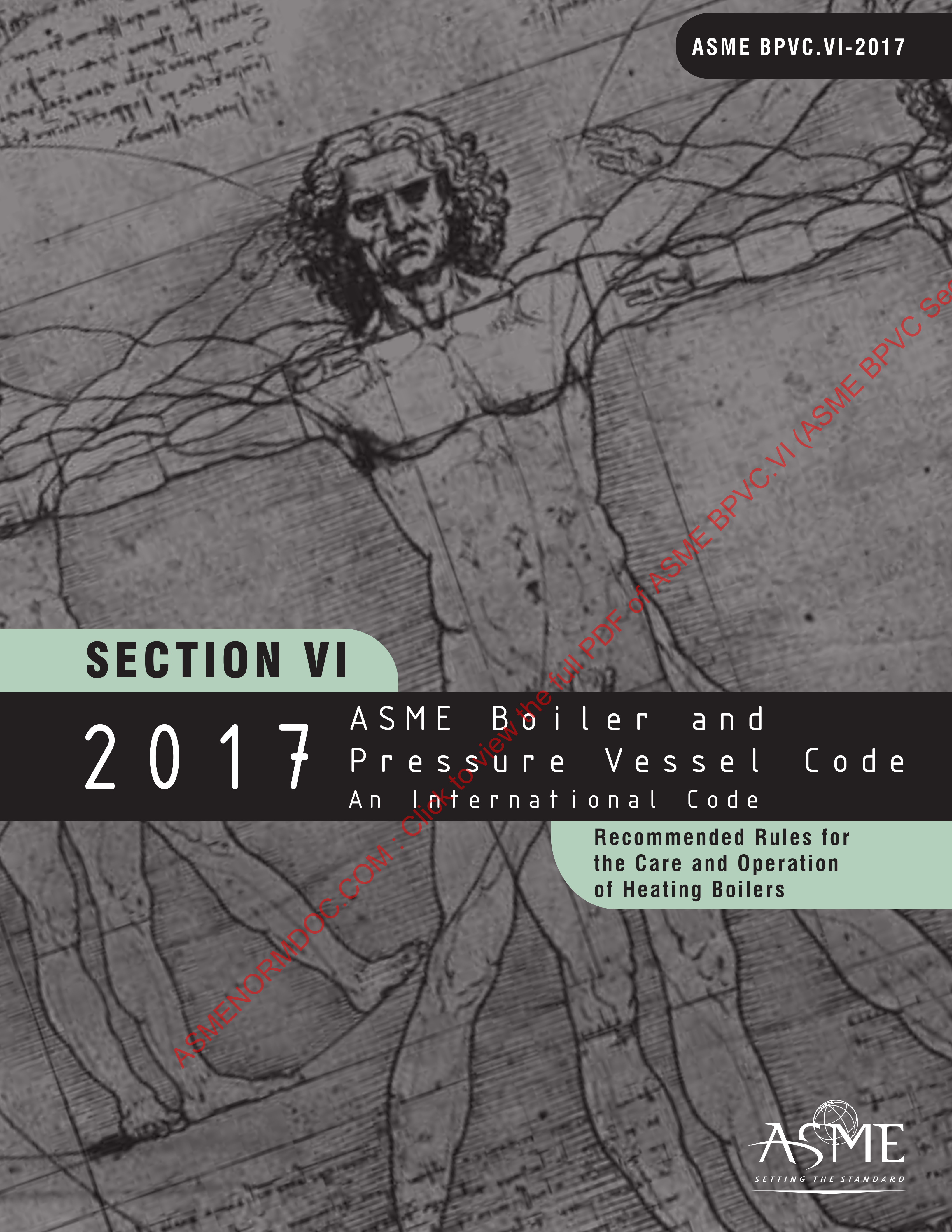
ASME BPVC.VI-2017



SECTION VI

2017 ASME Boiler and Pressure Vessel Code

An International Code

Recommended Rules for the Care and Operation of Heating Boilers

ASME

SETTING THE STANDARD

AN INTERNATIONAL CODE

2017 ASME Boiler & Pressure Vessel Code

2017 Edition

July 1, 2017

VI

RECOMMENDED RULES FOR THE CARE AND OPERATION OF HEATING BOILERS

ASME Boiler and Pressure Vessel Committee
on Heating Boilers

The American Society of Mechanical Engineers

Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: July 1, 2017

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

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CONTENTS

Figures

Table

(17)

LIST OF SECTIONS

SECTIONS

I Rules for Construction of Power Boilers

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

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

IV Rules for Construction of Heating Boilers

V Nondestructive Examination

VI Recommended Rules for the Care and Operation of Heating Boilers

VII Recommended Guidelines for the Care of Power Boilers

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

IX Welding, Brazing, and Fusing Qualifications

X Fiber-Reinforced Plastic Pressure Vessels

XI Rules for Inservice Inspection of Nuclear Power Plant Components

XII Rules for Construction and Continued Service of Transport Tanks

* The 2015 Edition of Section III was the last edition in which Section III, Division 1, Subsection NH, *Class 1 Components in Elevated Temperature Service*, was published. The requirements located within Subsection NH were moved to Section III, Division 5, Subsection HB, Subpart B for the elevated temperature construction of Class A components.

INTERPRETATIONS

Interpretations are issued in real time in ASME's Interpretations Database at http://go.asme.org/Interpretations. Historical BPVC interpretations may also be found in the Database.

CODE CASES

The Boiler and Pressure Vessel Code committees meet regularly to consider proposed additions and revisions to the Code and to formulate Cases to clarify the intent of existing requirements or provide, when the need is urgent, rules for materials or constructions not covered by existing Code rules. Those Cases that have been adopted will appear in the appropriate 2017 Code Cases book: "Boilers and Pressure Vessels" or "Nuclear Components." Supplements will be sent or made available automatically to the purchasers of the Code Cases books up to the publication of the 2019 Code.

FOREWORD*

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

(a) Committee on Power Boilers (I)

(b) Committee on Materials (II)

(c) Committee on Construction of Nuclear Facility Components (III)

(d) Committee on Heating Boilers (IV)

(e) Committee on Nondestructive Examination (V)

(f) Committee on Pressure Vessels (VIII)

(g) Committee on Welding, Brazing, and Fusing (IX)

(h) Committee on Fiber-Reinforced Plastic Pressure Vessels (X)

(i) Committee on Nuclear Inservice Inspection (XI)

(j) Committee on Transport Tanks (XII)

(k) Technical Oversight Management Committee (TOMC)

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

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

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

The Committee recognizes that tools and techniques used for design and analysis change as technology progresses and expects engineers to use good judgment in the application of these tools. The designer is responsible for complying with Code rules and demonstrating compliance with Code equations when such equations are mandatory. The Code neither requires nor prohibits the use of computers for the design or analysis of components constructed to the

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

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

requirements of the Code. However, designers and engineers using computer programs for design or analysis are cautioned that they are responsible for all technical assumptions inherent in the programs they use and the application of these programs to their design.

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

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

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

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

When required by context in this Section, the singular shall be interpreted as the plural, and vice versa, and the feminine, masculine, or neuter gender shall be treated as such other gender as appropriate.

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

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

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

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

The Certification Mark shall be used only for stamping and nameplates as specifically provided in the Code. However, facsimiles may be used for the purpose of fostering the use of such construction. Such usage may be by an association or a society, or by a holder of the Certification Mark who may also use the facsimile in advertising to show that clearly specified items will carry the Certification Mark. General usage is permitted only when all of a manufacturer's items are constructed under the rules.

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

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

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

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

SUBMITTAL OF TECHNICAL INQUIRIES TO THE BOILER AND PRESSURE VESSEL STANDARDS COMMITTEES (17)

1 INTRODUCTION

(a) The following information provides guidance to Code users for submitting technical inquiries to the applicable Boiler and Pressure Vessel (BPV) Standards Committee (hereinafter referred to as the Committee). See the guidelines on approval of new materials under the ASME Boiler and Pressure Vessel Code in Section II, Part D for requirements for requests that involve adding new materials to the Code. See the guidelines on approval of new welding and brazing materials in Section II, Part C for requirements for requests that involve adding new welding and brazing materials ("consumables") to the Code.

Technical inquiries can include requests for revisions or additions to the Code requirements, requests for Code Cases, or requests for Code Interpretations, as described below:

(1) Code Revisions. Code revisions are considered to accommodate technological developments, to address administrative requirements, to incorporate Code Cases, or to clarify Code intent.

(2) Code Cases. Code Cases represent alternatives or additions to existing Code requirements. Code Cases are written as a Question and Reply, and are usually intended to be incorporated into the Code at a later date. When used, Code Cases prescribe mandatory requirements in the same sense as the text of the Code. However, users are cautioned that not all regulators, jurisdictions, or Owners automatically accept Code Cases. The most common applications for Code Cases are as follows:

(-a) to permit early implementation of an approved Code revision based on an urgent need

(-b) to permit use of a new material for Code construction

(-c) to gain experience with new materials or alternative requirements prior to incorporation directly into the Code

(3) Code Interpretations

(-a) Code Interpretations provide clarification of the meaning of existing requirements in the Code and are presented in Inquiry and Reply format. Interpretations do not introduce new requirements.

(-b) If existing Code text does not fully convey the meaning that was intended, or conveys conflicting requirements, and revision of the requirements is required to support the Interpretation, an Intent Interpretation will be issued in parallel with a revision to the Code.

(b) Code requirements, Code Cases, and Code Interpretations established by the Committee are not to be considered as approving, recommending, certifying, or endorsing any proprietary or specific design, or as limiting in any way the freedom of manufacturers, constructors, or Owners to choose any method of design or any form of construction that conforms to the Code requirements.

(c) Inquiries that do not comply with the following guidance or that do not provide sufficient information for the Committee's full understanding may result in the request being returned to the Inquirer with no action.

2 INQUIRY FORMAT

Submittals to the Committee should include the following information:

(a) Purpose. Specify one of the following:

(1) request for revision of present Code requirements

(2) request for new or additional Code requirements

(3) request for Code Case

(4) request for Code Interpretation

(b) Background. The Inquirer should provide the information needed for the Committee's understanding of the Inquiry, being sure to include reference to the applicable Code Section, Division, Edition, Addenda (if applicable), paragraphs, figures, and tables. Preferably, the Inquirer should provide a copy of, or relevant extracts from, the specific referenced portions of the Code.

(c) Presentations. The Inquirer may desire to attend or be asked to attend a meeting of the Committee to make a formal presentation or to answer questions from the Committee members with regard to the Inquiry. Attendance at a BPV Standards Committee meeting shall be at the expense of the Inquirer. The Inquirer's attendance or lack of attendance at a meeting will not be used by the Committee as a basis for acceptance or rejection of the Inquiry by the Committee. However, if the Inquirer's request is unclear, attendance by the Inquirer or a representative may be necessary for the Committee to understand the request sufficiently to be able to provide an Interpretation. If the Inquirer desires to make a presentation at a Committee meeting, the Inquirer should provide advance notice to the Committee Secretary, to ensure time will be allotted for the presentation in the meeting agenda. The Inquirer should consider the need for additional audiovisual equipment that might not otherwise be provided by the Committee. With sufficient advance notice to the Committee Secretary, such equipment may be made available.

3 CODE REVISIONS OR ADDITIONS

Requests for Code revisions or additions should include the following information:

(a) Requested Revisions or Additions. For requested revisions, the Inquirer should identify those requirements of the Code that they believe should be revised, and should submit a copy of, or relevant extracts from, the appropriate requirements as they appear in the Code, marked up with the requested revision. For requested additions to the Code, the Inquirer should provide the recommended wording and should clearly indicate where they believe the additions should be located in the Code requirements.

(b) Statement of Need. The Inquirer should provide a brief explanation of the need for the revision or addition.

(c) Background Information. The Inquirer should provide background information to support the revision or addition, including any data or changes in technology that form the basis for the request, that will allow the Committee to adequately evaluate the requested revision or addition. Sketches, tables, figures, and graphs should be submitted, as appropriate. The Inquirer should identify any pertinent portions of the Code that would be affected by the revision or addition and any portions of the Code that reference the requested revised or added paragraphs.

4 CODE CASES

Requests for Code Cases should be accompanied by a statement of need and background information similar to that described in 3(b) and 3(c), respectively, for Code revisions or additions. The urgency of the Code Case (e.g., project underway or imminent, new procedure) should be described. In addition, it is important that the request is in connection with equipment that will bear the Certification Mark, with the exception of Section XI applications. The proposed Code Case should identify the Code Section and Division, and should be written as a Question and a Reply, in the same format as existing Code Cases. Requests for Code Cases should also indicate the applicable Code Editions and Addenda (if applicable) to which the requested Code Case applies.

5 CODE INTERPRETATIONS

(a) Requests for Code Interpretations should be accompanied by the following information:

(1) Inquiry. The Inquirer should propose a condensed and precise Inquiry, omitting superfluous background information and, when possible, composing the Inquiry in such a way that a "yes" or a "no" Reply, with brief limitations or conditions, if needed, can be provided by the Committee. The proposed question should be technically and editorially correct.

(2) Reply. The Inquirer should propose a Reply that clearly and concisely answers the proposed Inquiry question. Preferably, the Reply should be "yes" or "no," with brief limitations or conditions, if needed.

(3) Background Information. The Inquirer should provide any need or background information, such as described in 3(b) and 3(c), respectively, for Code revisions or additions, that will assist the Committee in understanding the proposed Inquiry and Reply.

If the Inquirer believes a revision of the Code requirements would be helpful to support the Interpretation, the Inquirer may propose such a revision for consideration by the Committee. In most cases, such a proposal is not necessary.

(b) Requests for Code Interpretations should be limited to an Interpretation of a particular requirement in the Code or in a Code Case. Except with regard to interpreting a specific Code requirement, the Committee is not permitted to consider consulting-type requests such as the following:

(1) a review of calculations, design drawings, welding qualifications, or descriptions of equipment or parts to determine compliance with Code requirements

(2) a request for assistance in performing any Code-prescribed functions relating to, but not limited to, material selection, designs, calculations, fabrication, inspection, pressure testing, or installation

(3) a request seeking the rationale for Code requirements

6 SUBMITTALS

(a) Submittal. Requests for Code Interpretation should preferably be submitted through the online Interpretation Submittal Form. The form is accessible at http://go.asme.org/InterpretationRequest. Upon submittal of the form, the Inquirer will receive an automatic e-mail confirming receipt. If the Inquirer is unable to use the online form, the Inquirer may mail the request to the following address:

Secretary
ASME Boiler and Pressure Vessel Committee
Two Park Avenue
New York, NY 10016-5990

All other Inquiries should be mailed to the Secretary of the BPV Committee at the address above. Inquiries are unlikely to receive a response if they are not written in clear, legible English. They must also include the name of the Inquirer and the company they represent or are employed by, if applicable, and the Inquirer's address, telephone number, fax number, and e-mail address, if available.

(b) Response. The Secretary of the appropriate Committee will provide a written response, via letter or e-mail, as appropriate, to the Inquirer, upon completion of the requested action by the Committee. Inquirers may track the status of their Interpretation Request at http://go.asme.org/Interpretations.

(17)

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January 1, 2017

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SUMMARY OF CHANGES

Errata to the BPV Code may be posted on the ASME Web site to provide corrections to incorrectly published items, or to correct typographical or grammatical errors in the BPV Code. Such Errata shall be used on the date posted.

Information regarding Special Notices and Errata is published by ASME at http://go.asme.org/BPVCerrata.

The 2017 Edition of BPVC Section VI is a complete rewrite; the 2015 Edition has been revised and reorganized in its entirety *(12-1918, 16-2739)*. Front matter changes given below are identified on the pages by a margin note, **(17)**, placed next to the affected area.

The Record Numbers cited in the previous paragraph and listed below are explained in more detail in "List of Changes in Record Number Order" following this Summary of Changes.

Page	*Location*	*Change (Record Number)*
vi	List of Sections	Updated
xi	Submittal of Technical Inquiries to the Boiler and Pressure Vessel Standards Committees	Revised in its entirety *(13-2222)*
xiv	Personnel	Updated

LIST OF CHANGES IN RECORD NUMBER ORDER

Record Number	Change
12-1918	Revised and updated Section VI in its entirety.
13-2222	Revised front guidance on interpretations in its entirety.
16-2739	Revised 8.5.4.1.

CROSS-REFERENCING AND STYLISTIC CHANGES IN THE BOILER AND PRESSURE VESSEL CODE

There have been structural and stylistic changes to BPVC, starting with the 2011 Addenda, that should be noted to aid navigating the contents. The following is an overview of the changes:

Subparagraph Breakdowns/Nested Lists Hierarchy

- First-level breakdowns are designated as (a), (b), (c), etc., as in the past.
- Second-level breakdowns are designated as (1), (2), (3), etc., as in the past.
- Third-level breakdowns are now designated as (-a), (-b), (-c), etc.
- Fourth-level breakdowns are now designated as (-1), (-2), (-3), etc.
- Fifth-level breakdowns are now designated as (+a), (+b), (+c), etc.
- Sixth-level breakdowns are now designated as (+1), (+2), etc.

Footnotes

With the exception of those included in the front matter (roman-numbered pages), all footnotes are treated as endnotes. The endnotes are referenced in numeric order and appear at the end of each BPVC section/subsection.

