connection (open to the atmosphere) is part of the design and should be piped to a safe catchment with no valve in the piping.
- b) Pressurized – The expansion tank may be pressurized with nitrogen or other inert gas as recommended by the fluid manufacturer and provisions made to provide a continuous recommended pressure. The pressure may be adjusted to meet the Net Positive Suction Head requirement of the circulating pump. Compressed air is not recommended as it oxidizes the thermal fluid. Carbon dioxide is not recommended as it dissolves into the fluid and can create cavitation or other problems in the system.

S5.5.4 CIRCULATING PUMP

It is essential that the pump selection be made by competent personnel that are knowledgeable to the requirements of the specific system. Special attention to hot and cold alignment requirements and pump cooling requirements must be considered. The circulating pump must:

- a) Provide the required fluid flow across the heater tube surface.
- b) Handle the Total System Head.
- c) Be specifically designed to handle the thermal fluid at the high temperatures as well as the viscosity requirements of cold start conditions. The pump should be rated for the maximum operating temperature of the fluid. A strainer should be located in each pump suction piping. Globe valves or other throttling valves should be considered in the pump discharge piping to throttle the pump if necessary to prevent it from running out on its curve. Dual pumps are often installed to provide 100% redundancy in the case of a pump failure. A flexible connection in and out of each pump is recommended.

S5.5.5 PIPING AND VALVES

- a) Carbon steel pipe such as SA-53 or SA-106 is preferred for the entire piping system. Seamless pipe should be used for thermal fluid piping. Copper, copper alloys, brass, bronze, aluminum, or cast iron should not be used as they are incompatible with most thermal fluids. All joints and connections NPS 1 (DN 25) and over (within the flow circuit) should be welded or flanged. Full penetration welds shall be used in the piping. All flange gaskets shall be suitable for the operating temperature, pressure, and fluid used. Special attention shall be given to the expansion of the piping due to the high temperatures involved. Valves shall be of steel material compatible for the thermal fluid and temperatures and shall be flanged or weld type manufactured from cast or forged steel or ductile iron. Valve internals and gland seals shall be made from materials suitable for use with high temperature fluids and compatible with the specific fluid utilized in the system. When 2-way valves are utilized in the piping system, a back pressure regulating valve or automatic bypass valve shall be incorporated to ensure the proper flow through

the heater at all times regardless of control valve position. If 3-way valves are used, balancing valves should be included.

- b) Design of piping supports should be in accordance with jurisdictional requirements, manufacturer's recommendations, and/or other industry standards as applicable. Thermal insulation used on the pipes and equipment should be selected for the intended purpose and for compatibility with the fluid. Where there is the potential for fluid system leaks (flanged joints, etc.), the thermal insulation selected should be non-absorbent. Laminated foam glass or cellular glass (nonabsorbent, closed cell) insulation are examples of suitable insulation.

S5.5.6 FUEL

See NBIC Part 1, 1.6.5 *Fuel*

S5.5.7 ELECTRICAL

(23)

- a) All wiring for controls, heat generating apparatus, and other appurtenances necessary for the operation of the thermal fluid heater(s) should be installed in accordance with the provisions of national or international standards and comply with the applicable local electrical codes.
- b) A manually operated remote shutdown switch or circuit breaker shall be located just outside the equipment room door and marked for easy identification. Consideration should also be given to the type and location of the switch to safeguard against tampering.
- c) A disconnecting means capable of being locked in the open position shall be installed at an accessible location at the heater so that the heater can be disconnected from all sources of potential. This disconnecting means shall be an integral part of the heater or adjacent to it.
- d) If the equipment room door is on the building exterior, the shutdown switch should be located just inside the door. If there is more than one door to the equipment room, there should be a shutdown switch located at each door of egress. For atmospheric-gas burners, and oil burners where a fan is on a common shaft with the oil pump, the complete burner and controls should be shut off. For power burners with detached auxiliaries, only the fuel input supply to the firebox need be shut off.
- e) Controls for Heat Generating Apparatus
 - 1) Oil and gas-fired and electrically heated thermal fluid heaters shall be equipped with suitable primary (flame safeguard) safety controls, safety limit switches and controls, and burners or electric elements by a nationally or internationally recognized standard.
 - 2) The symbol of the certifying organization that has investigated such equipment as having complied with a nationally recognized standard shall be affixed to the equipment and shall be considered as evidence that the unit was manufactured in accordance with that standard. Thermal fluid heater shall have:
 - a. Expansion tank low level switch, liquid level switch (or similar device) interlocked with the circulating pump operation to confirm minimum level in the expansion tank when the system is cold. This interlock prevents pump cavitation. The function of this device shall prevent burner and pump operation if the liquid level is not adequate.
 - b. Thermal fluid temperature operation control. This temperature actuated control shall shut down the fuel supply when the system reaches a preset operation temperature. This requirement does not preclude the use of additional operation control devices when required.
 - c. High temperature limit safety switch located on the thermal fluid heater outlet. This limit shall prevent the fluid temperature from exceeding the maximum allowable temperature of the

specific fluid. The high temperature limit safety switch set point should be set no higher than the maximum temperature specified by the fluid manufacturer, heater designer, or downstream process limits, whichever is lowest. Functioning of this control shall cause a safety shutdown and lockout. The manual reset may be incorporated in the temperature limit control. Where a reset device is separate from the temperature limit control, a means shall be provided to indicate actuation of the temperature sensing element. Each limit and operating control shall have its own sensing element and operating switch.