Submittal of Technical Inquiries to the Boiler and Pressure Vessel Standards Committees

Submittal of Technical Inquiries to the Boiler and Pressure Vessel Standards Committees has been moved to the front matter. This information now appears in all Boiler Code Sections (except for Code Case books).

Cross-References

It is our intention to establish cross-reference link functionality in the current edition and moving forward. To facilitate this, cross-reference style has changed. Cross-references within a subsection or subarticle will not include the designator/identifier of that subsection/subarticle. Examples follow:

- *(Sub-)Paragraph Cross-References.* The cross-references to subparagraph breakdowns will follow the hierarchy of the designators under which the breakdown appears.
  - If subparagraph (-a) appears in X.1(c)(1) and is referenced in X.1(c)(1), it will be referenced as (-a).
  - If subparagraph (-a) appears in X.1(c)(1) but is referenced in X.1(c)(2), it will be referenced as (1)(-a).
  - If subparagraph (-a) appears in X.1(c)(1) but is referenced in X.1(e)(1), it will be referenced as (c)(1)(-a).
  - If subparagraph (-a) appears in X.1(c)(1) but is referenced in X.2(c)(2), it will be referenced as X.1(c)(1)(-a).
- *Equation Cross-References.* The cross-references to equations will follow the same logic. For example, if eq. (1) appears in X.1(a)(1) but is referenced in X.1(b), it will be referenced as eq. (a)(1)(1). If eq. (1) appears in X.1(a)(1) but is referenced in a different subsection/subarticle/paragraph, it will be referenced as eq. X.1(a)(1)(1).

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ARTICLE 1
INTRODUCTION

The purpose of these recommended guidelines is to promote safety in the use of steam heating, hot water heating, and hot water supply boilers that are directly fired with oil, gas, electricity, coal, or other solid and liquid fuels. These guidelines are intended for use by those directly responsible for operating and maintaining heating and hot water supply boilers. These guidelines apply only to boilers subject to the service restrictions of Section IV, HG-101 of the ASME Boiler and Pressure Vessel Code, as follows:

(a) steam boilers for operation at pressures not exceeding 15 psi (100 kPa)

(b) hot water heating and hot water supply boilers for operation at pressures not exceeding 160 psi (1 100 kPa) and/or temperatures not exceeding 250°F (120°C)

These guidelines apply to the boiler proper and to pipe connections up to and including the valve or valves as required by the Code. Guidelines are also provided for operation of auxiliary equipment and appliances that affect the safe and reliable operation of heating boilers.

The use of the word "shall" in these Guidelines reflects the mandatory nature of the Section IV requirements. The reader should consult the latest edition of Section IV for the current requirements.

Formulating a set of guidelines that is applicable to all sites and types of installations is difficult; therefore, it may be advisable to depart from these guidelines in specific cases. Manufacturer's operating instructions should always be adhered to, as should any local jurisdictional requirements. Other industry-accepted codes and standards, such as the National Fire Protection Association's (NFPA) codes covering prevention of furnace explosions, are recommended for additional guidance.

These guidelines are not intended to be used in lieu of any required inspections and operations mandated by jurisdictions, the National Board Inspection Code, or insurance companies.

ARTICLE 2
GLOSSARY

acid: any chemical compound with a pH less than 7 containing hydrogen that dissociates to produce hydrogen ions when dissolved in water and is capable of neutralizing hydroxides or bases to produce salts.

acidity: the state of being acid; the degree or quantity of acid present.

air: a mixture of oxygen, nitrogen, and other gases that, with varying amounts of water vapor, form the atmosphere of the earth.

air–fuel mixture: the ratio of the weight of air to the weight of fuel in a mixture of air and fuel.

air moisture: the water vapor suspended in the air.

alkali: any chemical compound of a basic nature that dissociates to produce hydroxyl ions when dissolved in water and is capable of neutralizing acids to produce salts.

alkalinity: the state of being alkaline; the degree or quantity of alkali present in a solution, often expressed in terms of pH. In water analysis, it represents the carbonates, bicarbonates, hydroxides, and occasionally the borates, silicates, and phosphates present as determined by titration with a standard acid and generally expressed as calcium carbonate in parts per million.

atmospheric pressure: the barometric reading of pressure exerted by the atmosphere, which at sea level is 14.7 psi (101 kPa) or 29.9 in. Hg (101 kPa).

Authorized Inspection Agency (Inservice): either

(a) a jurisdictional authority as defined in the National Board Constitution, or

(b) an entity that is accredited by the National Board as satisfying the requirements of NB-369, Qualifications and Duties for Authorized Inspection Agencies (AIA) Performing Inservice Inspection Activities; NB-371, Accreditation of Owner-User Inspection Organizations (OUIO); or NB-390, Qualifications and Duties for Federal Inspection Agencies (FIA) Performing Inservice Inspection Activities

Authorized Inspection Agency (New Construction): an organization that is accredited by ASME in accordance with ASME QAI-1, Qualifications for Authorized Inspection, and meets the requirements of the National Board of Boiler and Pressure Vessel Inspectors.

Authorized Inspector: an Inspector who holds a valid National Board New Construction Commission with the appropriate endorsement and who is designated as such by an Authorized Inspection Agency.

baffle: a plate or wall for deflecting gases or liquids.

barometric pressure: atmospheric pressure as measured by a barometer, usually expressed in inches (millimeters) of mercury.

blowdown: a process for removing unwanted solid particulates and sludge from the boiler water. This process can be either manual or continuous. Valves are opened to use the boiler pressure to blow the particulates out of the boiler.

blower: a fan used to move air under pressure.

blowoff: a pipe connection provided with valves through which the water in the boiler may be blown out under pressure.

boiler: a fired pressure vessel in which water or some other fluid is heated or steam is generated.

boiler, firetube: a boiler with tubes that are surrounded by water and steam and through which the products of combustion pass.

boiler, hot water heating: a boiler designed to heat water for circulation through an external space-heating system.

boiler, hot water supply: a boiler used to heat water for purposes other than space heating.

boiler, watertube: a boiler in which the tubes contain water and steam with the heat being applied to the outside surface.

boiler layup: any extended period of time during which the boiler is not expected to operate and suitable precautions are made to protect it against corrosion, scaling, pitting, etc., on the water and fire sides.

breeching: a duct for the transport of the products of combustion between the boiler and the stack.

buckstay: a structural member placed against a furnace or boiler wall to restrain the motion of the wall.

burner: a device for the introduction of fuel and air into the combustion zone at the desired velocities, turbulence, and concentration to establish and maintain proper ignition and combustion of the fuel.

carbon: the element that is the principal combustible constituent of all fuels.

coal: solid hydrocarbon fuel formed by ancient decomposition of woody substance under conditions of heat and pressure.

coke: fuel consisting largely of the fixed carbon and ash in coal obtained by the destructive distillation of bituminous coal.

colloid: a substance microscopically dispersed throughout another substance but incapable of passing through a semipermeable membrane.

combustion: the rapid chemical reaction of oxygen with the combustible elements of a fuel resulting in the production of heat.

complete combustion: the complete oxidation of all the combustible constituents of a fuel.

condensate: water formed as a result of a phase change from gas to liquid.

control: a device designed to regulate the fuel, exhaust, air, water, or electrical supplies to a powered device. It may be manual, semiautomatic, or automatic.

convection: the transmission of heat by the circulation of a liquid or a gas. It may be natural or forced.

damper loss: the reduction in the static pressure of a gas flowing across a damper.

delayed combustion: continuation of combustion beyond the furnace.

differential temperature: the temperature differential between two spaces; for example, the difference in temperature between the inlet and outlet of the boiler.

distillation: vaporization of a substance with subsequent recovery of the vapor by condensation.

draft: a pressure difference that causes gases or air to flow through a chimney, vent, or boiler; also, a measurement of negative pressure in a vent used to indicate potential for flue gas flow.

drain: a valved connection at a low point for the removal of water.

drum: a cylindrical shell closed at both ends and designed to withstand internal pressure.

duct: an enclosed passage for air or gas flow.

electric ignition: ignition of a pilot or main flame by the use of an electric arc or glow plug.

excess air: air supplied for combustion in excess of that theoretically required for complete combustion.

expander: a tool used to create a permanent seal between a tube and a tubesheet or header by expanding the tube so it is compressed against the other surface.

extended surface: metallic heat-absorbing surface protruding beyond the tube wall.

fan: a machine consisting of a rotor and housing for moving air or gases.

fan, forced-draft: a type of pressurized fan producing a positive pressure within a system or equipment.

fan, induced-draft: a fan exhausting hot gases from heat-absorbing equipment.

feed pipe: a pipe through which water is conducted into a boiler.

fin: a projection from a surface subject to heat.

fin tube: a tube with one or more fins.

firetube: a tube in a boiler having water on the outside and carrying the products of combustion on the inside.

fixed carbon: the solid combustible residue remaining after coal, coke, or bituminous materials are heated and the volatile matter expelled. The fixed carbon content is determined by subtracting from 100% the percentages of moisture, volatile matter, and ash in a sample.

flame: a luminous body of burning gas or vapor.

flash point: the lowest temperature at which a volatile material can vaporize to form a combustible mixture in air.

float switch: a float-operated switch that makes and breaks an electric circuit in accordance with a change in a predetermined water level.

flow switch: a device that monitors the flow of air, steam, or liquid.

flue: a passage for products of combustion.

flue gas: the gaseous products of combustion.

furnace: the part of a boiler in which combustion of fuel takes place or in which primary furnace gases are conveyed.

gauge cock: a valve used to isolate a boiler from a measuring device such as a pressure gauge or gauge glass.

gauge glass: the transparent part of a water gauge assembly connected directly or through a water column to the boiler to indicate the water level in the boiler.

gauge pressure: the pressure above atmospheric pressure.

gas analysis: the determination of the percentages of various constituents of a gaseous mixture.

grate: the surface on which fuel is supported and burned, and through which air is passed for combustion.

grate bars: those parts of the fuel-supporting surface arranged to admit air for combustion.

handhole: an opening in a pressure part for access, too small for a person to enter.

header: piping that connects two or more boilers together.

heat balance: an accounting of the distribution from one medium to another.

heating surface: the surface that is exposed to the heating medium for absorption and transfer of heat to the heated medium as determined according to Section IV, HG-403.

hydrocarbon: a chemical compound of hydrogen and carbon.

hydrostatic test: a strength and water-tightness test of a closed pressure vessel by water pressure.

impingement: the striking of moving matter, such as the flow of steam, water, gas, or solids, against another surface.

inhibitor: a compound that slows down or stops an undesired chemical reaction such as corrosion or oxidation.

insulation: a material of low thermal conductivity used to reduce heat losses.

integral blower: a blower built as an integral part of a device to supply air thereto.

intermittent firing: a method of firing by which fuel and air are introduced into and burned in a furnace for a short period, after which the flow is stopped. The cycle is then repeated.

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 retaining items; it includes National Board member jurisdictions, defined as "jurisdictional authorities."

jurisdictional authority: a member of the National Board, as defined in the National Board Constitution.

lagging: a covering, usually of insulating material, on pipe or ducts.

load: the system demand for output of steam or hot water, in pounds (kilograms) per hour or British thermal units per hour (watts).

low-water fuel cutoff: a device that shuts down the fuel supply when the water level in the boiler drops below its safe operating level (the safe operating level is determined by the boiler Manufacturer).

makeup water: water introduced into the boiler to replace that lost or removed from the system.

manhole: the opening in a pressure vessel of sufficient size to permit a person to enter.

manifold: a pipe or header for collecting a fluid from, or distributing a fluid to, a number of pipes or tubes.

maximum allowable working pressure (MAWP): the maximum gauge pressure determined by employing the allowable stress values and design rules provided in Section IV.

mechanical draft: a differential pressure created by mechanical means.

modulation of burner: varying the burner firing rate to match the load demand.

neutralize: to counteract acidity with an alkali or alkalinity with an acid.

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.

operating pressure: the actual gauge pressure at the boiler outlet.

operating temperature: the actual temperature at the boiler outlet.

oxidation: the interaction between oxygen molecules and other substances.

packaged boiler: a boiler equipped and shipped complete with fuel-burning equipment, mechanical draft equipment, automatic controls, and accessories.

parts per million (ppm): the number of parts of a diluent in one million parts of the sample examined, which is typically air or water. In water, 1 mg/L is equivalent to 1 ppm.

pass: a confined passageway, containing heating surface, through which a gas flows in essentially one direction.

pH: a scale used to measure the degree of acidity or alkalinity of a solution. Solutions with a pH less than 7 are said to be acidic, and those with a pH greater than 7 are said to be alkaline. Water is very close to a pH of 7.

pilot flame: the flame, usually fueled by gas or light oil, that ignites the main flame.

pneumatic control: any control that uses compressed air as the actuating means.

polyphosphate: a form of phosphate that sequesters rather than precipitates hard water salts.

pour point: the temperature at which fluid begins to flow.

precipitation: the formation and settling out of solid particles in a solution.

pressure drop: the difference in pressure between two points.

pressure relief valve: a device designed to relieve pressure when the set pressure is reached.

pressure vessel: a closed vessel or container designed to confine a fluid at a pressure above atmospheric pressure.

primary air: air introduced with the fuel at the burners.

receiver: the tank portion of a condensate or vacuum return pump where condensate accumulates.

relay: an electrical device that opens or closes a circuit as its internal coil is energized or de-energized.

safety relief valve: an automatic pressure-relieving device actuated by the static pressure upstream of the valve and characterized by rapid opening or pop action, or by opening in proportion to the increase in pressure over the set pressure, depending on application.

safety valve: an automatic pressure-relieving device actuated by the static pressure upstream of the valve and characterized by full-opening pop action. It is used for gas or vapor service.

saturated air: air that contains the maximum amount of water vapor that it can hold at its temperature and pressure.

seal weld: a weld used primarily to prevent leakage.

seam: the joint between two plates joined together.

secondary air: air for combustion supplied to the furnace to supplement the primary air.

setting: the construction surrounding the boiler and/or the tubes consisting of refractory, insulation, casing, lagging, or some combination of these.

smoke boxes: a chamber in a boiler where the smoke, etc., from the furnace is collected before going out at the chimney.

spontaneous combustion: ignition of combustible material without apparent cause.

stay: a tensile stress member to hold material or other members rigidly in position.

steam gauge: a gauge for indicating the pressure of steam.

stoichiometric combustion: the complete oxidation of all the combustible constituents of a fuel at zero excess air.

stop valve: a valve that is used to isolate a boiler from the other parts of the system.

stud: a projecting pin serving as a support or means of attachment.

thermal efficiency: the ratio of the heat absorbed by the water and steam in a boiler to the available heat in the fuel fired, expressed as a percent.

titration: a method for determining volumetrically the concentration of a desired substance in solution by adding a standard solution of known volume and strength until the chemical reaction is completed as shown by a change in color of suitable indicator.

total air: the total quantity of air supplied to the fuel and products of combustion.

trap: a device installed in piping that is designed to prohibit the passage of steam but allow the passage of condensate and gases.

tube hole: a hole in a drum, header, or tubesheet to accommodate a tube.

tubesheet: a plate containing the tube holes.

vent: an opening in a vessel or other enclosed space for the removal of gas or other vapors.

viscosity: the measure of a fluid's resistance to flow.

water column: a vertical tubular member connected at its top and bottom to the steam and water space, respectively, of a boiler, to which the water gauge, gauge cocks, and high- and low-water-level alarms may be connected.

water gauge: the gauge glass and its fittings for attachment.

water heater: a vessel in which potable water is heated by the combustion of fuel, by electricity, or by any other source, and withdrawn for external use.

water heater, lined: a water heater with a corrosion-resistant lining designed to heat potable water.

water heater, unlined: a water heater made from corrosion-resistant materials designed to heat potable water.

water level: the elevation of the surface of the water in a boiler.

zeolite: originally a group of natural minerals capable of removing calcium and magnesium ions from water and replacing them with sodium. The term has been broadened to include synthetic resins that similarly soften water by ion exchange.

ARTICLE 3
TYPES OF BOILERS

3.1 CLASSIFICATION

Section VI classifies heating boilers by the ASME Certification, method of manufacture, category, method of heat input, and other design characteristics.

3.2 ASME CERTIFICATION MARK

Section IV provides requirements for using the Certification Mark with H or HLW designator.

3.2.1 Boilers Stamped With the Certification Mark With H Designator

Boilers stamped with the Certification Mark with H designator may be steam heating boilers, hot water heating boilers, or hot water supply boilers.

3.2.1.1 Steam heating boilers may be used in open or closed systems in accordance with Manufacturer's instructions and jurisdictional requirements and shall operate at 15 psi (100 kPa) or less.

3.2.1.2 Hot water heating boilers are intended for use in closed-loop systems with limited potential for corrosion of the boiler. Hot water heating boilers are limited to operation at 160 psi (1 100 kPa) or less and water temperatures not exceeding 250°F (120°C) at or near the boiler outlet.

3.2.1.3 Hot water supply boilers may be used for purposes other than space heating. They may be installed in open- or closed-loop systems. Hot water supply boilers are limited to operation at 160 psi (1 100 kPa) or less and water temperatures not exceeding 250°F (120°C) at or near the boiler outlet.

3.2.2 Potable Water Heaters Stamped With the Certification Mark With H or HLW Designator

Potable water heaters stamped with the Certification Mark with H or HLW designator may be used in open-loop systems and shall be constructed from corrosion-resistant materials or with a corrosion-resistant lining. Water heaters are limited to operation at 160 psi (1 100 kPa) or less and water temperatures not exceeding 210°F (99°C) at or near the water outlet.

3.3 METHOD OF MANUFACTURE

3.3.1 Fabricated Boilers

Fabricated boilers may be steel, stainless steel, copper, and less commonly, other metals or alloys. Some boilers use polymer or composite materials in the boiler pressure vessel and are generally classified as fabricated boilers within Section VI.

3.3.1.1 Firetube Boilers. In firetube boilers, the gases of combustion pass through the tubes and the water circulates around them.

3.3.1.1.1 Horizontal Return Tube (HRT). In an HRT, the boiler is often in a refractory or brick setting and the products of combustion flow under the boiler and return through the firetubes. The furnace may also be constructed of steel. See Figure 3.3.1.1.1-1.

3.3.1.1.2 Scotch-Type Boilers. The scotch boilers used in modern heating systems are similar to those originally designed for shipboard installation and are sometimes called scotch marine boilers. The furnace is a cylinder completely surrounded by water. Most scotch boilers are of the dry-back or partial wet-back design and are arranged for multiple gas passes. See Figure 3.3.1.1.2-1.

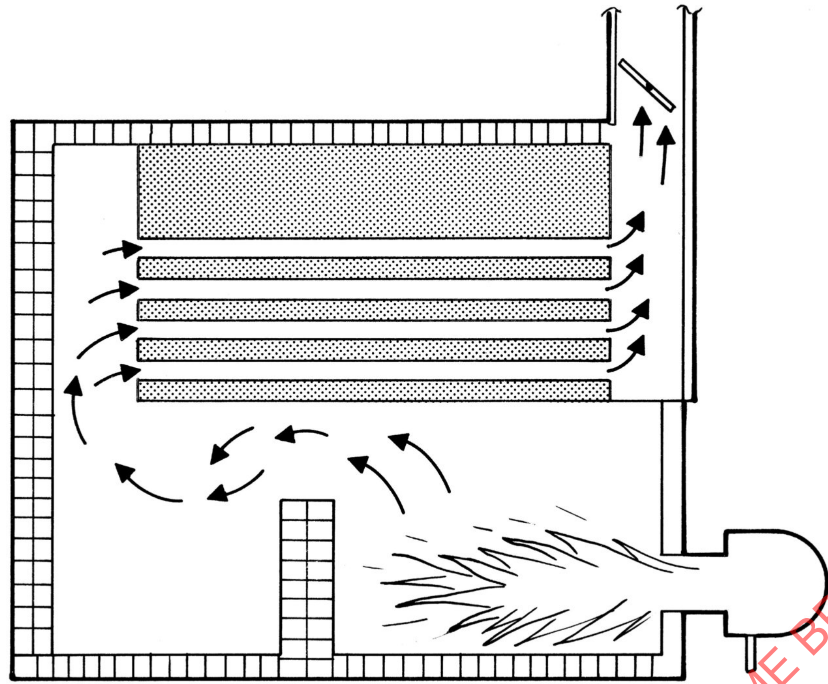
3.3.1.1.3 Firebox Boilers. Firebox boilers have the firebox integral with the boiler, such as in the oil field or locomotive type, and may be single or multiple pass. The furnace of this type of boiler is usually enclosed in a water-cooled upper sheet, called a crown sheet. Various tube and shell configurations, characterizing different Manufacturers' designs, complete the boilers. See Figures 3.3.1.1.3-1 and 3.3.1.1.3-2.

3.3.1.1.4 Vertical Firetube Boilers. In vertical firetube boilers, the products of combustion pass up or down through the tubes that are surrounded by water. See Figure 3.3.1.1.4-1.

3.3.1.2 Watertube Boilers

3.3.1.2.1 In watertube boilers, the water passes through the tube and the combustion gases pass around them. Refer to the Manufacturer's instructions for minimum water flow rate requirements.

Figure 3.3.1.1.1-1 Horizontal Tube, Brick-Set



3.3.1.2.2 Watertube boilers are made in a variety of configurations with respect to tube and drum arrangement. Tubes are made from a variety of materials, including steel, stainless steel, copper, and copper fin tube.

(a) Tray-Type Boilers. Tray-type boilers typically have a cast manifold that distributes water flow through a bank of straight tubes. Most of these boilers are constructed of finned tubes.

(b) Coil-Type Boilers. Coil-type boilers may be fabricated from a single tube or multiple tubes wrapped into a cylinder or any other coiled shape.

(c) Bent-Tube Boilers. Bent-tube boilers are typically constructed with multiple steel tubes connected to manifolds.

3.3.2 Cast Boilers

3.3.2.1 Cast boilers are most commonly iron but may be constructed of aluminum or other metals. Cast boilers are made in two general types: sectional and one-piece (monoblock). The sections of a sectional boiler can be stacked either vertically or horizontally and are held together with tie rods, with the waterways sealed by push nipples or elastomer seals, and in rare cases, screwed nipples. See Figures 3.3.2.1-1 and 3.3.2.1-2.

3.3.2.2 Manufacturer's instructions should be followed when adjusting nipples or tie rods. Either inadequate or excess tension on tie rods may be detrimental to the boiler.

3.3.3 Vacuum Boilers

Vacuum boilers are factory-sealed steam boilers that are operated below atmospheric pressure.

3.4 CATEGORY

Boiler category is determined according to ANSI Z21.13/CSA 4.9 and relates to the potential for condensation of the products of combustion in the venting and heat exchanger and the potential for positive pressure in the venting. Venting is discussed in Article 5.

3.4.1 Noncondensing Boilers

Noncondensing boilers are Category I or Category III boilers. These boilers do not require any special construction or provisions for condensate.

3.4.2 Condensing Boilers

3.4.2.1 Condensing boilers can be constructed in a variety of designs but typically have the vent connection near the bottom of the boiler and include a drain for condensate. Condensing boilers are high-efficiency boilers that may cool the products of combustion below the dew point, resulting in condensation inside the heat exchanger and vent stack. The condensate that forms is corrosive and requires corrosion-resistant venting and neutralization of condensate.

3.4.2.2 Condensing boilers may also be referred to as Category II or Category IV boilers. A boiler categorized as a condensing boiler is not necessarily designed for condensing operation. Consult the Manufacturer's installation and operation instructions for optimal operating conditions for the boiler.

Figure 3.3.1.1.2-1 Gas Flow Patterns of Scotch-Type Boilers

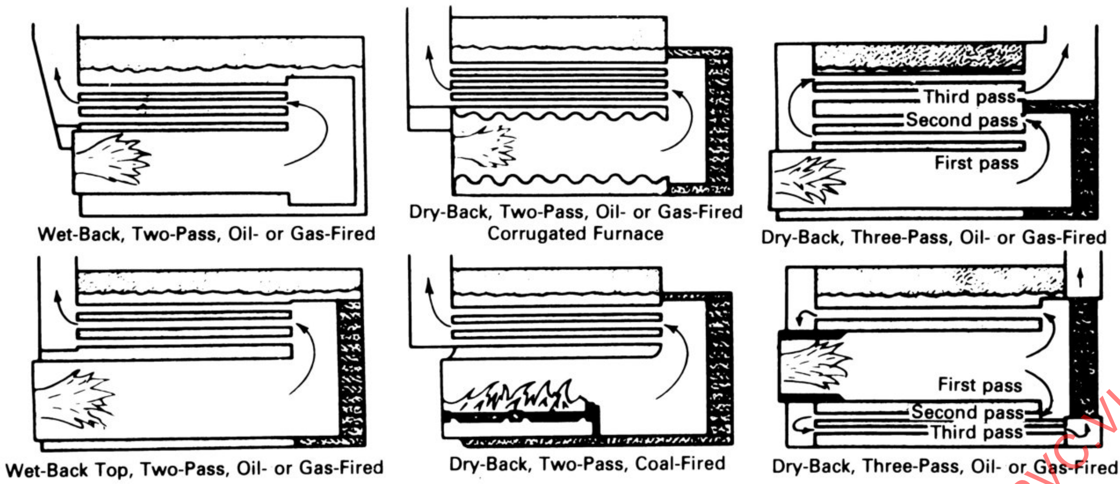


Figure 3.3.1.1.3-1 Type C Firebox Boiler

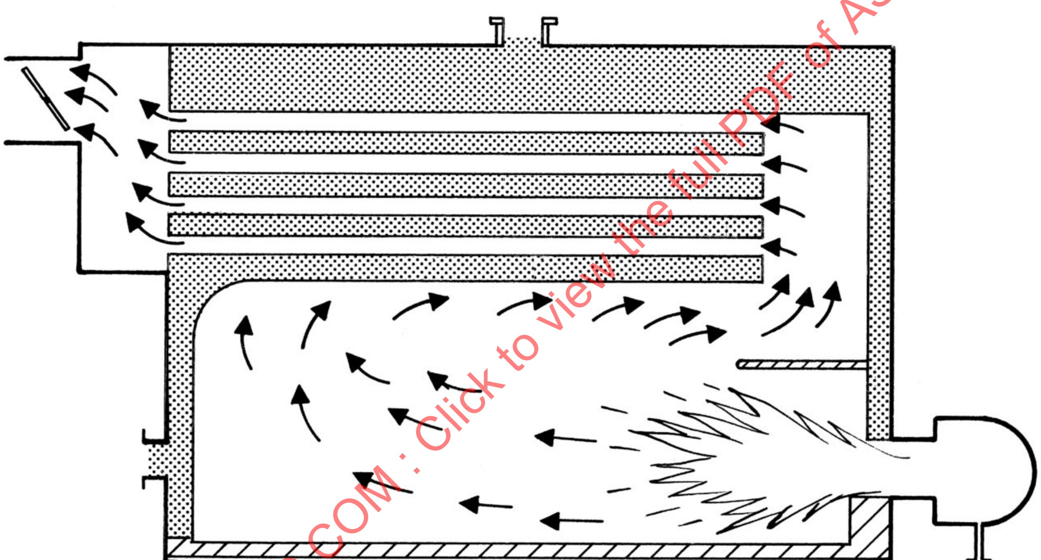


Figure 3.3.1.1.3-2 Three-Pass Firebox Boiler

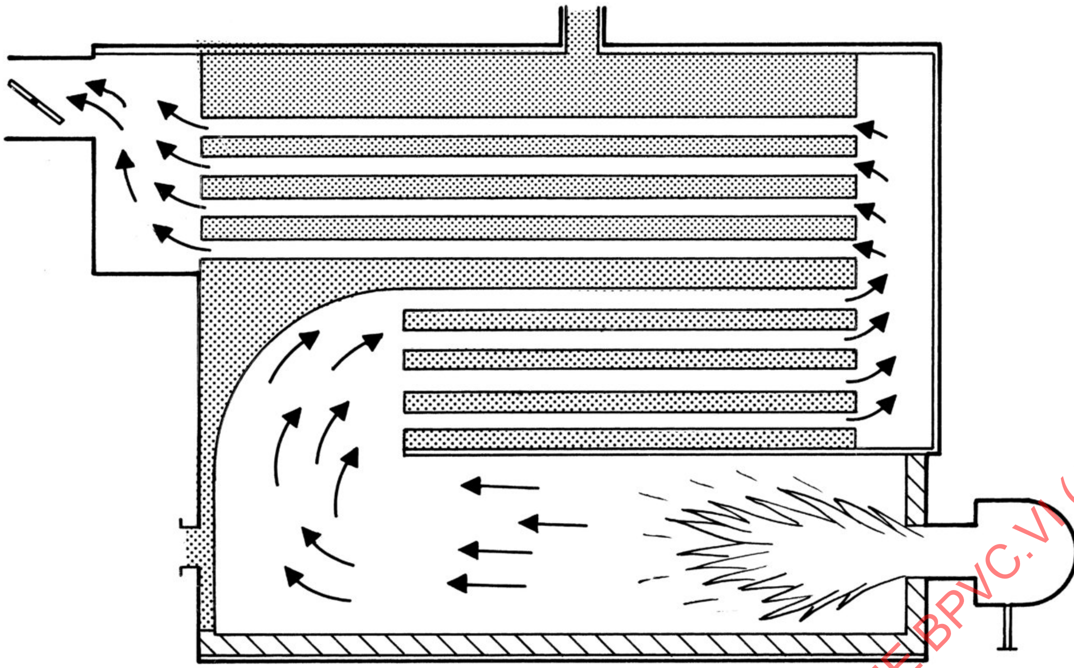


Figure 3.3.1.1.4-1 Vertical Firetube Boiler

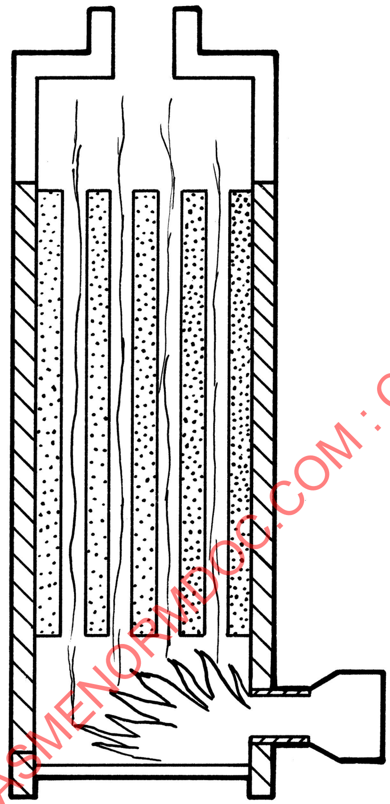


Figure 3.3.2.1-1 Horizontal Sectional Cast Iron Boiler

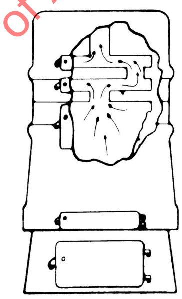
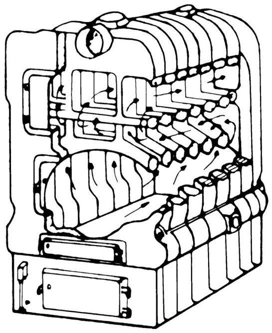


Figure 3.3.2.1-2 Vertical Sectional Cast Iron Boiler



ARTICLE 4
FUELS AND FUEL-BURNING EQUIPMENT

4.1 TYPES OF FUELS

Fuels for boilers are available in gaseous, liquid, or solid form, and some boilers use electricity as their heat source. Care must be taken to ensure that the boiler, burner, and ancillary equipment are designed for the fuel to be utilized.

4.1.1 Gaseous Fuels

4.1.1.1 Natural Gas. Natural gas used for fuel has a wide range of heating values. Methane is the principle component of natural gas, but ethane, propane, and butane may also be present, along with trace amounts of other hydrocarbons. The heating value of the gas depends on the percent of each hydrocarbon present in the mixture, but it typically varies from a low of 950 Btu/ft^3 (35.4 MJ/m^3) to a high of 1,150 Btu/ft^3 (42.9 MJ/m^3).

4.1.1.2 Manufactured Gas. Manufactured gas should not be confused with natural gas since manufactured gas, or artificial gas as it is sometimes called, is produced from coal, coal-and-oil mixtures, or petroleum. The heating value of manufactured gas ranges from a low of 350 Btu/ft^3 (13.0 MJ/m^3) to a high of 600 Btu/ft^3 (22.4 MJ/m^3).

4.1.1.3 Digester Gas. Digester gas, or biogas as it is sometimes called, is produced by the breakdown of organic matter in the absence of oxygen. It is a renewable energy source and is composed primarily of methane and carbon dioxide with trace amounts of hydrogen and nitrogen. The heating value, which depends mostly upon the methane concentration (typically 40% to 70% by volume), varies from 600 Btu/ft^3 (22.4 MJ/m^3) to 900 Btu/ft^3 (33.6 MJ/m^3). The properties of the gas may vary by site. It is important to realize that the gas may be corrosive from either moisture content or the presence of sulfur.

4.1.2 Liquid Fuels

4.1.2.1 Liquefied Petroleum Gas (LPG). Commonly known as propane, liquefied petroleum gas is stored in tanks at high pressure to keep it in a liquid state. Storage may be either above- or belowground, using storage and handling procedures in accordance with the requirements of NFPA 58 and local regulations. When the pressure on the liquefied fuel is reduced to that required for the burner, the fuel changes from its liquid state to a gas. Propane or butane gas has a heating value of 2,300 Btu/ft^3 (85.7MJ/m^3) to 3,300 Btu/ft^3 (122.9 MJ/m^3). Because of significant heating value differences between liquefied petroleum gas and other gases, the fuel-burning equipment must be modified when changing from the liquefied fuel to another gas, or vice versa. Since propane is colorless and heavier than air, precaution is recommended when working with propane.

4.1.2.2 Fuel Oils. Fuel oils are graded in accordance with specifications of the American Society for Testing and Materials. Oils are classified by their viscosities. Other characteristics of fuel oils that determine their grade, classification, and suitability for given uses are flash point, pour point, water and sediment content, sulfur content, ash, and distillation characteristics. Fuel oils are prepared for combustion in most low-pressure boiler burners by atomization (spraying). The following are commonly used types of atomization:

(a) high-pressure mechanical atomization
(b) low-pressure mechanical atomization
(c) centrifugal atomization (rotary cup)
(d) compressed air atomization
(e) steam atomization

4.1.2.2.1 Oil Grade Types

(a) Grade Number 1. Grade Number 1 is a light-viscosity distillate oil intended for vaporizing pot-type burners. The heating value is approximately 135,000 Btu/gal (37 600 MJ/m^3).