- d. Primary flame safety control for each main burner assembly. This control shall deenergize the main fuel shut off valve and shut off pilot fuel upon loss of flame at the point of supervision. The function of this control shall cause a safety shutdown and lockout.
 - e. Power burners and mechanical draft atmospheric burners shall provide for the preignition purging of the combustion chamber and flue passes. The purge shall provide no fewer than four air changes or greater as specified by the manufacturer.
 - f. Proof of flow interlock-thermal fluid heaters require a minimum flow rate to ensure proper velocities and film temperatures through the heater. A low flow condition can cause overheating, degradation of the fluid or heater coil or tube failure. Activation of this interlock shall cause a safety shutdown of the burner and pump. One or more interlocks shall be provided to prove minimum flow through the heater at all operating conditions.
 - g. A high stack temperature switch interlock – in the event of a high stack temperature (indication of improper combustion or cracked coil) this device shall shut off the burner and circulating pump and cause a lockout condition.
- 3) In accordance with jurisdictional and environmental requirements, manufacturer's recommendations, and/or other industry standards, as applicable, thermal fluid heaters may also have:
- a. An inert gas smothering system (steam or CO₂) – this system is used to quench combustion in the event of a cracked heater coil or tube. The gas smothering system should be installed per local codes and requirements. A typical system may include two stack limit switches, an alarm and valve to allow inert gas to enter the combustion chamber. One stack limit is set at a value above the typical stack temperature for the equipment [e.g. 1,000. °F (540°C)] and the second is set at 100 °F (40°C) above the first. If the limit is tripped, the pump and burner will shut down. If the second limit is tripped, the inert gas shall enter the combustion chamber to quench the flame.
 - b. A high inlet pressure switch – this normally closed switch senses pressure at the heater inlet and its setpoint is determined based on the system design pressure when the system is cold. Activation of this switch indicates a restriction in flow and should shutdown the burner and pump and cause a lockout condition.
 - c. A low inlet pressure switch – this normally open switch senses pressure at the heater inlet and its setpoint is determined based on system pressure when the system is operating at temperature. Activation of this switch indicates a restriction in flow and should shutdown the burner and pump and cause a lockout condition.
 - d. A high outlet pressure switch – this normally closed switch senses pressure at the heater outlet and its setpoint is determined based on the system pressures when the system is at operating temperature. Activation of this switch indicates a restriction in flow and should shutdown the burner and pump and cause a lockout condition. Note: the setpoint of this switch should be lower than the safety relief valve setting.
- 4) These devices shall be installed in accordance with jurisdictional and environmental requirements, manufacturer's recommendations, and/or industry standards, as applicable.

S5.5.8 VENTILATION AND COMBUSTION AIR

See NBIC Part 1, 1.6.6 *Ventilation and Combustion Air*.

S5.5.9 LIGHTING

See NBIC Part 1, 1.6.7 *Lighting*.

S5.5.10 EMERGENCY VALVES AND CONTROLS

All emergency shutoff valves and controls shall be accessible from a floor, platform, walkway, or runway. Accessibility shall mean within a 6 ft. (1.8 m) elevation of the standing space and not more than 12 in. (305 mm) horizontally from the standing space edge.

S5.6 DISCHARGE REQUIREMENTS

S5.6.1 CHIMNEY OR STACK

See NBIC Part 1, Section 1.6.8 *Chimney or Stack*.

S5.6.2 DRAINS

A suitable low point drain fitted with a stop valve shall be provided in the heater or connecting piping to allow the heat transfer media to be drained out of the pressure vessel and/or piping when necessary. The valve may either be locked in the closed position or a blank flange can be installed downstream of the valve. The valve should never be opened when there is temperature on the system.

S5.6.3 AIR VENT

A manual air vent valve should be installed on the high point of the system piping. This valve is typically used when filling or draining the system. The valve should never be opened when there is temperature on the system or when a pressurized system is utilized.

S5.7 OVERPRESSURE PROTECTION

S5.7.1 GENERAL REQUIREMENTS

Thermal fluid heaters shall be provided with overpressure protection in accordance with the code of construction.

S5.7.2 PRESSURE RELIEF VALVES

Thermal fluid heaters shall be equipped with one or more pressure relief valves unless the option for overpressure protection by system design is utilized (when permitted by the original code of construction). When pressure relief devices are used, the following shall apply:

- a) Pressure relief valve(s) shall be of a totally enclosed type.
- b) A lifting lever shall not be used in pressure relief valve(s). A body drain is not required.

- c) Pressure relief valves shall be in accordance with the code of construction and designed for liquid, vapor, or combination service as required for the specific installation, service fluids, and overpressure conditions.
- d) Cast iron fittings shall not be used.
- e) Copper and copper alloys shall not be used.
- f) The inlet connection to the valve shall be not less than NPS $\frac{1}{2}$ (DN 15).

S5.7.3 LOCATION

Pressure relief valves shall be connected to the heater in accordance with the original code of construction.

S5.7.4 CAPACITY

The pressure relief valve(s) shall have sufficient capacity to prevent the pressure vessel from exceeding the maximum pressure specified in the vessel code of construction.

S5.7.5 SET PRESSURE

- a) When a single relief valve is used, the set pressure marked on the device shall not exceed the maximum allowable working pressure.
- b) When more than one pressure relief valve is provided to obtain the required capacity, only one pressure relief valve set pressure needs to be set at or below the maximum allowable working pressure. The set pressure of the additional relief valves shall be such that the pressure cannot exceed the maximum pressure permitted by the code of construction.

S5.7.6 INSTALLATION

Pressure relief valves and the associated discharge piping shall be installed in accordance with the heater Manufacturer's recommendations. The installation of the pressure relief valves required for Thermal Fluid Heaters shall include but not be limited to following requirements.

- a) The pressure relief valve shall be provided with discharge piping. The cross-sectional area of the discharge piping shall not be less than the full area of the valve outlet. The size of the discharge lines shall be such that any pressure that may exist or develop will not reduce the relieving capacity or adversely affect the operation of the attached pressure vessel relief valves. Discharge piping shall be as short and straight as possible and arranged to avoid undue stress on the pressure relief valve.
- b) The pressure relief valve shall be connected to the pressure vessel in accordance with the original code of construction.
- c) The cross sectional area of the piping between the heater and the relief valve shall be sized either to avoid restricting the flow to the pressure relief valves or made at least equal to the inlet area of the pressure relief valves connected to it.
- d) When two or more required pressure relief valves are placed on one connection, the inlet cross-sectional area of this connection shall be sized either to avoid restricting the flow to the pressure relief valves or made at least equal to the combined inlet areas of the pressure relief valves connected to it.
- e) Unless permitted by the code of construction, there shall be no intervening stop valve between the vessel and its pressure relief valve(s), or between the pressure relief valve and the point of discharge.

- f) Pressure relief valve discharges shall be arranged such that they are not a hazard to personnel or other equipment and, when necessary, lead to a safe location, such as a catchment tank, for the disposal of fluids being relieved.
- g) Discharge lines from pressure relief valves shall be designed to facilitate drainage. Drain piping shall discharge to a safe location for the disposal of the fluids being relieved. The possibility of solidification of fluid leakage into the discharge piping system shall be considered.
- h) The pressure relief valve discharge shall be connected to a closed, vented storage tank with solid piping (no drip pan elbow or other air gap). The storage tank should be located as close to the system as possible, but away from flammable surfaces. Overflow or high level protection should be considered. The capacity of the storage tank should consider the volume of fluid which may be relieved or sized in accordance with the heater manufacturer's recommendation. Storage tanks located outdoors shall be located such that water cannot collect in the vessel.