(b) Grade Number 2. Grade Number 2 is a distillate oil used for general purpose heating. The heating value is approximately 138,000 Btu/gal (38 500 MJ/m^3). This is the most common grade of oil burned in Section IV boilers.

(c) Grade Number 4. Grade Number 4 is an oil heavier than Number 2 but not heavy enough to require preheating facilities. Because the oil is no longer available in many locations as a straight-run distillate, but is a mix of Number 2 and heavier oils, it may be necessary in northern climates to provide tank heaters or small recirculating preheaters to ensure delivery of the blended fuel to the burner. If the fuel is not blended properly, the Number 2 oil and the heavier oil may separate in time. Many dealers blend the two grades of oil in the tank truck while delivering to the location. This may result

in physical separation of the two grades if they stand in the tank for any length of time. The heating value is approximately 147,000 Btu/gal (41 000 MJ/m^3).

(d) Grade Number 5. Grade Number 5 has been divided into hot Number 5 and cold Number 5. The "hot" grade requires preheating and the "cold" may be burned as is from the tank, but because of the increased demand for distillate products, the residual oils may be lower in quality and may require preheating for good results. Sometimes Grade Number 5 is a mix of Number 2 and Number 6. The usual heating value is approximately 152,000 Btu/gal (42 400 MJ/m^3).

(e) Grade Number 6. Grade Number 6 is a residual-type oil for use in burners equipped with recirculating preheaters. Number 6 fuel oil is sometimes referred to as Bunker C. The typical heating value is approximately 153,000 Btu/gal (42 600 MJ/m^3).

4.1.2.2.2 Preheating Requirements. The correct temperature range must be used for each grade of preheated oil. Preheating at too low of a temperature will negatively affect atomization and may cause poor combustion, smoke, and high fuel consumption. Preheating at too high of a temperature can cause the oil to coke in the burner. The oil delivered to the burner must be preheated to the temperature recommended by the burner manufacturer for the grade of fuel used.

4.1.2.2.3 Biodiesel. Biodiesel is a biodegradable, nontoxic, clean-burning fuel that can be made from any fat or vegetable oil, including recycled cooking oil.

4.1.3 Solid Fuels

4.1.3.1 Coal. Coal comes in various grades with a wide range of heating values. Coals are ranked according to their content, in percent by weight, of volatile matter, fixed carbon, ash, and moisture. While coal ranking cannot be totally defined by any one of these items, typically coals with high levels of fixed carbon tend to have higher heating values than those with lower fixed-carbon percentages, and high levels of moisture tend to reduce the heating value.

4.1.3.1.1 Anthracite Coal. Anthracite coal is dense, stonelike in structure, and shiny black in color. Because of its hardness, it can be handled with little breakage. When ignited, it burns freely with a short, relatively smokeless flame and does not coke. It has very little volatile matter and is commonly referred to as hard coal. Semianthracite is not as hard as anthracite and is higher in volatile matter. It is dark gray in color and of granular structure. Semianthracite swells considerably in size when burning, but it does not coke. The heating value of anthracite and semianthracite coals, as received, is 12,000 Btu/lb (29.7 MJ/kg) to 13,000 Btu/lb (30.2 MJ/kg).

4.1.3.1.2 Bituminous Coal. This classification covers a wide range of coals, from the high grades found in the eastern part of the United States to the lower grades found in the western regions. Bituminous coal, commonly called soft coal, is the most extensively used of all coals. The various types of soft coal differ in composition, properties, and burning characteristics. Some are firm in structure and present no handling problem, while others tend to break when handled. Bituminous coal ignites rather easily and burns readily, usually with a long flame. Medium-volatile and high-volatile coals coke in the fire and smoke when improperly burned. The "as received" heating value of bituminous coals varies from approximately 10,500 Btu/lb (24.2 MJ/kg) to 14,500 Btu/lb (33.7 MJ/kg).

4.1.3.1.3 Subbituminous Coal. Subbituminous coal is noncoking and is black in color, similar to bituminous coal. This type of coal is high in volatile matter and ignites easily; it also has a tendency toward spontaneous combustion when drying. Subbituminous coal has a low sulfur content, often less than 1%, and its heating value ranges from 8,300 Btu/lb (19.3 MJ/kg) to 11,500 Btu/lb (26.7 MJ/kg).

4.1.3.1.4 Lignite. Lignite is sometimes referred to as brown coal and is primarily found in the western United States. This type of coal has a relatively low heating value, typically between 4,300 Btu/lb (10.0 MJ/kg) and 8,600 Btu/lb (20 MJ/kg). The heating value depends upon the moisture content, which can reach as high as 66%, and ash content, which can vary from 6% to 19%. The relatively high moisture content makes it susceptible to spontaneous combustion, which can cause problems in storage and transportation. The use of lignite is usually feasible only where other types of coal are not available and large deposits are relatively close to the point of use.

4.1.3.1.5 Pulverized Coal. Pulverized coal is coal that has been crushed and dried. Like liquids and gaseous fuels, it can be transported through pipes. Due to its extremely volatile nature, extreme care should be exercised when handling this fuel. High- and medium-volatile bituminous coals are commonly pulverized, and the degree of fineness is dependent upon the type of coal being pulverized. The density of pulverized coal varies from 35 lb/ft^3 (561 kg/m^3) to 55 lb/ft^3 (881 kg/m^3), and the heating value varies from 11,000 Btu/lb (25.6 MJ/kg) to 12,900 Btu/lb (30 MJ/kg).

4.1.3.2 Wood. Wood has been used for centuries for fuel and continues to be used today where firewood is abundant and transportation costs are relatively low. Wood is typically sold by the cord, which is a wood pile 8 ft × 4 ft × 4 ft. The moisture content of the wood greatly influences the heat content, which can vary from 6,400 Btu/lb (14.9 MJ/kg) to 8,000 Btu/lb (18.6 MJ/kg). Handling costs for both the wood and the ash it produces can make the use of wood for energy generation more costly than the use of other fuels.

4.1.4 Electricity

Although electricity is in itself not a fuel, it is used as a source of heat for heating boilers. The two general methods of application are electrodes and immersed direct-resistance elements. When electrodes are used, the boiler water serves as the heating element by offering resistance to the passage of current between the immersed electrodes. Direct-resistance elements create heat by the resistance offered to the passage of electric current through the immersed element.

4.2 FUEL-BURNING EQUIPMENT

4.2.1 Gas-Burning Equipment

Gas-burning equipment can be an atmospheric or power burner (natural draft or forced-draft) or a combination burner.

4.2.1.1 Atmospheric Burners. Atmospheric burners depend upon natural draft for combustion air. There are several types of atmospheric burners, most of which fall into the general classifications of single- or multiport type.

4.2.1.2 Power Burners. Power burners depend on a blower to supply combustion air and include the following types:

(a) Natural Draft Burners. Natural draft burners operate with a furnace pressure slightly less than atmospheric. The proper draft condition is maintained by either natural draft or an induced-draft fan.

(b) Forced-Draft Burners. Forced-draft burners are designed to operate with a furnace pressure higher than atmospheric. These burners are equipped with sufficient blower capacity to force products of combustion through the boiler without the help of natural or induced draft.

4.2.1.3 Combination Fuel Burners. Combination fuel burners are designed to burn more than one fuel, with either manual or automatic switchover from one fuel to another.

4.2.2 Liquid-Burning Equipment

An oil burner mechanically mixes fuel oil and air for combustion under controlled conditions. Ignition is accomplished by an electric spark, electric resistance wire, gas pilot flame, or oil pilot flame.

4.2.2.1 Pressure-Atomizing Burners (Gun Type). Pressure-atomizing burners (gun type) are divided into two classes: high-pressure and low-pressure mechanical atomization.

(a) The high-pressure mechanical-atomizing type is characterized by an air tube, usually horizontal, with a pressurized oil supply centrally located in the tube and arranged so that a spray of atomized oil is introduced at approximately 100 psig (700 kPa) and mixed in the combustion chamber with the airstream emerging from the air tube. The oil is supplied to the burner by a fuel delivery unit that serves as a pressure-flow-regulating device as well as a pumping device. Where electric ignition is employed, a high-voltage transformer is used to supply approximately 10,000 V to create an ignition arc across a pair of electrodes located above the nozzle. Where gas ignition is employed on a larger burner, a gas pilot is used. The firing rate is governed by the size of the nozzle used. Multiple nozzles are used on some of the larger burners, and variable flow nozzles are used on others. A low-fire start on a modulating burner that employs a variable flow nozzle is accomplished by supplying the oil at a reduced pressure. A low-fire start on a multiple-nozzle burner is accomplished by permitting oil flow to only one or two of the nozzles.

(b) The low-pressure atomizing burner differs from the high-pressure type mainly by having means for supplying a mixture of oil and primary air to the burner nozzle. The air meeting the mixture in the furnace is "secondary air" that provides for complete combustion. The air pressure before mixing and the pressure of the air-oil mixture vary with different makes of burners but are in the low range of 1 psig to 15 psig (7 kPa to 100 kPa) for air and 2 psig to 7 psig (14 kPa to 48 kPa) for the mixture. Capacity of the burners is varied by making pump stroke or orifice changes on the oil pumps.

4.2.2.2 Steam-Atomizing Burners. Steam-atomizing burners use steam to atomize heavy-grade fuel oil. Steam is usually supplied by the boiler being operated.

4.2.2.3 Air-Atomizing Burners. In this type of burner, the compressed air or steam is used as the atomizing medium. An air compressor is usually provided as part of the burner, although the air may be supplied from another source.

4.2.2.4 Horizontal Rotary Cup Burner. The horizontal rotary cup burner uses the principle of centrifugal atomization. The oil is prepared for combustion by centrifugal force, which spins it off a cup rotating at high speed into an airstream, causing the oil to break up into a spray. This type can be used with all grades of fuel oil. Modulated firing can be provided on these burners.

4.2.3 Solid-Fuel-Burning Equipment

Generally, stokers are used when burning coal or wood. Stokers provide a mechanical means for feeding the fuel and supplying combustion air. They are built in several types, the most common of which are underfeed, spreader, and chain grate. Pulverized coal is transported in a manner similar to that used for a liquid and is burned in suspension as it is sprayed into the combustion chamber.

ARTICLE 5
BOILER ROOM FACILITIES AND INSTALLATION

5.1 GENERAL

5.1.1 Scope

This Article covers the recommended procedures for the safe, economical operation and maintenance of automatically fired boilers.

5.1.2 Intention

It is not intended that this Article serve as operating instructions for any specific heating plant. Due to the wide variety of types and makes of equipment used, this Article should be supplemented with equipment manufacturers' instructions concerning maintenance and care and specific written operating instructions for each system.

5.1.3 Installation

Heating boilers should be installed in accordance with the rules and regulations of the local jurisdiction, most of which have adopted nationally recognized standards that must be followed. However, in the absence of local jurisdictional rules, the following national standards and codes may be used for the installation of heating boilers:

ANSI Z21.13/CSA 4.9, Gas-Fired Low Pressure Steam and Hot Water Boilers
Publisher: The American National Standards Institute (ANSI), 25 West 43rd Street, New York, NY 10036 (www.ansi.org)

ASME B31.9, Building Service Piping
ASME CSD-1, Controls and Safety Devices for Automatically Fired Boilers
Publisher: The American Society of Mechanical Engineers (ASME), Two Park Avenue, New York, NY, 10016-5990 (www.asme.org)

NBBI NB-23, National Board Inspection Code (NBIC), Part 1, Installation
Publisher: National Board of Boiler and Pressure Vessel Inspectors (NBBI), 1055 Crupper Avenue, Columbus, OH 43229 (www.nationalboard.org)

NFPA 31, Standard for the Installation of Oil-Burning Equipment
NFPA 54, National Fuel Gas Code
NFPA 85, Boiler and Combustion Systems Hazards Code
Publisher: National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169 (www.nfpa.org)

UL 834, Heating, Water Supply, and Power Boilers — Electric
Publisher: Underwriter Laboratories, Inc. (UL), 333 Pfingsten Road, Northbrook, IL 60062-2096; Order Address: Comm 2000, 151 Eastern Avenue, Bensenville, IL 60106 (www.ul.com)

5.1.4 New Boilers — Acceptance and Examination

5.1.4.1 Examination for Contractual Acceptance. Before any new heating plant (or boiler) is accepted for operation, a final (or acceptance) review should be completed by the owner or their representative, and all items of exception corrected by the installation contractor. The review should confirm that all equipment called for is furnished and installed in accordance with the plans and the Manufacturer's instructions and specifications, and should include a test of all controls by a person familiar with the control system.

5.1.4.2 Operational Examination. Before a boiler is put into operation for the first time, it should be examined as required by law. Subsequent examinations should also be made as required by local law. The insurance company insuring the boiler may be able to provide guidance on the applicable law.

5.2 LIGHTING

The boiler room should be well lit to allow safe operation of all equipment, entry, and exit. Proper lighting will allow the operator to visually examine all instrumentation and safety controls, and to check for any abnormal condition. The boiler room should have an emergency light source in case of power failure.

5.3 VENTILATION AND COMBUSTION AIR

5.3.1 Combustion Air

The boiler room must have an adequate air supply to permit clean, safe combustion to minimize soot formation and maintain a minimum of 19.5% oxygen in the air of the boiler room. The combustion and ventilation air may be supplied by either an unobstructed air opening or power ventilation fans.

5.3.2 Air Openings

Unobstructed air openings should be sized on the basis of 1 in.^{2} (650 mm^2) free area per 2,000 Btu/hr (0.586 kW) maximum fuel input of the combined burners located in the boiler room or as specified by the National Fire Protection Association (NFPA) standards for oil- and gas-burning installation for the particular job conditions. The boiler room air supply openings must be kept clear at all times. The National Board Inspection Code and the Manufacturer's instruction should also be referenced for additional guidance.

5.4 CLEARANCES

Heating boilers should be located so as to provide adequate space for proper operation, maintenance, and examination of equipment and appurtenances. Clearances should be provided in accordance with the Manufacturer's instructions, subject to acceptance by the jurisdiction.

5.5 FIRE PROTECTION

Fire protection apparatus and fire prevention procedures for boiler room areas should conform to the recommendations of NFPA and local jurisdictional requirements.

5.6 ELECTRICAL SUPPLY

5.6.1 Wiring

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

5.6.2 Switches or Circuit Breakers

A manually operated remote heating plant shutdown switch or circuit breaker should be located just outside the boiler room door and marked for easy identification. Consideration should also be given to the type and location of the switch to safeguard against tampering. If the boiler 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 boiler room, there should be a switch located at each door.

5.6.2.1 For oil burners where the fan is on a common shaft with the oil pump, the complete burner and controls should be shut off.

5.6.2.2 For power burners with detached auxiliaries, only the fuel input supply to the boiler need be shut off.

5.7 FUEL SUPPLY

Fuel systems, whether firing gas, oil, coal, or other substances, should be installed in accordance with jurisdictional and environmental requirements, Manufacturer's instructions, and/or industry standards, as applicable.

5.8 CHIMNEY OR VENT

5.8.1 Installation

Chimneys or vents should be installed in accordance with jurisdictional requirements, Manufacturer's recommendations, and/or industry standards, as applicable. All possible draft conditions (based on modulation and quantity of boilers) should be considered when designing/installing the exhaust vent. It is important to locate exhaust vents in such a way that they do not become blocked by snow, ice, or other natural or man-made obstructions. The vent material used must be in compliance with the Manufacturer's instructions.

5.8.2 Handling of Condensate

Condensing boilers are listed as either Category II (negative pressure, condensing) or Category IV (positive pressure, condensing) appliances, and venting material should be listed and labeled to the appropriate UL specification. Follow the boiler Manufacturer's recommendations for provisions for trapping and draining condensate. Care must be taken to ensure that the condensate drain piping is not exposed to temperatures where water/condensate will freeze in the lines. Condensate may require pH neutralization. Consult local authorities for jurisdictional requirements.

5.9 PIPING — WATER AND DRAIN CONNECTIONS

5.9.1 General

Figures 5.9.1-1 through 5.9.1-5 show recommended piping arrangements. Guidance for the design of piping systems may be found in ASME B31.9.