The following shall be considered for discharge piping hazards:

- 1) Both thermal and chemical reactions (personnel hazard);
 - 2) Combustible materials (fire hazard);
 - 3) Surface drains (pollution and fire hazard); and
 - 4) Heat tracing for systems using high freeze point fluids (prevent blockage).
- i) Pressure relief valve discharge capacity for liquid service shall be determined from the following equation:

U.S. Customary Units:

$$W = 2,407 KA \sqrt{(P - P_d)w}$$

SI Units:

$$W = 5.092 KA \sqrt{(P - P_d)w}$$

where,

W = Liquid Capacity in lb/hr (kg/hr).

A = Discharge Area of Pressure relief Valve, in² (mm²)

K = coefficient of discharge for valve design

P = (Set pressure + OP + Atmosphere pressure, psia (MPa)

OP = Overpressure required for Pressure Relief Valve to reach capacity specified in code of construction

P_d = Pressure at discharge of valve, psia (MPa)

w = Specific weight of liquid at inlet condition lb/ft³ (kg/m³)

To convert lb/hr of water to gal/min, multiply the capacity in lb/hr by 1/500.

S5.8 TESTING AND ACCEPTANCE

S5.8.1 GENERAL

- a) Care shall be exercised during installation to prevent loose weld material, welding rods, small tools, and miscellaneous scrap metal from getting into the thermal fluid system. Where possible, an inspection of the interior of the thermal fluid heater and its appurtenances shall be made for the presence of foreign debris prior to making the final closure.
- b) Safe operation should be verified by a person familiar with heater system operations for all heaters and connected appurtenances and all pressure piping connecting them to the appurtenances and all piping.
- c) In bolted connections, the bolts, studs, and nuts shall be marked as required by the original code of construction and be fully engaged (e.g., the end of the bolt or stud shall protrude through the nut).
- d) Washers shall only be used when specified by the manufacturer of the part being installed.

S5.8.2 PRESSURE TEST

Prior to initial operation, the completed thermal fluid heater system, including pressure piping, pumps, stop valves, etc., shall be pressure tested in accordance with the manufacturer's recommendations. Hydrostatic testing of the system is not recommended due to possible contamination of the system. All pressure testing should be witnessed by an Inspector.

S5.8.3 NONDESTRUCTIVE EXAMINATION

Thermal fluid heater components and subcomponents shall be nondestructively examined as required by the governing code of construction.

S5.8.4 SYSTEM TESTING

Prior to final acceptance, an operational test shall be performed on the complete installation. The test data shall be recorded and the data made available to the jurisdictional authorities as evidence that the installation complies with the provisions of the governing code(s) of construction. This operational test may be used as the final acceptance of the unit.

S5.8.5 FINAL ACCEPTANCE

See NBIC Part 1, 1.6.9, *Final Acceptance*.

S5.8.6 INSTALLATION REPORT

- a) Upon completion, inspection, and acceptance of the installation, the installer should complete and certify the *Boiler Installation Report I-1*. See NBIC Part 1, 1.4.5.1.
- b) The *Boiler Installation Report* should be submitted as follows:
 - 1) One copy to the Owner; and
 - 2) One copy to the Jurisdiction, if required.

SUPPLEMENT 6**SPECIAL REQUIREMENTS FOR THE INSTALLATION OF CONDENSING BOILERS****S6.1 SCOPE**

NBIC Part 1, Supplement 6 provides requirements for various aspects of the installation of Condensing Boilers which are unique from other products covered by this section.

S6.2 DETERMINATION OF ALLOWABLE OPERATING PARAMETERS

The allowable operating parameters of the combustion air intake and the exhaust gas venting shall be in accordance with jurisdictional, environmental and manufacturers recommendations, as applicable.

S6.3 GENERAL REQUIREMENTS

Condensing boilers shall meet all the requirements of NBIC Part 1, Section 1, Section 3, and this Supplement. The jurisdictional or National Building Codes may require the installation of a Carbon Monoxide (CO) detector/alarm in the boiler room.

S6.4 FLUE GAS VENTING SYSTEM PIPING REQUIREMENTS

- a) The vent piping shall be corrosion resistant and fabricated from either stainless alloy or plastic material as defined by the boiler manufacturer and certified for the application.
- b) The diameter of the vent piping shall be as defined by the boiler manufacturer and shall not be reduced, except as allowed by the boiler manufacturer.
- c) The "Total Equivalent Length" of the vent piping, and the pressure drop through the vent piping, shall not exceed that stated in the Boiler Manufacturer's Installation Manual. (Note: Equivalent Length includes the pressure loss effect of various pipe fittings, such as elbows, etc.) Horizontal pipe runs shall slope toward the boiler and the condensate collection point.
- d) The termination point of the vent piping shall be positioned such that there is no possibility of vented flue gas being entrained in the combustion air intake, as defined by the manufacturer and National Fuel Gas Code (ANSI Z223.1). Additionally the vent termination shall be located above the highest known snowline for the location involved, and be designed in such a manner, so as to prevent freezing.
- e) This supplement requires the owner/user/installer contact the authority having Jurisdiction regarding the installation of carbon monoxide (CO) detector/alarm in boiler rooms in which condensing boilers are to be installed.

S6.5 SEALED COMBUSTION SYSTEM REQUIREMENTS

- a) The location of the outside air intake, relative to the flue gas vent, shall be such that there shall be no cross contamination with products of combustion or other airborne corrosive or hazardous contaminants, as defined by the manufacturer. Additionally the location of the combustion air intake shall be above the highest known snowline for the location involved.
- b) The diameter, length and routing of the combustion air intake piping shall be such that the pressure drop through the system, including any filters, shall not exceed the maximum pressure drop stated by the boiler/burner manufacturer.

S6.6 CONDENSATE DRAIN SYSTEM REQUIREMENTS

The flue gas condensate from an individual boiler shall be collected at a single point, and the routing of the drain piping shall include the following features:

- a) A water trap, the height of which cannot be varied by field manipulation, and is in accordance with boiler manufacturers requirements.
- b) A visible means of ensuring that the condensate water trap contains the correct water level.
- c) A discharge point away from occupied areas.
- d) A method of controlling the pH of the condensate prior to its discharge into a sewer system, if required by local building Codes.

SUPPLEMENT 7

INSTALLATION OF GRAPHITE PRESSURE EQUIPMENT

S7.1 SCOPE

This supplement provides guidelines for the installation of impregnated graphite pressure vessels.

S7.2 GLOSSARY OF TERMS

Impregnated graphite – composite manufactured by impregnating porous graphite with chemically resistant synthetic resins used in the construction of graphite pressure equipment. With special processing the graphite becomes impregnated, even to gases and under pressure. The final product partakes of the properties of both graphite and resin, but the predominant characteristics are similar to graphite which gives the most useful properties with its natural corrosion resistance and conductivity as a heat exchange material. Unlike corrosion resistant metals, graphite does not depend on the formation of a surface film or oxide for corrosion resistance, nor does it exhibit a measurable corrosion rate. Once rendered impregnated, however, the chemical inertness of graphite may be limited by the characteristics of the resin. For example, phenolic resin is resistant to most acids, salt solutions and organic compounds but may not be suitable for alkalis and strong oxidizing chemicals that may degrade and weaken the material with no visible/measurable sign of material loss.

End components – Components attached to the main shell of graphite pressure equipment including heads, channels, domes, and tubesheets

Cold wall effect – a detrimental condition that promotes corrosion due to a temperature gradient between the inside of a lined vessel and its exterior. Cold wall effect may be caused locally by attachments that protrude through insulation, or more generally by failure to install insulation.

S7.3 GENERAL REQUIREMENTS

S7.3.1 RECEIVING AND INITIAL INSPECTION OF GRAPHITE PRESSURE EQUIPMENT

Graphite equipment should be thoroughly inspected and tested as it is received in order to identify any in transit damage. Whenever possible, this inspection should be made before the exchanger is removed from the carrier. To verify the unit has arrived in an undamaged condition, a pressure test may be performed. The bolt torques and spring heights should be verified prior to a pressure test. This pressure test shall not exceed the MAWP of the vessel. Where freezing could occur, open all vents and drains after a pressure test to drain out all water from all passes and pockets to prevent freeze damage. Follow other good practices such as to prime the unit with an antifreeze solution and/or drain and dry it completely. Graphite equipment may arrive from the manufacturer under low pressure and/or with shock detectors as an indication of undamaged arrival. Any crating should be inspected both for direct damage and/or evidence of improper handling. If there is any evidence of damage, notify the manufacturer.

Graphite pressure equipment may be shipped unassembled for later assembly. Review any packing or check list. All parts should be carefully inspected. The surfaces of graphite parts should be thoroughly examined. Avoid pry bars, chisels, wedges or excessive force to separate any protective covers from graphite nozzles or openings. Activity around graphite surfaces should progress gently and with caution.

Prior to installation, bolt torques and spring heights should be verified. Additionally, the manufacturer may be consulted for recommended commissioning activities such as thermal cycling and bolt retorquing.

S7.3.2 EQUIPMENT PARAMETERS/CLEARANCES/MOVEMENT

In many cases, graphite pressure equipment is of modular construction and may be assembled or disassembled in the field. The construction details can be obtained by consulting the bill of materials and the assembly drawing provided by the manufacturer. Sufficient space for assembly and installation should be provided. Consideration should be given to the orientation of the equipment for maintenance or disassembly.

Impregnated graphite is more susceptible to damage from mishandling than metal components. Therefore, the following recommendations should be considered:

- a) Lifting and transportation should be done at designated lifting points or per manufacturer's recommendations;
- b) Use only soft slings when handling;
- c) Graphite parts should be protected with a barrier if steel cables or chains are employed; and
- d) Avoid lifting by placing slings directly around the graphite.

S7.3.3 SUPPORTS/FOUNDATIONS

See NBIC Part 1, 1.6.1 for general requirements on supports, foundations, and settings.

Foundations and supports should be adequate to prevent settling or the transmission of stresses, vibrations or shock loads to the graphite pressure vessel. Any base structure should be designed to support the exchanger and also to eliminate movements or moments caused by, but not limited to, possible hydraulic thrusts of process and service fluids. Additionally, graphite pressure equipment should be level and square so that all piping connections may be made without excessive force.

Graphite pressure equipment may include lined components that may or may not be insulated. Any structural support attachments should avoid direct contact with lined components, which could create a cold wall effect.

S7.3.4 PIPING CONNECTIONS

Impregnated graphite pressure equipment may require connection to graphite nozzles. Before connecting piping, graphite gasket surfaces including serrations should be thoroughly cleaned to prevent any leakage of fluids. A suitable solvent should be used to completely remove all dirt or contaminants from connections. Use caution so as not to scratch or gouge the graphite surface. Graphite piping connections require gaskets specific for graphite applications. Refer to graphite equipment manufacturer for any spring settings, gasket recommendations, and bolt torque recommendations.

Flexible attachments such as expansion joints and bellows are recommended for impregnated graphite connections. Flexible attachments should be installed as close to the nozzles as possible. These are recommended to isolate the equipment from stress caused by vibration, misalignment, thermal expansion of the piping, or other loads.

After positioning and initial tightening of graphite connections, the bolts/ nuts should be tightened to the torque value on bolt torque charts or assembly drawings provided by the manufacturer. Bolts should be tightened in multiple stages and in a diametrically staggered (i.e. star) pattern starting with a torque value that is a small percentage of the final torque value until design values are achieved.

S7.3.5 INSTRUMENTS AND CONTROLS.

Pressure: See NBIC Part 1, 4.4.2 and 4.5 for requirements related to pressure indicating devices and pressure relief devices.

Temperature control: Automatically controlled systems, such as for heating of impregnated graphite pressure equipment, may be considered. The temperature control should provide for over temperature protection such that temperature is regulated to maintain a specified operating limit which shall be less than the maximum allowable temperature.

Sensors: Continuous monitoring is suggested since process streams used in graphite heat exchangers are usually corrosive and a failure path or crossover to the service side should be identified with immediate corrective action.

Flow control: In order to avoid damage (e.g., erosion, hammering, shock) to the graphite components, instrumentation should be installed to control and monitor flow.

S7.3.6 POST-INSTALLATION ACTIVITIES

- a) Due to the nature of impregnated graphite, the surface is subject to light scratches and it is often difficult to distinguish scratches from cracks without further investigation. Consult the manufacturer as required.
- b) Graphite pressure equipment may be damaged by concentrated hydroblasting or pressure washing. Avoid sandblasting graphite pressure equipment.
- c) Careful consideration should be given to painting graphite pressure equipment because improper painting can damage the equipment.

SUPPLEMENT 8**INSTALLATION OF PRESSURE VESSELS FOR HUMAN OCCUPANCY (PVHOS)****S8.1 SCOPE**

This Supplement provides general information and guidance for installation to help manufacturers, owners, users, inspectors, and jurisdictional authorities understand PVHO systems and their unique characteristics. The PVHO systems covered in this supplement include only monoplace (single human occupancy) medical systems used for Hyperbaric Oxygen Therapy (HBO). The PVHO system is comprised of one or more monoplace PVHOs each with pressurization and vent controls, monitoring, and communication supplied by facility medical gas systems or dedicated breathing gas systems, gas distribution, controls, and gas storage.