5.9.2 Provisions for Expansion and Contraction

The following provisions should be made for the expansion and contraction of steam and hot water mains connected to boilers:

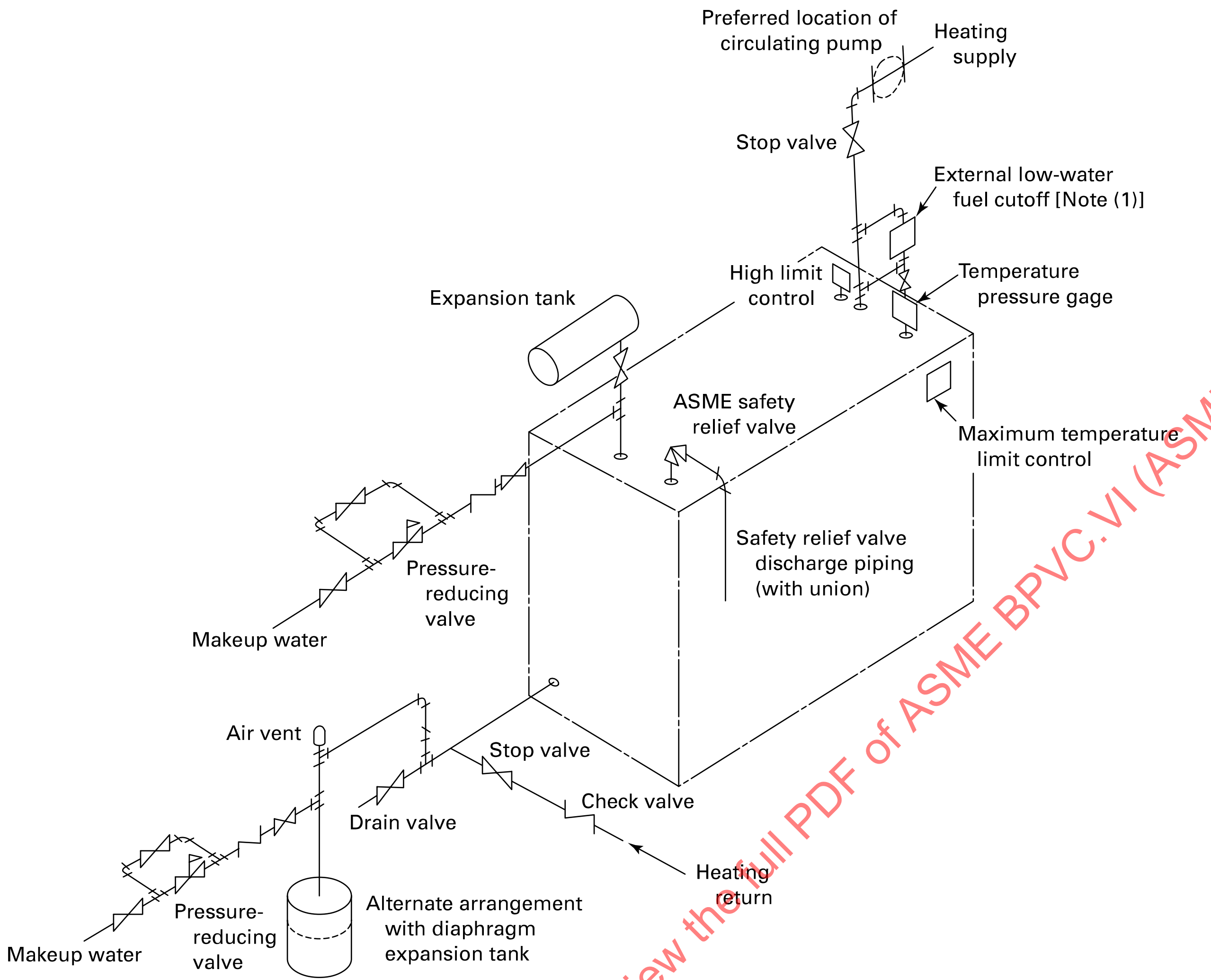
(a) Pipe connections should be substantially anchored at suitable points.

(b) Swing or expansion joints should be used so there will be no undue stress transmitted to the boiler(s).

5.9.3 Steam Boiler Return Pipe Connections

5.9.3.1 The return pipe connections of each boiler supplying a gravity-return steam-heating system shall be so arranged as to form a loop similar to that shown

Figure 5.9.1-1 Single Hot Water Heating Boiler — Acceptable Piping Installation



GENERAL NOTE: Plumbing codes may require the installation of a reduced-pressure principle backflow preventer on a boiler when the makeup water source is from a potable water supply.

NOTE: (1) Recommended control. See 8.5.1. Acceptable shutoff valves or cocks in the connecting piping may be installed for convenience of control testing and/or service.

in Figures 5.9.1-3 and 5.9.1-5 so that the water in each boiler cannot be forced out below the safe water level.

5.9.3.2 For hand-fired boilers with a normal grate line, the recommended pipe sizes detailed as "A" in Figure 5.9.1-3 are as follows:

(a) NPS 1½ (DN 40) for 4 ft^2 (0.4 m^2) or smaller firebox area at the normal grate line

(b) NPS 2½ (DN 65) for areas larger than 4 ft^2 (0.4 m^2) up to 15 ft^2 (1.4 m^2)

(c) NPS 4 (DN 100) for 15 ft^2 (1.4 m^2) or larger

5.9.3.3 For automatically fired boilers that do not have a normal grate line, the recommended pipe sizes detailed as "A" in Figure 5.9.1-3 are

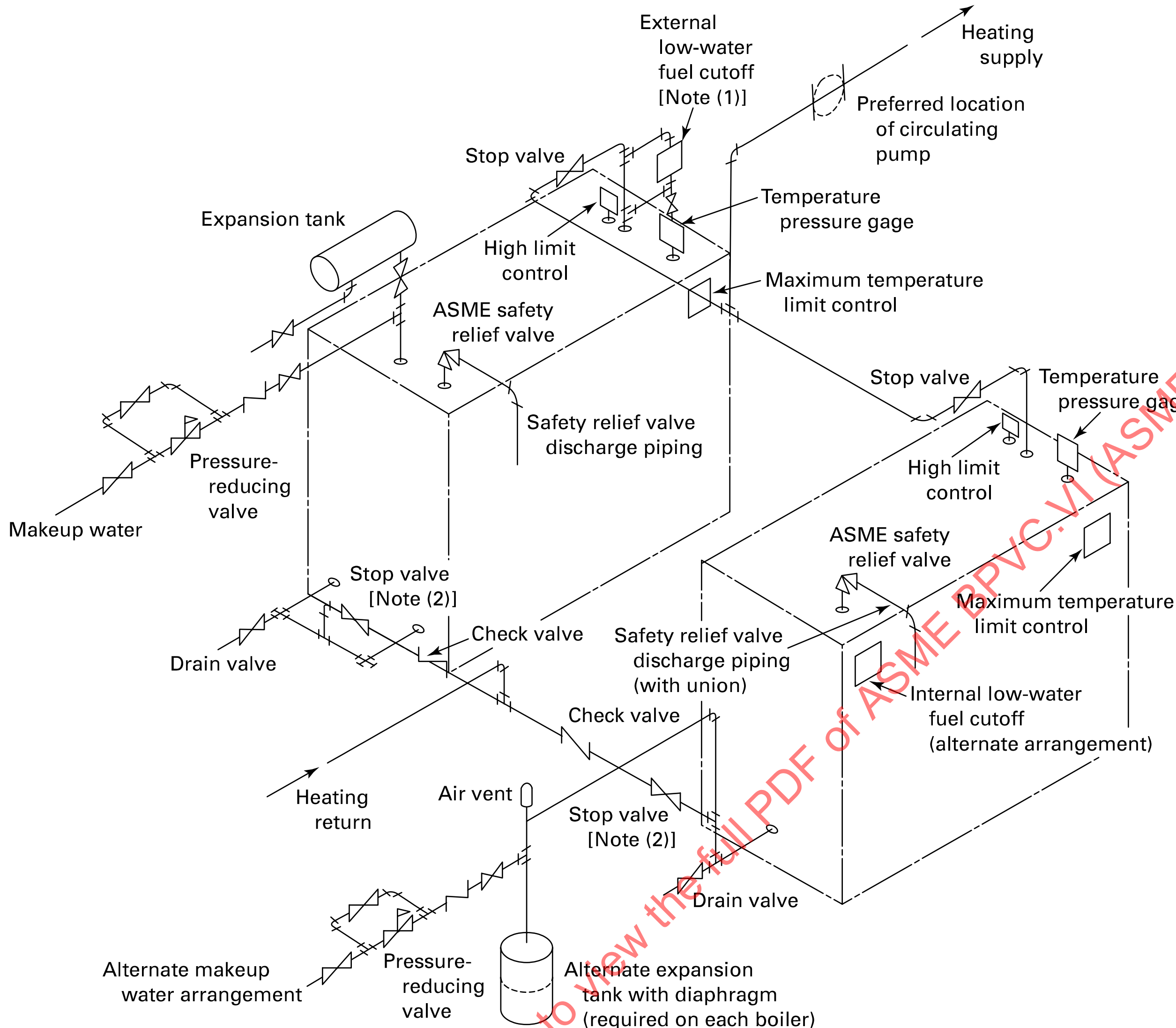
(a) NPS 1½ (DN 40) for boilers with a minimum safety valve relieving capacity of 250 lb/hr (113 kg/h) or less

(b) NPS 2½ (DN 65) for boilers with a minimum safety valve relieving capacity of 251 lb/hr (114 kg/hr) to 2,000 lb/hr (900 kg/h), inclusive

(c) NPS 4 (DN 100) for boilers with a minimum safety valve relieving capacity greater than 2,000 lb/hr (900 kg/h)

5.9.3.4 Provision shall be made for cleaning the interior of the return piping at or close to the boiler. Washout openings may 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.

Figure 5.9.1-2 Hot Water Heating Boilers in Battery — Acceptable Piping Installation



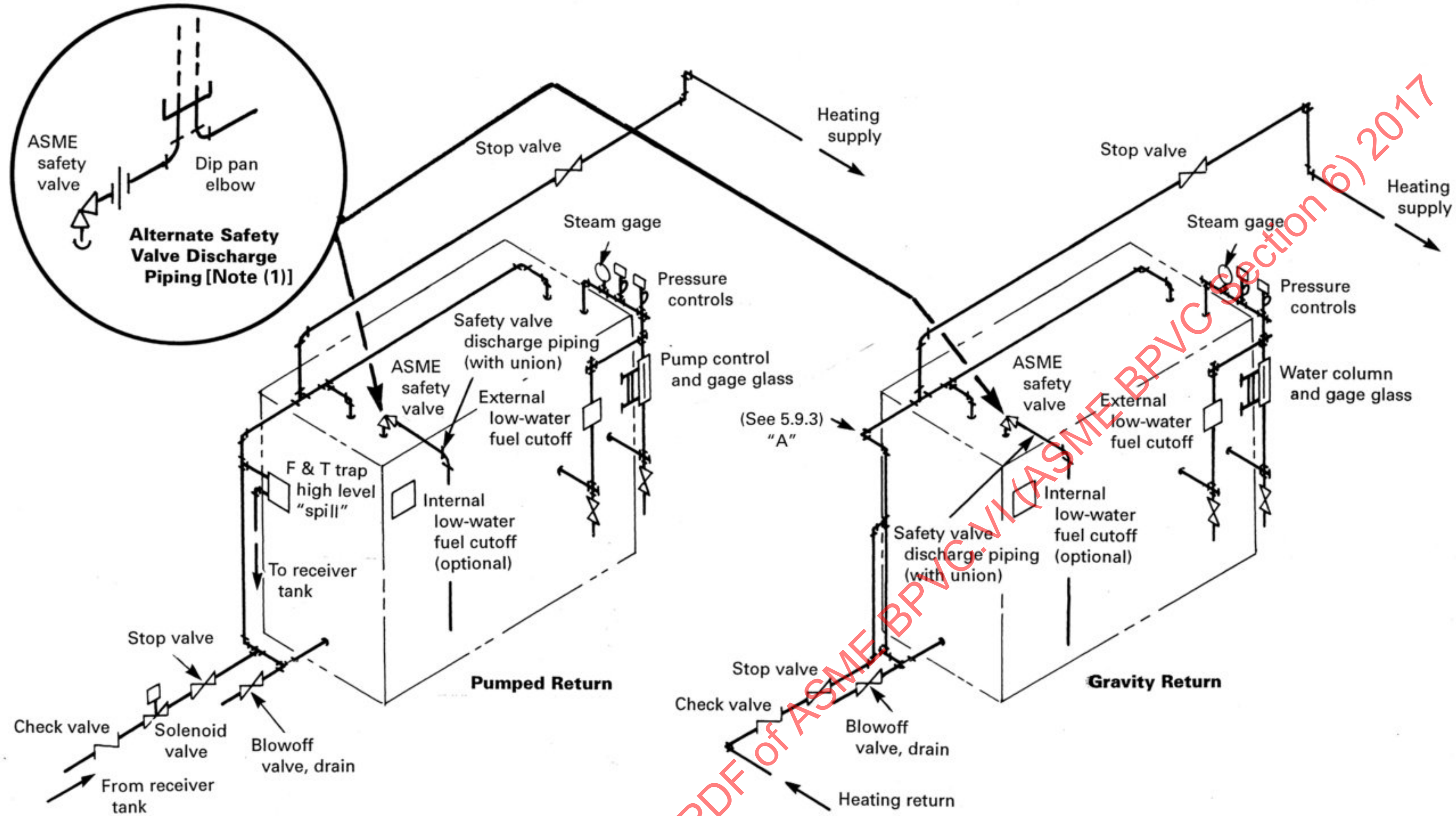
GENERAL NOTE: Plumbing codes may require the installation of a reduced-pressure principle backflow preventer on a boiler when the makeup water source is from a potable water supply.

NOTES:

(1) Recommended control. See 8.5.1. Acceptable shutoff valves or cocks in the connecting piping may be installed for convenience of control testing and/or service.

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

Figure 5.9.1-3 Single Steam Boilers — Acceptable Piping Installation

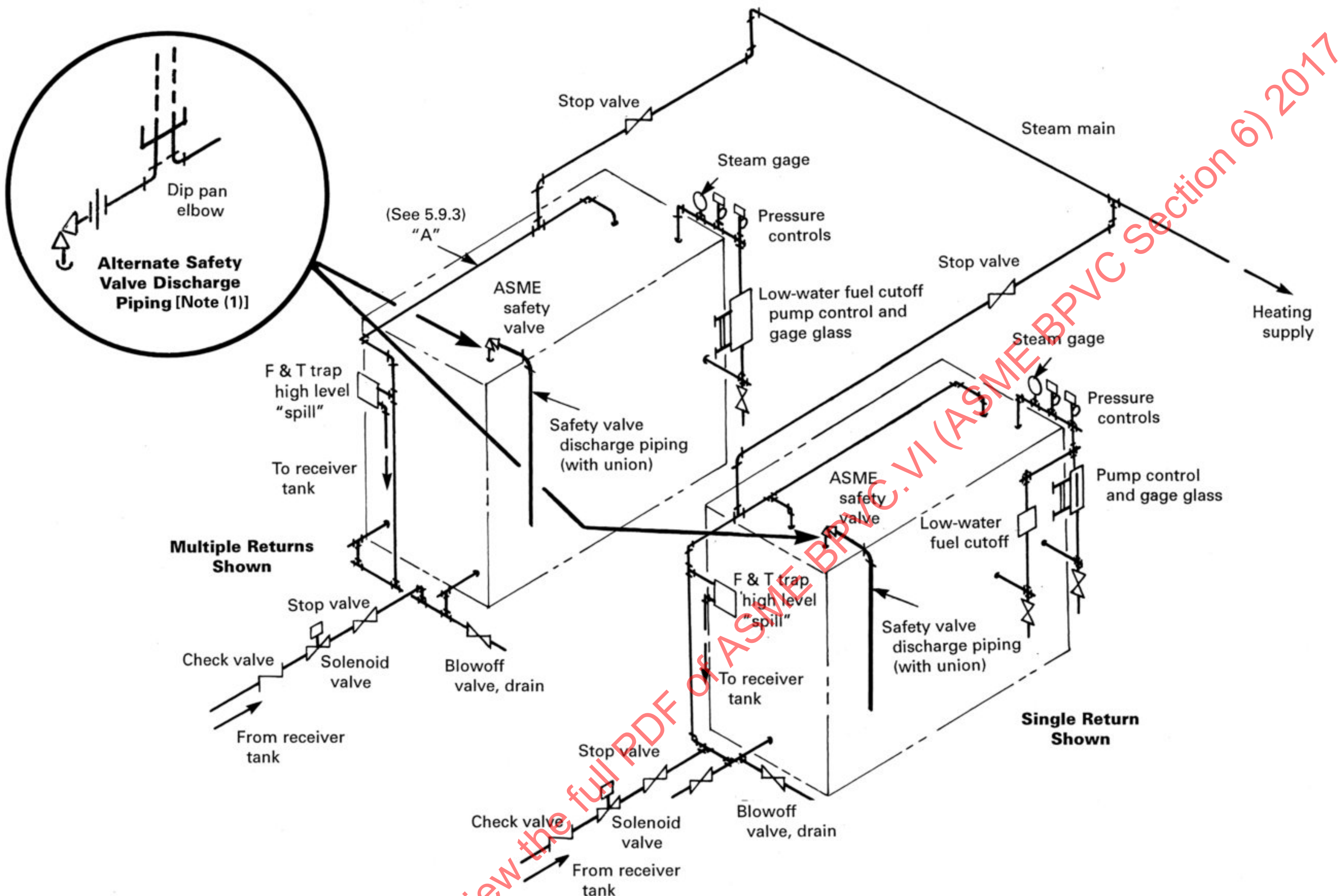


GENERAL NOTES:

(a) Plumbing codes may require the installation of a reduced-pressure principle backflow preventer on a boiler when the makeup water source is from a potable water supply.
(b) Return loop connection was designed to eliminate the necessity of check valves on gravity return systems, but in some localities a check valve is a legal requirement.
(c) When pump discharge piping exceeds 25 ft (7.6 m), install swing check valves at pump discharge.
(d) If pump discharge is looped above normal boiler waterline, install a spring-loaded check valve at return header and at pump discharge.
(e) Where supply pressures are adequate, makeup water may be introduced directly to a boiler through an independent connection.