S8.2 GENERAL

A pressure vessel for human occupancy, as defined by ASME PVHO-1 is a pressure vessel that encloses one or more human beings within its pressure boundary while it is subject to internal or external pressure that exceeds a 2 psi (15 kPa) differential pressure. PVHOs include, but are not limited to submersibles, diving bells, personal transfer capsules, decompression chambers, recompression chambers, hyperbaric chambers, high-altitude chambers, and medical hyperbaric oxygenation facilities.

S8.3 DOCUMENTATION, REGISTRATION, AND REGULATORY REQUIREMENTS

- a) PVHO systems should be designed and constructed in accordance with ASME PVHO-1. This code requires Section VIII for steel and other allowed vessel materials and therefore should bear a "U" or "U2" ASME designator and forms. PVHO-1 also has several Code Cases that address PVHOs manufactured from non-Section VIII materials such as reinforced fabrics. PVHO Code Cases are subject to jurisdictional authority and should have all the documentation required by the Code Case, but not necessarily Section VIII forms.
- b) Viewport acrylic windows should be designed and constructed in accordance with PVHO -1 and maintained following the rules of PVHO-2. The owner/user should follow PVHO-2 and manufacturer manuals for in-service guidance.
- c) The manufacturer should retain PVHO system documentation or submit and register with the National Board, subject to jurisdictional and/or regulatory authorities.
- d) The PVHO system owner should have copies of the following documents on site:
 - 1) Manufacturer Data Report for Section VIII vessel (Form U1-A or U2-A);
 - 2) Manufacturer Data Report for PVHO-1 Form GR-1;
 - 3) PVHO-1 Forms VP-1 through VP-5;
 - 4) PVHO system Installation Instructions; and
 - 5) PVHO system operation and maintenance manuals.
- e) Unique PVHO Characteristics
 - 1) Fire hazard due to oxygen enrich environment;
 - 2) Fire hazard due to in-service hydrocarbon contamination;
 - 3) Rapid decompression hazard;

- 4) Pressure boundary valves at PVHO penetrators
- 5) Cleanliness of gases inside the PVHO system
- 6) In-service life expectancy of flat disc acrylic windows in protected environments, including cylindrical windows, can be up to twenty years with periodic inspections.
- 7) Manual and/or pneumatic control systems
- 8) Heat, UV light, and solvents are harmful to acrylic windows

S8.4 PVHO SYSTEM CONFIGURATION AND INSTALLATION

- a) The PVHO includes the following pressure boundary components.
 - 1) Shells and heads of revolution
 - 2) Openings and their reinforcement
 - 3) Nozzles and other connections
 - 4) Door seals and quick actuating closures
 - 5) Viewports including acrylic windows
 - 6) A quick opening manual shutoff valve shall be located between the chamber and pressure relief valve (burst discs are prohibited)
 - 7) Quick-opening manual valve shall be sealed open using a frangible seal.
- b) The PVHO system, comprised of one or more monoplace PVHOs each with operational controls, should be supplied by a hospital or clinic medical gas system. Installers of medical gas systems that meet NFPA 99 Chapter 5 requirements should be qualified to, and hold third-party certification, in accordance with American Society of Safety Engineers ASSE 6010.
- c) Facility Installation
 - 1) PVHO systems installed and operated within buildings are subject to local building codes, National Fire Protection Association NFPA 99, and applicable jurisdictional and regulatory requirements.
 - 2) The rooms designated for PVHO systems should be adequately sized allowing operation and inspection access to all sides of the PVHO system and dedicated to only hyperbaric system operation.
 - 3) PVHO system oxygen exhaust and ventilation lines shall be independently piped to the building exterior.
 - 4) Temperature in the PVHO room should be maintained for patient comfort.
- d) Electrical
 - 1) All electrical controls should be located external of the PVHO.
 - 2) PVHO electrical powered control equipment should be connected to grounded facility outlets matching the equipment power specifications.
 - 3) PVHO electrical penetration connectors should be as specified by the manufacturer and checked for leak tightness.
 - 4) Electrical wiring should be supported to prevent obstruction or tripping hazard.

- 5) Electrical systems within the PVHO should protect low-voltage communication and monitoring equipment from being exposed to voltages greater than 28 volts AC and currents greater than 0.5 amps and should be grounded in accordance with NFPA 99 Chapter 14.

e) PVHO Controls

- 1) Medical PVHO controls, piping, hoses, connections, pressure gages, control valves, gas system should meet PVHO-1 Section 4 – Piping Systems and Section 5 – Medical Hyperbaric Systems.
- 2) PVHO pressurization, ventilation, and depressurization controls should be manual or pneumatic.
- 3) The operator at the PVHO control station should be present and have visual sight and audio communication with PVHO occupant during operation.
- 4) Separate oxygen and air supply to the PVHO and occupant should be from the facility medical gas systems or a standalone medical gas system.
- 5) The gas system should be sized (both flow and volume) for normal and emergency PVHO operations in accordance with manufacturer specification or manual. The owner should have this information available on-site.
- 6) The facility gas system piping or tubing and controls should be secured to the facility structure up to the adjacent PVHO wall connects. Hoses or tubing connect to these wall connections and supply the gases to the PVHO operational controls. Hoses or tubing should be secured to prevent obstruction or tripping hazards.

f) Facility Medical Gas System

- 1) NFPA Chapter 5 requirements shall apply to the medical gas supplies from the source to the wall valve adjacent to the PVHO.
- 2) The PVHO-1 requirements should apply to PVHO gas supplies downstream of the facility medical gas wall valve.

g) Standalone Medical Gas System

- 1) The PVHO system includes a gas storage system that supplies gas to the PVHO controls for pressurization, ventilation, depressurization, and occupant breathing. The storage system is comprised of control valves, gages, and manifolds that attached to installed tanks or removable cylinders (i.e. DOT).
- 2) For manifolds attached to removable cylinders, there should be additional controls allowing isolation and depressurization prior to change-out of cylinders.
- 3) The gas distribution with installed tanks and or cylinders should meet PVHO-1 and NFPA 99 Chapter 5 or equivalent.
- 4) The storage system should be configured to supply the PVHO from two separate supplies.

h) Internal System Cleanliness and Toxicity

- 1) PVHO systems include breathing gas systems with air and oxygen enriched gases (greater than 25% oxygen) that should be cleaned and maintained to NFPA 99 Chapter 5 and national standards (e.g., Compressed Gas Association).
- 2) Manufacturer maintenance manuals should be available on site and provide guidance for the owner or user to maintain system cleanliness and prevent contamination during operation and maintenance.
- 3) Hoses should be off-gas toxicity tested prior to installation.