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

Figure 5.9.1-4 Steam Boilers in Battery — Pumped Return — Acceptable Piping Installation



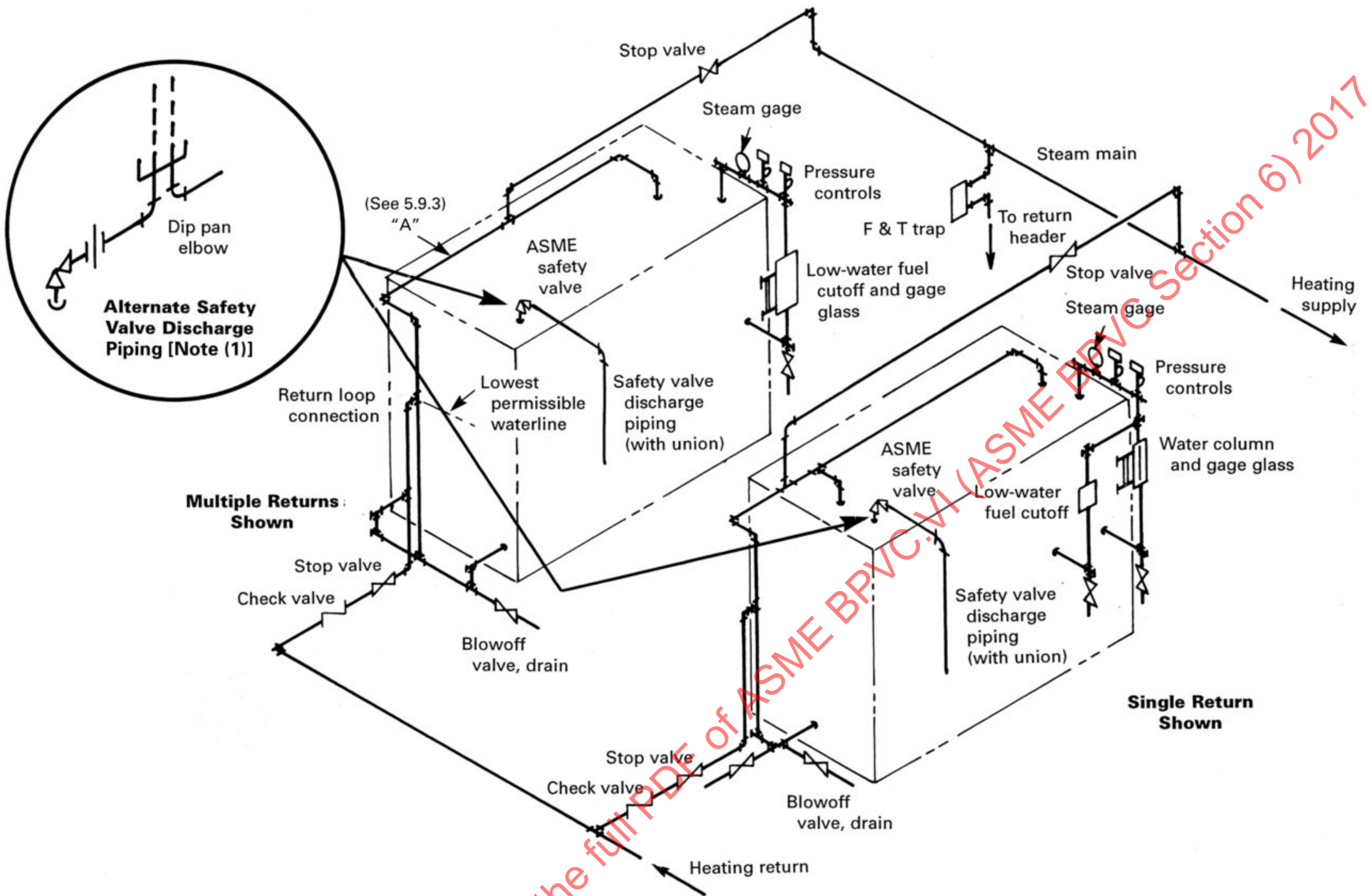
GENERAL NOTES:

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

(b) Plumbing codes may require the installation of a reduced-pressure principle backflow preventer on a boiler when the makeup water source is from a potable water supply.

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

Figure 5.9.1-5 Steam Boilers in Battery — Gravity Return — Acceptable Piping Installation



GENERAL NOTES:

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

(b) Plumbing codes may require the installation of a reduced-pressure principle backflow preventer on a boiler when the makeup water source is from a potable water supply.

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

5.9.4 Feedwater and Makeup Water Connections

5.9.4.1 Water Connections. Proper and convenient water-fill connections should be installed, and provisions should be made to prevent boiler water from backfeeding into the service water supply. Provision should also be made in every boiler room for a convenient water supply that can be used to flush out the boiler and clean the boiler room floor. Water piping should be installed such that the boiler is not supporting the piping. Refer to the Manufacturer's instructions for information regarding required water flow rates and supply pressure so that piping is sized accordingly.

5.9.4.2 Steam Boilers. Feedwater or water treatment shall be introduced into a boiler through the return 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. Feedwater or water treatment shall not be introduced through openings or connections provided for inspection or cleaning of the safety valve, blowoff, water column, water gauge glass, or pressure gauge. The 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 piping system.

5.9.4.3 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 of the safety relief valve, pressure gauge, or temperature gauge. 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 return piping system.

5.9.4.4 Valve Ratings. The minimum pressure rating of all check valves, stop valves, cocks, or backflow preventers with check valve(s) shall be not less than the pressure rating stamped on the boiler, and the temperature rating of such check valves, cocks, or backflow preventers, including all internal components, shall be not less than 250°F (120°C).

5.9.4.5 Backflow Preventer. Some jurisdictions may require installation of a backflow preventer in the feedwater connection.

5.9.5 Bottom Blowoff Valve

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 Table 5.9.5-1. The discharge piping shall be full size to the point of discharge. Boilers having a capacity of 25 gal (91 L) or less are exempt from these requirements, except that they must have a NPS $^3/_4$ (DN 20) minimum drain valve.

5.9.6 Drains

Each steam or hot water boiler may have one or more drain connections piped to a floor drain.

5.9.6.1 Drain Connections. Proper and convenient drain connections should be provided for draining boilers. Unobstructed floor drains, properly located in the boiler room, facilitate proper cleaning of the boiler room. Floor drains that are used infrequently should have water poured into them periodically to prevent the entrance of sewer gases and odors. If there is a possibility of freezing, an antifreeze mixture should be used in the drain traps.

5.9.6.2 Drain Valve. 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. The minimum size of the drain piping shall be NPS $^3/_4$ (DN 20). The discharge piping shall be full size to the point of discharge. When the blowoff connection is located at the lowest water-containing space, a separate drain connection is not required. The minimum pressure rating of valves and cocks used for blowoff or drain purposes shall be not less than the pressure rating stamped on the boiler but in no case shall it be less than 30 psi (200 kPa). The temperature rating of such valves and cocks shall be not less than 250°F (120°C). Many jurisdictions have requirements stipulating the maximum temperature and quality of the water going to the drain, which should be considered when installing the equipment.

5.9.6.3 Condensing Boilers. Follow the boiler Manufacturer's instructions for provisions for trapping and draining condensate. Be aware that the condensate can be acidic and may require neutralization or other special handling. Materials compatible with the condensate must be used. Consult local authorities for jurisdictional requirements.

5.9.7 Stop Valves

5.9.7.1 Installation

(a) For single steam boilers, stop valves shall be installed in the supply pipe and return pipe connections to permit testing the safety valve without pressurizing the system.

Table 5.9.5-1 Size of Bottom Blowoff Piping, Valves, and Cocks

Minimum Required Safety Valve Capacity, lb (kg) of Steam/hr [Note (1)]	Blowoff Piping, Valves, and Cocks Min. Size, NPS (DN)
Up to 500 (226)	3/4 (20)
501 to 1,250 (227 to 567)	1 (25)
1,251 to 2,500 (568 to 1 134)	1 1/4 (32)
2,501 to 6,000 (1 135 to 2 721)	1 1/2 (40)
6,001 (2 722) and larger	2 (50)

NOTE: (1) To determine the discharge capacity of safety relief valves in terms of Btu, the relieving capacity in lb of steam/hr is multiplied by 1,000.

(b) For single hot water heating boilers, stop valves should be located at an accessible point in the supply and return pipe connections, as near the boiler nozzle as is convenient and practical, to permit the draining of the boiler without draining the system and to permit testing of the safety relief valve without pressurizing the system.

(c) For multiple boiler installations, stop valves should be installed in each supply and return of two or more boilers connected to a common system to permit draining of individual boilers without draining the entire system.

5.9.7.2 Valve Specifications

5.9.7.2.1 All valves or cocks may be ferrous or nonferrous.

5.9.7.2.2 The minimum pressure rating of all valves or cocks shall be not less than the pressure rating stamped on the boiler, and the temperature rating of such valves or cocks, including all internal components, shall be not less than 250°F (120°C).

5.9.7.2.3 Valves may be threaded, flanged, or compression type, or have ends suitable for welding or brazing.

5.9.7.2.4 All valves or cocks with stems or spindles shall have adjustable pressure-type packing glands or self-adjusting seals suitable for the intended service.

All plug-type cocks shall be equipped with a guard or gland suitable for the intended service. All 1/4-turn-valve operating mechanisms shall have a tee or lever handle arranged to be parallel to the pipe in which it is located when the cock is open.

5.9.7.2.5 All valves or cocks shall have tight closure when under boiler hydrostatic test pressure.

5.9.8 Modular Boilers

A modular boiler is an assembly of small boilers designed to take the place of a single large boiler. The small boilers are called modules and are intended to be installed as a unit, without any intervening stop valves between the modules, with a single inlet and a single outlet. Modules may be under one jacket or may be individually jacketed. It is important that the Manufacturer's installation instructions be followed to ensure proper assembly, correct control location, and proper flow through each module.

Figures 5.9.8-1 and 5.9.8-2 show the two piping arrangements that are specified by various Manufacturers.

5.9.8.1 Individual Modules

(a) The individual modules shall comply with all the requirements of Section IV, Part HG. The individual modules shall be limited to a maximum input of 400,000 Btu/hr (gas), 3 gal/hr (oil) [11 L/h (oil)], or 117 kW (electricity).

(b) Each module of a modular steam heating boiler shall be equipped with

(1) steam gauge
(2) water gauge glass
(3) operating limit control
(4) low-water cutoff
(5) safety valve
(6) bottom blowoff valve
(7) drain valve

(c) Each module of a hot water heating boiler shall be equipped with

(1) pressure/altitude gauge
(2) thermometer
(3) operating temperature control
(4) safety relief valve
(5) drain valve

5.9.8.2 Assembled Modular Boilers

(a) The individual modules shall be manifolded together at the job site without any intervening valves. The header or manifold piping is field piping and is exempt from Section IV requirements.

(b) The assembled modular steam heating boiler shall also be equipped with

(1) feedwater connection
(2) return pipe connection
(3) safety limit control

(c) The assembled modular hot water heating boiler shall also be equipped with

(1) makeup water connection
(2) provision for thermal expansion
(3) stop valves
(4) high-temperature limit control
(5) low-water fuel cutoff

Figure 5.9.8-1 Modules Connected With Parallel Piping

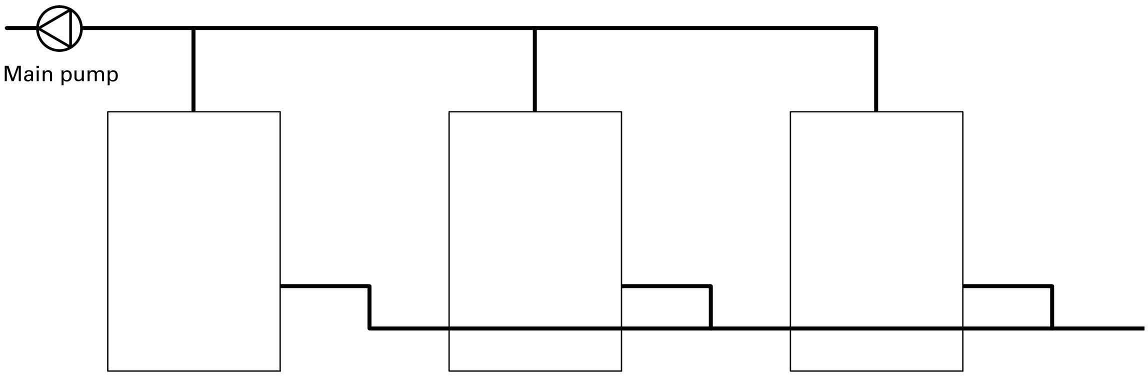
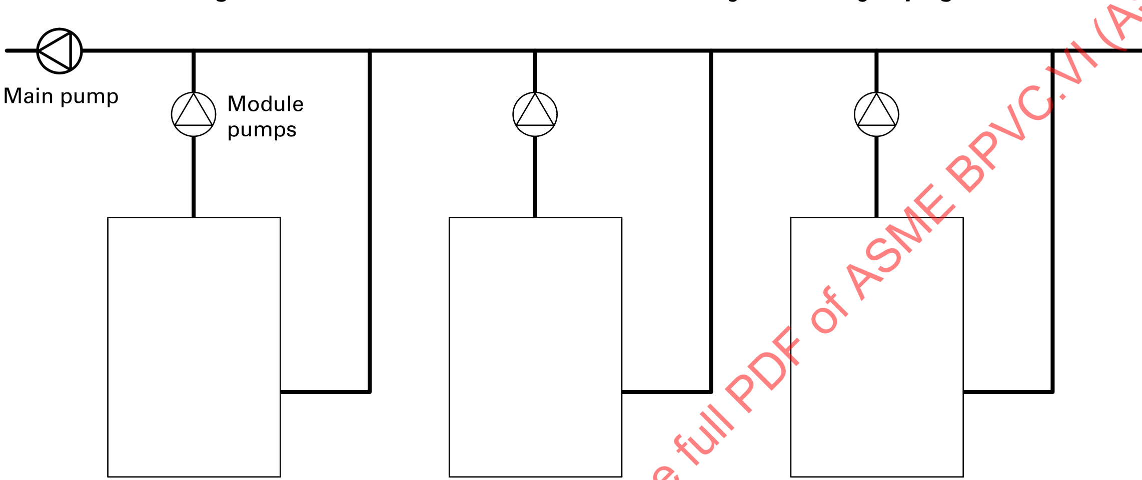


Figure 5.9.8-2 Modules Connected With Primary–Secondary Piping



5.10 SAFETY

Safety is very important to boiler operation and it should be foremost in the minds of those who are assigned to operate and maintain heating systems. Only properly trained and qualified personnel should work on or operate mechanical equipment; adequate supervision should be provided.

5.11 HOUSEKEEPING

Generally, a neat boiler room indicates a well-run plant. The boiler room should be kept free of all material and equipment not necessary to the operation of the heating system. Good housekeeping should be encouraged, and procedures should include routine examinations to maintain the desired level of cleanliness.

5.12 POSTING OF CERTIFICATES AND/OR LICENSES

Some states and municipalities require licensing or certification of personnel who operate or maintain heating equipment. Also, some authorities require posting of inspection certificates in the boiler room. The supervisor in charge of a given installation should ensure such requirements are met.

5.13 RECORD KEEPING, LOGS, ETC.

5.13.1 Drawings, Diagrams, Instruction Books, Etc.

All drawings, wiring diagrams, schematic arrangements, Manufacturers' descriptive literature and spare parts lists, and written operating instructions should be kept permanently in the boiler room or other suitable location so they will be available to those who operate and maintain the boiler. Where space permits, drawings and diagrams should be framed or sealed in plastic and hung adjacent to the related equipment. Other material should be assembled and enclosed in a suitable binder. When changes or additions are made, the data and drawings should be revised accordingly.

5.13.2 Logbook

A permanent logbook should be provided in each boiler room to record maintenance work, inspections, examinations, certain tests, and other pertinent data. Brief details of repairs or other work done on a boiler plant (including time started, time completed, and signature of person in charge) should be recorded. Performance and results of tests, inspections, or other routines required by codes or laws, insurance company inspection reports, and initial acceptance test data should be recorded.

5.13.3 Maintenance Schedules and Records

A suggested chart-type log for scheduling and recording work performed on maintenance, testing, and examination during a 1-yr period is shown in Mandatory Appendix I, Figures I-1-1 and I-1-2. The routine work normally performed on heating boilers is listed. As each portion of the work is completed, the person performing the work should date and initial the log in the appropriate space.

ARTICLE 6
OVERPRESSURE PROTECTION

6.1 PRESSURE RELIEF VALVES

6.1.1 General

Pressure relief valves are used to relieve excessive pressure generated within a boiler. The pressure relief valve (or valves) is the final line of protection against overpressure in the boiler. They discharge a volume of steam and hot water when relieving (see 6.4, Pressure Relief Valve Discharge Piping). This is the single most important safety device on any boiler. These valves shall bear the Certification Mark, as illustrated in Figure 6.1.1-1, with HV or V designator to signify compliance with Section IV, HG-402.