- i) Maintenance
 - 1) PVHO system should be maintained in accordance with PVHO-2 and manufacturer's maintenance manual.
 - 2) Periodic window inspections should be performed in accordance with PVHO-2.
 - 3) Replacement windows should meet PVHO manufacturer specifications with new PVHO-1 VP-1 to VP-5 forms and once installed checked for leak tightness.

S8.5 RESPONSIBILITIES

The owner/user, manufacturer, installer, and inspector shall verify the following is part of the PVHO system installation and documentation available on-site.

Does the PVHO have the applicable ASME VIII and PVHO certification mark and label plate?

- a) Is the PVHO registered with the National Board, if required by the jurisdictional authority?
- b) Are the PVHO documentation forms available on-site, signed, and dated? Forms should include:
 - 1) U1 or U2 M Manufacturer Data Report
 - 2) PVHO GR-1 Manufacturer Data Report
 - 3) PVHO Window VP-1 through VP-5 forms
 - 4) Acrylic window markings traceable to the VP forms
- c) Is the PVHO pressure relief valve constructed in accordance with ASME Section VIII?
- d) Does PVHO have a quick opening manual shutoff valve between PVHO and relief valve, and is the manual valve sealed open with a frangible seal?
 - 1) Are piping and controls labelled and color coded?
 - 2) Are there external heat sources close to the PVHO that could damage the windows?
 - 3) Is there room lighting and emergency building lighting that illuminates the PVHO interior and control station?
 - 4) Are the acrylic windows free of crazing, discoloration, cracks, chips, scratches, gouges, or pits?
 - 5) Do pressure piping or hoses that connect to the PVHO have shutoff valves?
 - 6) For door closures that are pressure loaded, does the closure meet quick actuating closures per ASME Section VIII?
 - 7) Does the operator position at the control station allow for visual and audible communication with the PVHO occupant?
 - 8) Are there local procedures prohibiting personal warming, cellular, sparking, or entertainment devices from entering the PVHO?
 - 9) Are the PVHO and support system rooms posted with signage to prohibit smoking or open flames?
 - 10) Are there system operating manuals on-site?
 - 11) Is there a qualified PVHO system operator?
 - 12) Is there at least one gage measuring the PVHO internal pressure?

S8.6 OTHER CODES, STANDARDS, AND REFERENCES

The following codes, standards, and references may be used as guidance.

- a) ASME Section VIII Division 1 and Division 2
- b) ASME PVHO-1 Safety Standard for Pressure Vessel for Human Occupancy: PVHO System Design
- c) ASME PVHO-2 Safety Standard for Pressure Vessel for Human Occupancy: In-Service Guidelines
- d) ASME Bulletin STP-PT-047 PVHO Medical Chamber
- e) NFPA 99 Health Care Facilities
- f) ASSE 6010

SUPPLEMENT 9

HIGH-TEMPERATURE WATER BOILERS

S9.1 SCOPE

A high-temperature water boiler is a power boiler in which water is heated and operates at a pressure in excess of 160 psig (1.1 MPa) and/or temperatures in excess of 250° (121°C).

S9.2 INSTALLATION REQUIREMENTS

In addition to the requirements listed in Part 1, Section 1 and Part 1, Section 2 for Power Boilers, the requirements below shall apply:

- a) High-temperature water boilers shall be provided with a means of adding water to the boiler or system while under pressure.
- b) The recirculating return line for a high-temperature water boiler shall be provided with the stop valve, or valves, required for the main discharge outlet on the boiler.
- c) Each high-temperature water boiler shall have a drain of NPS 1 (DN25) minimum, which discharges to a safe location.
- d) Each high-temperature water boiler shall have a temperature gage or other reporting device located to provide an accurate representation of the temperature at or near the boiler outlet.
- e) For high-temperature water boilers, safety relief valves shall have a closed bonnet, and valve bodies shall not be constructed of cast iron.
- f) The required relieving capacity in pounds per hour of the safety or safety relief valves on a high-temperature water boiler shall be determined by dividing the maximum output in Btu/hr at the boiler nozzle obtained by the firing of any fuel for which the unit is designed by one thousand.
- g) Discharge piping from pressure relief valves on high-temperature water boilers shall have adequate provisions for water drainage as well as steam venting.
- h) Piping for high-temperature water boilers shall include provisions for the expansion and contraction of hot-water mains connected to the boiler(s) so there will be no undue strain transmitted to the boiler(s).
- i) Expansion tanks shall have sufficient volume to handle the required expansion of the total system at the required operating temperature.
 - 1) A low-pressure interlock and a low-water level interlock are recommended.
- j) It is essential that the pump selection provides the required flow through the boiler, handles the total system head, and be specifically designed to handle water at the required operating temperature. Proof of flow is recommended for forced circulation boilers.
- k) Each high-temperature water boiler shall be protected from over-temperature by two temperature-operated controls.
 - 1) Each boiler shall have a control that will cut off the fuel supply when the water temperature reaches an operating limit, which shall be less than the maximum allowable temperature.
 - 2) In addition to the above, each high-temperature water boiler shall have a safety limit control with manual reset that will cut off the fuel supply to prevent the water temperature from exceeding the maximum allowable temperature at the boiler outlet.

(23) **SUPPLEMENT 10**
OVERPRESSURE PROTECTION FOR ORGANIC FLUID VAPORIZERS

S10.1 GENERAL REQUIREMENTS

Organic fluid vaporizers shall be provided with overpressure protection in accordance with the code of construction. The vaporizer shall be designed in accordance with the rules of the code of construction for a working pressure of at least 40 psi (280 kPa) above the operating pressure at which it will be used.

S10.2 PRESSURE RELIEF DEVICES

Organic fluid vaporizers shall be equipped with one or more pressure relief devices unless the option for overpressure protection by system design is utilized (when permitted by the original code of construction).

When pressure relief devices are used, the following shall apply:

- a) Pressure relief valve(s) shall be of a totally enclosed type;
- b) A lifting lever shall not be used in pressure relief valve(s). A body drain is not required;
- c) Pressure relief valves and rupture disks shall be in accordance with the code of construction and designed for liquid, vapor, or combination service as required for the specific installation, service fluids, and overpressure conditions;
- d) Cast iron fittings shall not be used;
- e) Copper and copper alloys shall not be used; and
- f) The inlet connection to the valve shall be not less than NPS ½ (DN 15).

S10.3 LOCATION

Pressure relief devices shall be connected to the vaporizers in accordance with the original code of construction.

S10.4 CAPACITY

The pressure relief device(s) shall have sufficient capacity to prevent the pressure vessel from exceeding the maximum pressure specified in the vessel code of construction.

S10.5 SET PRESSURE

- a) When a single relief device is used, the set pressure marked on the device shall not exceed the maximum allowable working pressure.
- b) When more than one pressure relief device is provided to obtain the required capacity, only one pressure relief device set pressure needs to be set at or below the maximum allowable working pressure. The set pressure of the additional relief devices shall be such that the pressure cannot exceed the maximum pressure permitted by the code of construction.

S10.6 INSTALLATION

The pressure relief devices and its associated discharge piping shall be installed in accordance with original code of construction. The installation of pressure relief devices for organic fluid vaporizers shall include but be not limited to following requirements.

- a) A rupture disk may be installed between the pressure relief valve and the vaporizer to minimize the loss by leakage of material through the pressure relief valve, provided the following requirements are met:
 - 1) The cross-sectional area of the piping to a vaporizer shall be not less than the required relief area of the rupture disk;
 - 2) The maximum pressure of the range for which the disk is designed to rupture does not exceed the opening pressure for which the pressure relief valve is set or the maximum allowable working pressure of the vessel;
 - 3) The opening provided through the rupture disk, after breakage, is sufficient to permit a flow equal to the capacity of the attached valve, and there is no interference with the proper functioning of the valve, but in no case shall this area be less than the inlet area of the valve;
 - 4) A pressure gage, try cock, free vent, or a suitable telltale indicator should be provided in a space between a rupture disk and the pressure relief valve. This arrangement permits the detection of disk rupture or leakage;
 - 5) Every rupture disk shall have a specified bursting pressure at a specified temperature and shall be marked with a lot number; and
 - 6) Every rupture disk shall be guaranteed by its manufacturer to burst within plus or minus 5% of its specified bursting pressure.
- b) The pressure relief valve should be provided with suitable discharge piping in accordance with the vaporizer manufacturer's recommendations and the fluid manufacturer's recommendations; and any applicable safety concerns and any applicable codes and standards should be considered. Any discharge piping should not affect the performance or capacity of the relief valve.
- c) A suitable condenser that will condense all the vapors discharged from the pressure relief valve or other safe catchment may be used.
- d) At least once yearly, pressure relief valves shall be disconnected from the vaporizer for inspection and repair if necessary. Pressure relief valves shall be tested after repair and then replaced on the vaporizer.

(23) **SUPPLEMENT 11**
INSTALLATION OF HIGH-PRESSURE COMPOSITE PRESSURE VESSELS

S11.1 SCOPE

This supplement provides requirements for the installation of high-pressure composite pressure vessels. This supplement is applicable to pressure vessels with a maximum allowable working pressure (MAWP) not exceeding 15,000 psi (103.4 MPa), and is applicable to the following classes of vessels:

- a) Metallic vessel with a Fiber Reinforced Plastic (FRP) hoop wrap over the shell part of the vessel (both load sharing);
- b) Metallic vessel with a full FRP wrap (both load sharing);
- c) FRP vessel with a non-load sharing metallic liner; and
- d) FRP vessel with a non-load sharing non-metallic liner.

S11.2 SUPPORTS

Design of supports, foundations, and settings shall consider the dead loads, live loads, wind, and seismic loads. Vibration and thermal expansion shall also be considered. The design of supports, foundations, and settings shall be in accordance with ASCE/SEI 7, Minimum Design Loads for Buildings and Other Structures. The importance factors used in calculating the seismic and wind loads shall be the highest value specified for any category in ASCE/SEI 7.

S11.3 CLEARANCES

The pressure vessel installation shall allow sufficient clearance for normal operation, maintenance, and inspection. Stacking of pressure vessels is permitted. The minimum clear space between pressure vessels shall be 1 ft. vertical and 2 ft. horizontal. Vessel nameplates shall be visible for inspection after installation. The location of vessels containing flammable compressed natural gas fluids shall comply with the requirements of the National Fire Protection Association's (NFPA) NFPA 52, Vehicular Natural Gas Fuel Systems Code. The location of vessels containing hydrogen or other flammable fluids shall comply with NFPA 2, Hydrogen Technologies Code. The vessel owner shall document the vessel pressure and pipe diameters used as a basis for compliance with NFPA 2 location requirements.

S11.4 PIPING LOADS

Piping loads on vessel nozzles shall be determined by a formal flexibility analysis per ASME B31.12: Paragraph IP-6.1.5(b). The piping loads shall not exceed the maximum nozzle loads defined by the vessel manufacturer.

S11.5 MECHANICAL CONNECTIONS

Mechanical connections shall comply with the pressure vessel manufacturer's instructions, and with the requirements of the Jurisdiction. Connections to threaded nozzles shall have primary and secondary seals. The seal design shall include a method for detecting a leak in the primary seal. Seal functionality shall be demonstrated at the initial pressurization of the vessel.

S11.6 PRESSURE INDICATING DEVICES

Each pressure vessel shall be equipped with a pressure gage mounted on the vessel. The dial range shall be from 0 psi to not less than 1.25 times the vessel MAWP. The pressure gage shall have an opening not to exceed 0.055 in. (1.4 mm) (No. 54 drill size) at the inlet connection. In addition, vessel pressure shall be monitored by a suitable remote pressure indicating device with alarm having an indicating range of 0 psi to not less than 1.25 times the vessel MAWP.

S11.7 PRESSURE RELIEF DEVICES

Each pressure vessel shall be protected by pressure relief devices per the following requirements:

- a) Pressure relief devices shall be suitable for the intended service;
- b) Pressure relief devices shall be manufactured in accordance with a national or international standard and certified for capacity (or resistance to flow for rupture disk devices) by the National Board;
- c) Dead weight or weighted lever pressure relief valves are prohibited;
- d) Pressure relief valves shall not be fitted with lifting devices;
- e) The pressure relief device shall be installed directly on the pressure vessel with no isolation valves between the vessel and the pressure relief device except:
 - 1) When these isolation valves are so constructed or positively controlled below the minimum required capacity, that closing the maximum number of valves at one time will not reduce the pressure relieving capacity, or
 - 2) Upon specific acceptance of the Jurisdiction, an isolation valve between vessel and its pressure relief device may be provided for vessel inspection and repair only. The isolation valve shall be arranged so it can be locked or sealed open.
- f) The discharge from pressure relief device(s) shall be directed upward to prevent any impingement of escaping fluid upon the vessel, adjacent vessels, adjacent structures, or personnel. The discharge must be to outdoors, not under any structure or roof that might permit formation of a "cloud". The pressure relief device(s) discharge piping shall be designed so that it cannot become plugged by animals, insects, rainwater, or other materials;
- g) When a single pressure relief device is used, it shall be set to operate at a pressure not exceeding the MAWP of the vessel. When the required capacity is provided in more than one pressure relief device, only one device need be set at or below the MAWP, and the additional device(s) may be set to open at higher pressures but in no case at a pressure higher than 105% of the MAWP. The requirements of ASME Section X, RR-130 shall also apply;
- h) The pressure relief device(s) shall have sufficient capacity to ensure the pressure vessel does not exceed the MAWP of that specified in the original code of construction;
- i) The owner shall document the basis for selection of the pressure relief device(s) used, including capacity;
- j) The owner shall have such analysis available for review by the Jurisdiction;
- k) Pressure relief devices and discharge piping shall be supported so that reaction forces are not transmitted to the vessel;
- l) Heat detection system: a heat activated system shall be provided so that vessel contents will be vented per S11.7 f), if any part of the vessel is exposed to a temperature greater than 220°F (104°); and

- m) Positive methods shall be incorporated to prevent overfilling of the vessel.