6.1.2 Safety Valves

A safety valve is an automatic pressure-relieving device actuated by the pressure generated within the boiler and characterized by full-opening pop action. It is used for steam service. Valves are of the spring-loaded pop type and are factory set and sealed. See Figure 6.1.2-1.

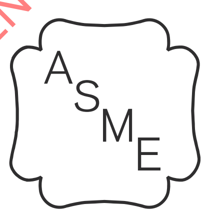
6.1.3 Safety Relief Valves

A safety relief valve is an automatic pressure-relieving device actuated by the pressure generated within the boiler. It is used primarily on water boilers. Valves of this type are spring loaded without full-opening pop action and have a factory-set, nonadjustable pressure setting. See Figure 6.1.3-1.

6.1.4 Temperature and Pressure Safety Relief Valves

A temperature and pressure safety relief valve is a safety relief valve, as described in 6.1.3, that also incorporates a thermal-sensing relief element that is actuated by the upstream water temperature.

Figure 6.1.1-1 Official Certification Mark



6.2 PRESSURE RELIEF VALVE REQUIREMENTS

6.2.1 Safety Valve Requirements for Steam Boilers

6.2.1.1 Each steam boiler shall have one or more officially rated safety valves, identified with the Certification Mark with HV or V designator, of the spring pop type adjusted and sealed to discharge at a pressure not to exceed 15 psi (100 kPa).

6.2.1.2 No safety valve for a steam boiler shall be smaller than NPS $\frac{1}{2}$ (DN 15).

No safety valve shall be larger than NPS 4 (DN 100). The inlet opening shall have an inside diameter equal to or greater than the seat diameter.

6.2.1.3 The minimum relieving capacity of a valve or valves shall be governed by the capacity marking on the boiler called for in Section IV, HG-530.

6.2.1.4 The minimum valve capacity in pounds per hour (kilograms per hour) shall be determined by dividing the maximum output in British thermal units per hour (kilowatts) at the boiler nozzle, obtained by the firing of any fuel for which the unit is installed, by 1,000 (0.646).

6.2.1.5 The safety 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 psi (35 kPa) above the maximum allowable working pressure.

6.2.1.6 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 to be in accordance with 6.2.1.5. The additional valves required, on account of changed conditions, may be installed on the outlet piping, provided there is no intervening valve.

6.2.2 Safety Relief Valve Requirements for Hot Water Boilers

6.2.2.1 Each hot water heating or supply boiler shall have at least one officially rated safety relief valve that is of the automatic reseating type, identified with the Certification Mark with HV or V designator, and set to relieve at or below the maximum allowable working pressure of the boiler.

Figure 6.1.2-1 Safety Valve

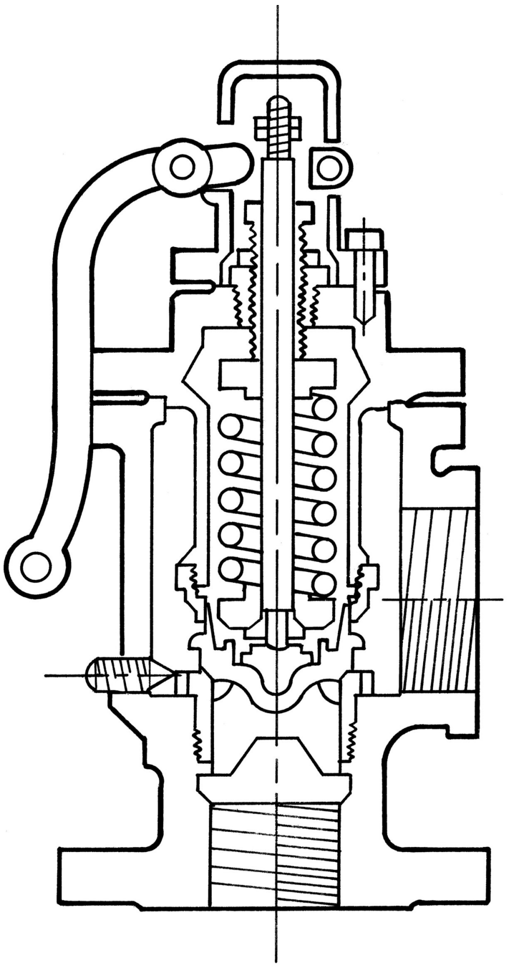
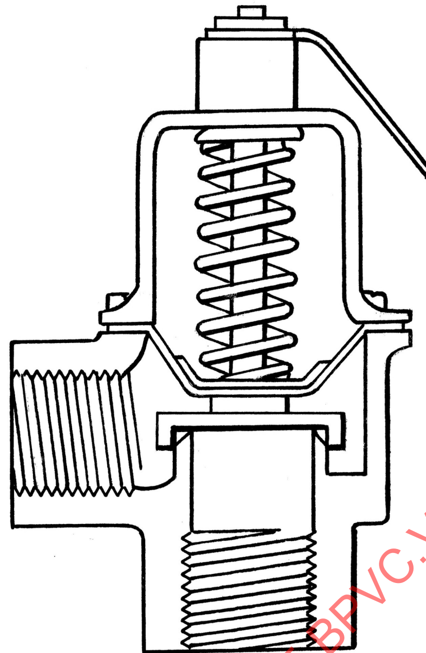


Figure 6.1.3-1 Safety Relief Valve



6.2.2.2 Hot water heating or 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 6.2.2.1, one or more officially rated temperature and pressure safety relief valves that is of the automatic reseating type, identified with the Certification Mark with HV designator, and set to relieve at or below the maximum allowable working pressure of the boiler.

6.2.2.3 When more than one safety relief valve is used on either hot water heating or hot water supply boilers, the additional valves shall be officially rated and may have a set pressure within a range not to exceed 6 psi (40 kPa) above the maximum allowable working pressure of the boiler up to and including 60 psi (400 kPa), and 5% for those boilers having a maximum allowable working pressure exceeding 60 psi (400 kPa).

6.2.2.4 No safety relief valve shall be smaller than NPS $^3/_4$ (DN 20) nor larger than NPS $4^1/_2$ (DN 115) except that boilers having a heat input not greater than 15,000 Btu/hr (4.4 kW) may be equipped with a rated safety relief valve of NPS $^1/_2$ (DN 15).

6.2.2.5 The required relieving capacity in British thermal units per hour of the safety relief valve shall be not less than the maximum allowable input for a water heater or the minimum relieving capacity in pounds per hour (kilograms per hour) on the nameplate of the boiler. If the marking on the safety relief valve is in pounds per hour (kilograms per hour), determine the British thermal units per hour by multiplying by 1,000 (0.646). The relieving capacity for electric water heaters and electric water boilers shall be 3,500 Btu/hr (1.0 kW) per kilowatt of input.

6.3 MOUNTING

6.3.1 General

Pressure relief valves shall be located in the top or side of the boiler. The top or side of the boiler means the highest practicable part of the boiler proper, but in no case shall the safety valve be located on the boiler below the normal operating level, and in no case shall the safety relief valve be located below the lowest permissible water level. Pressure relief valves 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.

6.3.2 Requirements for Common Connections for Two or More Valves

6.3.2.1 When a boiler is fitted with two or more safety valves on one connection, this connection shall have a cross-sectional area not less than the combined areas of inlet connections of all the safety valves with which it connects.

6.3.2.2 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 safety valve or safety relief valve larger than NPS $4\frac{1}{2}$ (DN 115), 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 mounted on a Y-base.

6.3.3 Threaded Connections

A threaded connection may be used for attaching a valve.

6.3.4 Prohibited Mountings

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

6.3.5 Shutoff Valves

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

6.4 PRESSURE RELIEF VALVE DISCHARGE PIPING

6.4.1 Discharge Piping

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 thereinto and shall be as short and straight as possible and so 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 (see Figure 6.4.1-1). When an elbow is placed on a safety or safety relief valve discharge pipe, it shall be located close to the valve outlet downstream of the union.

6.4.2 Piping Arrangement

The discharge from pressure relief valves shall be so arranged as to minimize the 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 (see Figure 6.4.1-1). The size and arrangement of discharge piping shall be independent of other discharge piping and 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.

6.5 TEMPERATURE AND PRESSURE SAFETY RELIEF VALVES

Hot water heating or supply boilers limited to a water temperature of 210°F (99°C) may have one or more officially rated temperature and pressure safety relief valves installed. The requirements of 6.1 through 6.4 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 safety relief valves.

(c) When the temperature and pressure safety relief valve is mounted 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.

6.6 VALVE REPLACEMENT

Safety valves and safety relief valves requiring repairs shall be replaced with a new valve or repaired by the manufacturer.

6.7 TRY-LEVER TEST FOR SAFETY VALVES (STEAM BOILERS)

(a) Prior to Test. As precautionary measures, all personnel concerned with conducting a safety valve test should be briefed on the location of all shutdown controls to be used in the event of an emergency, and there should be at least two people present during the test. Care should be taken to protect those present from escaping steam.

(b) Frequency of Test. A try-lever test of the safety valve should be performed every 30 days that the boiler is in operation or after any period of inactivity.

(c) Procedure

Step 1. With the boiler under a minimum of 5 psi (35 kPa) pressure, lift the try lever on the safety valve to the wide-open position and allow steam to be discharged for 5 sec to 10 sec.

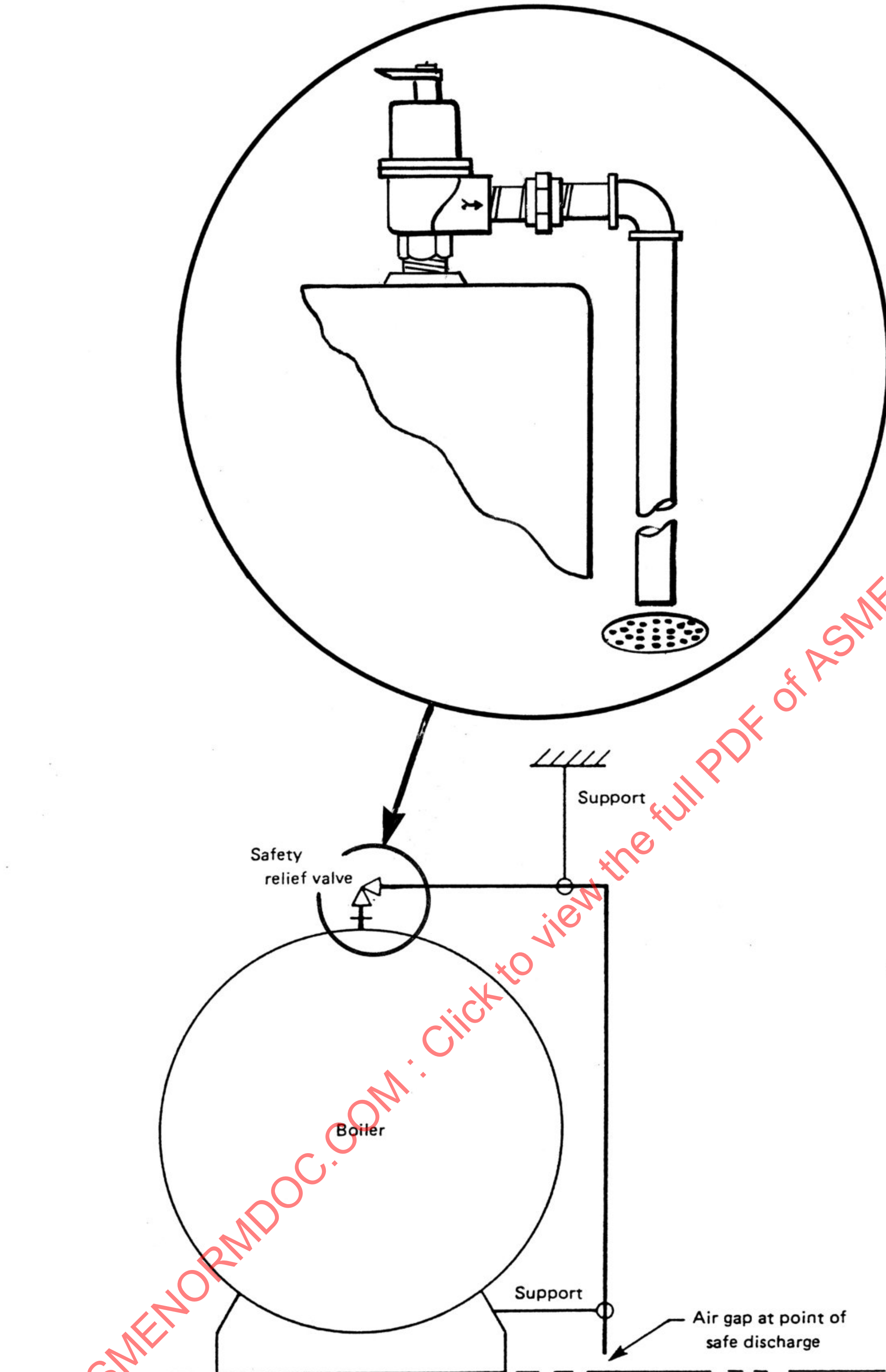
Step 2. Release the try lever and allow the spring to snap the disk to the closed position.

(a) If the valve simmers, operate the try lever two or three times to allow the disk to seat properly.

(b) If the valve continues to simmer, it must be replaced or repaired by an authorized representative of the safety valve manufacturer.

Step 3. Examine the valve for evidence of scale or encrustation within the body. Do not disassemble the valve or attempt to adjust the spring setting.

Figure 6.4.1-1 Safety Relief Valve Discharge Pipe



Step 4. Enter the date of this test into the boiler logbook.

It is advisable to have a chain attached to the try lever of the valve to facilitate this test and allow it to be conducted in a safe manner from the floor.

6.8 TRY-LEVER TEST FOR SAFETY RELIEF VALVES (WATER BOILERS)

(a) Frequency of Test. A try-lever test of the safety relief valve should be conducted every 30 days during the heating season, after any prolonged period of inactivity, and prior to the annual safety relief valve test.

(b) Procedure

Step 1. Check the safety relief valve discharge piping to determine that it is properly installed and supported.

Step 2. Check and log the system operating pressure and temperature.

Step 3. Lift the try lever on the safety relief valve to the full-open position and hold it for at least 5 sec or until clean water is discharged.

Step 4. Release the try lever and allow the spring to snap to the closed position.

(a) If the valve leaks, operate the try lever two or three times to clear the seat of any foreign matter preventing proper seating. As safety relief valves are normally piped to the floor or near a floor drain, it may take some time to determine if the valve has shut completely.

(b) If the safety relief valve continues to leak, it must be replaced before the boiler is returned to operation.

Step 5. Check that system operating pressure and temperature have returned to normal.

Step 6. Check again to ensure the safety relief valve has closed completely and is not leaking.

ARTICLE 7
SYSTEM ACCESSORIES

7.1 STEAM BOILERS

7.1.1 Steam Trap

A steam trap is a device put on steam lines and on the outlet of heating units to permit the exit of air and condensate but to prevent the passage of steam. The types of steam traps in common use are thermostatic, float, combination float and thermostatic, and bucket. See Figures 7.1.1-1 through 7.1.1-4.

7.1.2 Condensate Return Pump Loops

7.1.2.1 Condensate return pumps are used on either one- or two-pipe steam systems to return condensate to the boiler where this cannot be done by gravity. They are generally used in conjunction with a reservoir (condensate return tank) and a float-operated switch for starting the pump motor.

7.1.2.2 Where two boilers are connected together and served from one condensate return pump, a vacuum breaker may be required on the idle boiler to prevent the formation of a vacuum that will affect the functioning of the feed valve.

7.1.2.3 The return pipe connections of each boiler supplying a gravity return of a steam heating system should be so arranged as to form a loop similar to that shown in Figure 7.1.2.3-1 so that the water in each boiler cannot be forced below the safe water level. The loop is required in gravity systems and may be included in pump return systems.

7.1.2.4 Pumped feedwater returns, when connected to a return loop, should be connected directly to the lower boiler connection of the loop because under some circumstances a connection to the return loop near the boiler waterline may cause objectionable noise or water hammer.

7.1.3 Vacuum Return Pump

The vacuum return pump is used in larger steam systems to create a partial vacuum in the return lines of the heating system and thus assist in the return of the condensate, elimination of air, and equal distribution of steam.

7.1.4 Economizer (Steam Boiler)

An economizer is a heat exchanger in which feedwater to be supplied to a boiler or water heater is heated by flue gases exiting the boiler or water heater. When such an economizer is supplied with a Section IV boiler or water heater, it falls within the scope of Section IV rules. The economizer may be constructed in accordance with rules of either Section IV or Section VIII, Division 1.

7.2 HOT WATER BOILERS

7.2.1 Air Eliminators

Air eliminators are sometimes installed on hot water boilers to eliminate air from the system as it is released from the water within the boiler.