S11.8 ASSESSMENT OF INSTALLATION

- a) Isolation valve(s) shall be installed directly on each vessel, but not between the vessel and the pressure relief device except as noted in S11.7 e).
- b) Vessels shall not be buried.
- c) Vessels may be installed in a vault subject to a hazard analysis, verified by the manufacturer, owner, user, qualified engineer, or the Jurisdiction, to include as a minimum the following:
- 1) Ventilation;
 - 2) Inlet and outlet openings;
 - 3) Access to vessels;
 - 4) Clearances;
 - 5) Intrusion of ground water;
 - 6) Designed for cover loads;
 - 7) Explosion control;
 - 8) Ignition sources;
 - 9) Noncombustible construction;
 - 10) Remote monitoring for leaks, smoke, and fire; and
 - 11) Remote controlled isolation valves.
- d) Fire and heat detection/suppression provisions shall comply with the requirements of the Jurisdiction and, as a minimum, include relief scenarios in the event of a fire or impending overpressure from heat sources.
- e) Installation locations shall provide the following:
- 1) Guard posts shall be provided to protect the vessels from vehicular damage per NFPA 2 or NFPA 52, as appropriate. Protection from wind and seismic events shall be provided;
 - 2) Supports and barriers shall be constructed of non-combustible materials;
 - 3) Vessels shall be protected from degradation due to direct sunlight;
 - 4) Access to vessels shall be limited to authorized personnel;
 - 5) Any fence surrounding the vessels shall be provided with a minimum of two gates. The gates shall open outward, and shall be capable of being opened from the inside without a key;
 - 6) Access for initial and periodic visual inspection and NDE of vessels, supports, piping, pressure gages or devices, relief devices and related piping, and other associated equipment;
 - 7) Completed installations shall be validated as required by the Jurisdiction as addressing all the above, and any requirements of the Jurisdiction, prior to first use. This verification shall be posted in a conspicuous location near the vessel and, when required, on file with the Jurisdiction. Certificates shall be updated as required by mandated subsequent inspections;

- 8) Piping installation shall comply with the requirements of ASME B31.12, NFPA 52, or NFPA 2; and
- 9) The vessels shall be electrically bonded and grounded per NFPA 55, Compressed Gases and Cryogenic Fluids Code.

S11.9 LADDERS AND RUNWAYS

See NBIC Part 1, Section 1.6.4 Ladders and Runways.

PART 1, SECTION 7

INSTALLATION — 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 1, SECTION 8
INSTALLATION — 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 1, SECTION 9 INSTALLATION — 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 1, SECTION 10

INSTALLATION — 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
13-01	2013	3	1.8.5 q)	Personnel Qualified IAW ANSI/ASME N45.2.23

2011 INTERPRETATIONS

Interpretation	Edition	Part	Section	Subject
11-06	2011	3	3.2.5	Calculations / Start of Work
11-05	2011	2	5.2.2 – 5.2.3	Replacement of Stamped Data on Corrugator Rolls
11-04	2011	3	1.7	Application of “VR” Stamp
11-03	2011	2	2.5.8	Test Frequencies
11-02	2011	3	4.4.2 a)	Liquid Pressure Test Requirements
11-01	2011	3	3.3.2	Routine Repair Considerations

2007 INTERPRETATIONS

Interpretation	Edition	Addenda	Part	Section	Subject
07-16	2007		3	3.3.5.2	Requirement for Repair / Alteration Plan
07-15	2007	2008	2	S2.10.6	Average Pitch
07-14	2007	2009	3	3.3.3	Replacement of Pressure Retaining Parts
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04-22	2004		RC-1130	Inspector Verification of NDE Performed
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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04-18	2004	2005	RD-3010	Re-rating Using a Later Edition/Addenda of The Original Code of Construction
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04-13	2004		RC-1020, RC-1030, Appendix 4, & RC-3022	Replacement of a Cast Iron Section
04-12	2001	2003	RD-1030, RC-1050(c)	Post Weld Heat Treatment of Parts
04-11	2001	2003	RC-1050(c), RC-2050, & RC-2051	Requirements for Testing Replacement Parts
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04-09	2004		RC-2031	Routine Repairs
04-08	2004		RE-1050	Fabricated Replacement Critical Parts
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04-05	2001	2003	RC-1050(c) & RC-2050	"R" Stamp Holder Installation of Code Manufacturer Supplied Parts
04-04	2004		RC-3022(b) & (d)	Re-rating of Pressure-Retaining Items for Lethal Service/Removal of Insulation
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01-38	2001	2003	RD-3022(d)	Design Only "R" Stamp Holders Pressure Testing and Form R-2
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01-36	2001	2002	RC-1020(b)	Application of "R" Stamp on Non-Code Pressure Retaining Items

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01-34	2001	2002	RD-1040(i)(6)	Shielding Gas Dewpoint Temperature
01-33	2001	2002	UG-45	Evaluation of Inservice Pressure Vessels and Requirement of UG-45
01-32	2001	2002	Introduction	Are Reference Codes and Standards Acceptable
01-31	2001	2002	RB-3238	Determination of Remaining Life Applicable to Boilers and Pressure Vessels
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01-25	2001		RC-3050	Documenting Alterations Performed by Two "R" Stamp Organizations
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01-23	2001		RC-2031(a)(1)	Routine Repairs
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01-09	1998	2000	RC-2031(a)(1)	Routine Repairs
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95-56	1995	1996	RA-2231(b)(1)	Acceptance of Code Cases 1923 & 1945
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95-28	1995		RC-2031	R-1 Forms Inspector Involvement for Routine Repairs
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95-21	1995		Appendix 4	Repairs to PWHT Vessels Without Subsequent PWHT
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