Figure 7.1.1-1 Thermostatic Trap

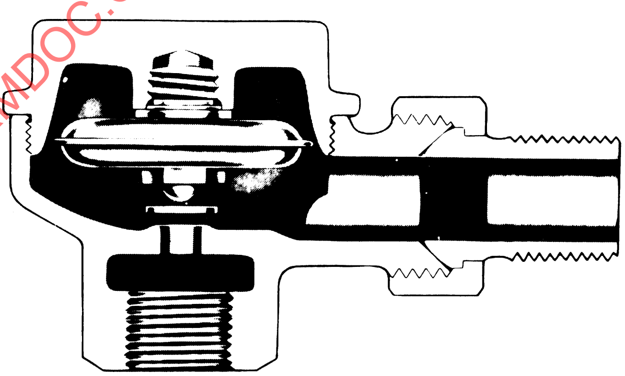


Figure 7.1.1-2 Float Trap

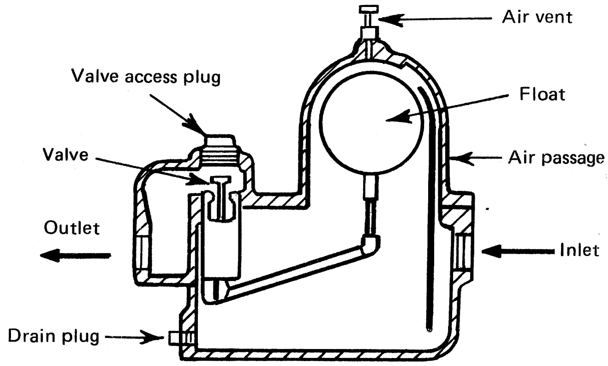
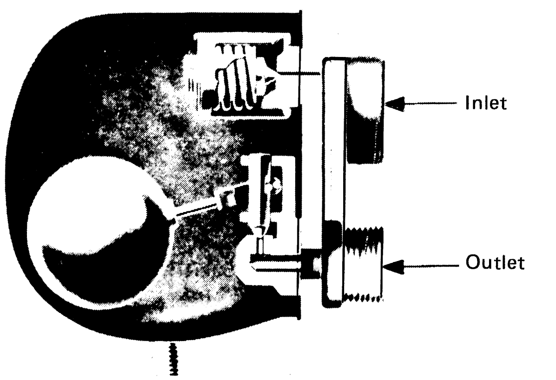


Figure 7.1.1-3 Float and Thermostatic Trap



7.2.2 Circulators (Circulating Pumps)

Circulators are basically centrifugal pump units used on hot water heating systems to force the flow of water through the system.

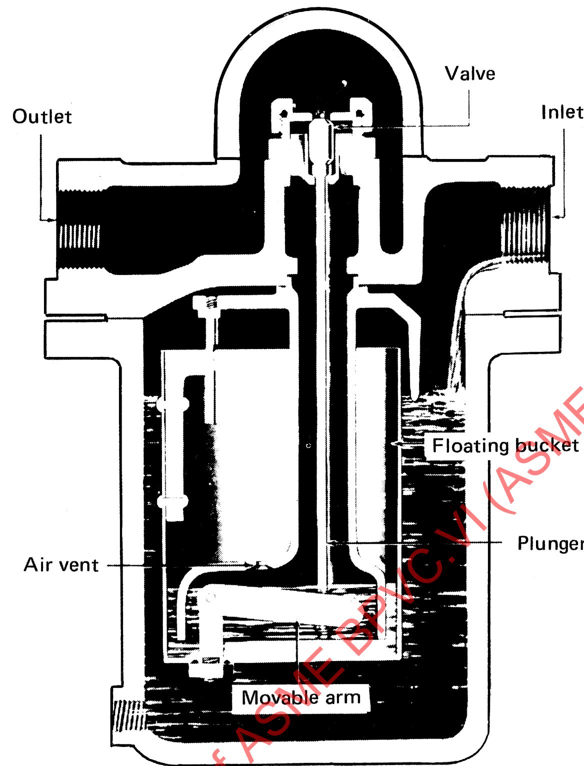
7.2.3 Economizer (Hot Water Boiler)

An economizer is a heat exchanger in which return water to be supplied to a boiler or water heater is heated by flue gases exiting the boiler or water heater. When such an economizer is supplied with an ASME Section IV boiler or water heater, it falls within the scope of Section IV rules. The economizer may be constructed in accordance with the rules of either Section IV or Section VIII, Division 1.

7.2.4 Expansion Tank

Expansion tanks are used on hot water systems to allow for the expansion of the water when it is heated. A gas cushion in the tank allows for the expansion or contraction of the water as it is heated or cooled. All hot water heating systems incorporating hot water tanks or fluid relief columns shall be so installed as to prevent freezing.

Figure 7.1.1-4 Bucket Trap With Trap Closed



7.2.4.1 Systems With Open Expansion Tank. If the system is equipped with an 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 should be carried within the building to a suitable plumbing fixture or the basement.

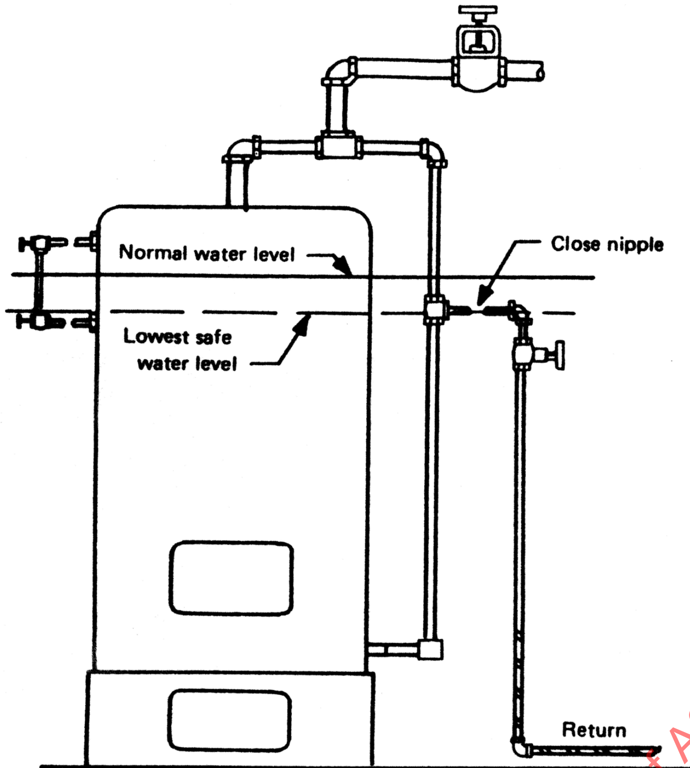
7.2.4.2 Closed-Type Systems. If the system is of the closed type, an airtight tank or other suitable gas cushion shall be installed that will be consistent with the volume and capacity of the system, and it shall be suitably designed for a hydrostatic test pressure of $2^1/_2$ times the allowable working pressure of the system. Expansion tanks for systems designed to operate above 30 psi (200 kPa) shall be constructed in accordance with Section VIII, Division 1. Provisions shall be made for draining the tank without emptying the system, except for pre-pressurized tanks.

7.2.4.3 Minimum Capacity of Closed-Type Tank. The minimum capacity of the closed-type expansion tank may be determined from the following equation:

(U.S. Customary Units)

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

Figure 7.1.2.3-1 Typical Return Loop



(SI Units)

$$V_t = \frac{(0.000738T - 0.03348)V_s}{(P_a/P_f) - (P_a/P_o)}$$

where

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

7.2.5 Storage Tanks for Hot Water Supply Systems

If a system is to utilize a storage tank that exceeds a nominal water-containing capacity of 120 gal (454 L), the tank shall be constructed in accordance with the rules of Section IV, Part HLW; Section VIII, Division 1; or Section X. For tanks constructed to Section X, the maximum allowable temperature marked on the tank shall equal or exceed the maximum water temperature marked on the boiler.

ARTICLE 8
CONTROLS AND INSTRUMENTATION

8.1 LOW-WATER FUEL CUTOFFS AND WATER FEEDERS

Low-water fuel cutoffs are designed to provide protection against hazardous low-water conditions in heating boilers. Records indicate that many boiler failures result from low-water conditions. Low-water fuel cutoffs may be divided into two general types, float and probe.

8.1.1 Float-Type Low-Water Fuel Cutoffs

Float-type low-water fuel cutoffs may be in combination with a water feeder or constructed as a separate unit. The combination feeder–cutoff units are generally used on steam boilers while the cutoff units are sometimes installed as the sole cutoff on hot water boilers or as a second cutoff on steam boilers. A feeder–cutoff combination adds water as needed to maintain a minimum water level and stops the firing device if the water level falls to the lowest permissible level. Both operations are accomplished by the movement of the float that is linked to the water valve or pump control and burner cutoff switch. The units that serve as fuel cutoffs only are basically the same as the combination unit but without the water feeder valve (see Figure 8.1.1-1). A water feeder installation normally acts as an operating device to maintain a predetermined safe water level in the boiler.

8.1.2 Electric-Probe-Type Low-Water Fuel Cutoffs

Electric-probe-type low-water fuel cutoffs may be contained in a water column mounted externally on the boiler or may be mounted on the boiler shell. Some consist of two electrodes (probes) that under normal conditions are immersed in the boiler water with a small current being conducted from one electrode to the other to energize a relay. Others use one probe, and the boiler shell, in effect, becomes the other probe. If the water level drops sufficiently to uncover the probes, the current flow stops and the relay operates to shut off the burner. See Figure 8.1.2-1.

Figure 8.1.1-1 Float-Type Low-Water Cutoff

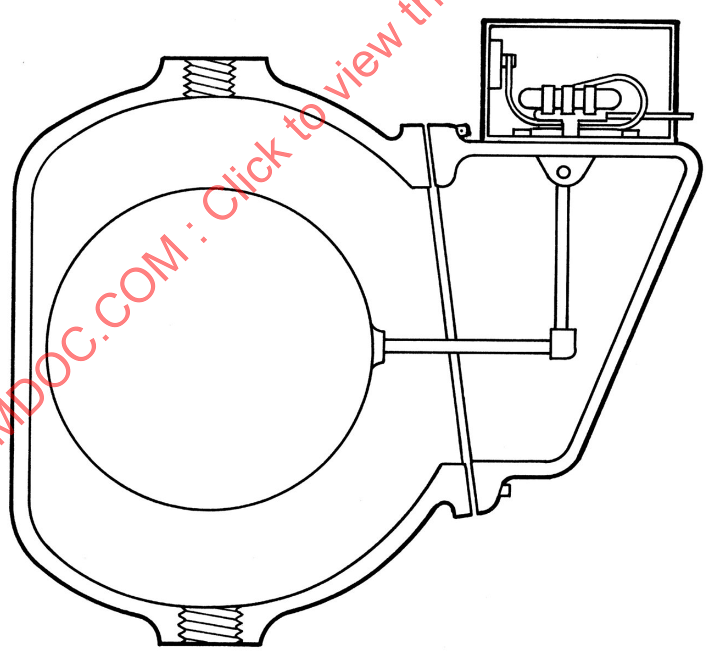
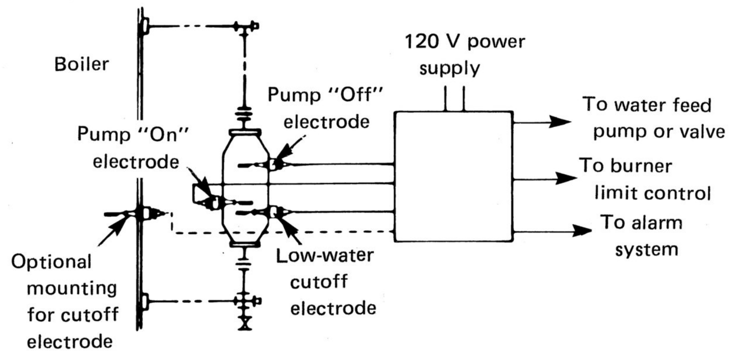
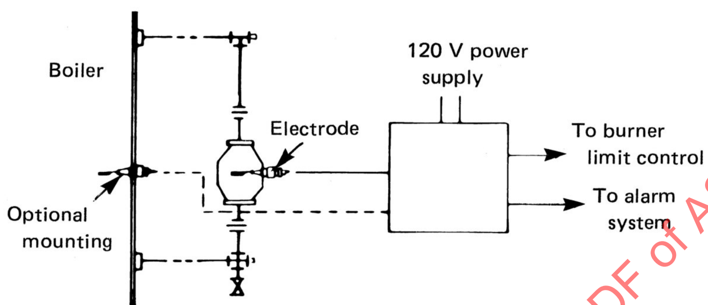


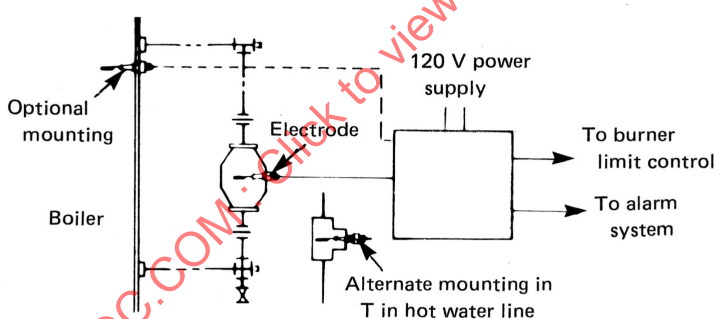
Figure 8.1.2-1 Probe-Type Low-Water Cutoff



Automatic Boiler Water Feed and Low-Water Cutoff — For Steam



Low-Water Cutoff — For Steam



Low-Water Cutoff — For Hot Water

8.2 PRESSURE GAUGE

8.2.1 General

Each steam boiler shall have a steam gauge or a compound steam gauge connected to its steam space, water column, or steam connection. Each hot water heating or hot water supply boiler should have a pressure gauge connected to it or to its flow connection in such a manner that the point of connection cannot be shut off from the boiler.

8.2.2 Mounting

On a steam boiler, a siphon tube (pigtail) is required to protect the gauge from steam. A cock should be provided, placed on the pipe near the gauge, to facilitate servicing of the gauge. Piping or tubing for pressure gauge connections shall be of nonferrous metal when smaller than NPS 1 (DN 25). The handle of the cock shall be parallel to the pipe in which it is located when the cock is open.

8.2.3 Types of Pressure Gauges

Pressure gauges may be either mechanical or electronic.

(a) Mechanical Gauges (Analog). The scale on a water boiler pressure gauge should be graduated to not less than $1\frac{1}{2}$ times nor more than $3\frac{1}{2}$ times the pressure at which the safety relief valve is set. The scale on the dial of a steam boiler pressure gauge should be graduated to not less than 30 psi (200 kPa) nor more than 60 psi (414 kPa).

(b) Electronic Gauges. Electronic gauges should

(1) be powered from the boiler power supply, have a backup power supply, and have a display that remains on at all times

(2) have a full-scale range of $1\frac{1}{2}$ times the safety relief valve pressure setting

(3) be accurate to within ±2% of full scale

(4) have a transducer compatible with both liquids and gases and be temperature compensated

(5) have an operating temperature range of 32°F to 250°F (0°C to 120°C) unless otherwise required by the application

8.2.4 Calibration

The gauge used on a boiler should be calibrated at least once per year. This can be accomplished by comparing it to a master-calibrated gauge or using a deadweight tester. If the gauge is damaged or cannot be calibrated to provide consistent readings, it should be discarded and replaced with a new gauge.

8.3 CONTROLS

8.3.1 General

Automatically fired boilers may be equipped with operating, limit, safety, and programming controls that may be electrically or pneumatically operated. The functions of these controls are described in 8.3.4 through 8.3.7.

8.3.2 Spare Parts

Spare parts for controls, including electronic components that require time for procurement, should be maintained in stock supply.

8.3.3 Power for Electrically Operated Controls

All controls should be powered with a potential of 150 V or lower with one side grounded. A separate equipment ground conductor should be brought to the control panel frame with ground continuity ensured to the fuel valve. All operating coils of control devices should be connected to the neutral side of the control circuit, and all control limit switches or contacts should be in the ungrounded (hot) side of the control circuit. If an isolating transformer is used, it should be bonded to the control panel frame. The equipment ground is not required when the isolating transformer is used. Do not fuse control transformers above their rated current value because these devices are current limiting and an oversize fuse may not blow under short-circuit conditions.

8.3.4 Operating Controls

The operating controls shall

(a) start, stop, and modulate the burner (if desired) in response to the system's demand, keeping steam pressure or hot water temperature at or below the limit control setting

(b) maintain proper water level in steam boilers

(c) maintain proper water pressure in hot water heating boilers

8.3.5 Limit Controls

The limit controls shall stop the burner

(a) when the steam pressure exceeds 15 psi (100 kPa) for steam boilers

(b) when the water temperature exceeds 250°F (120°C) for hot water boilers

(c) when the water level drops below the minimum permissible level

(d) when required in the event of unusual conditions such as

(1) high stack temperature

(2) high or low gas-fuel pressure

(3) high or low fuel-oil temperature

8.3.6 Safety Controls

The safety controls shall

(a) stop fuel flow in case of ignition failure

(b) stop fuel flow in case of main flame interruption

(c) stop fuel flow in case of mechanical draft failure

(d) stop fuel flow in case of circuit failure

(e) stop fuel flow and cause lockout in case of high or low gas pressure, when the boiler is so equipped

8.3.7 Programming Controls

Programming controls, when used, provide proper sequencing of the operating, limit, and safety controls to ensure that all conditions necessary for proper burner operation are satisfied. Included in a programmed control are prepurge and postpurge cycles to remove accumulated gases.

8.4 STEAM HEATING BOILERS

8.4.1 Low-Water Fuel Cutoffs

8.4.1.1 Requirements for the type and number of low-water fuel cutoffs are dictated by local codes, NBIC, ASME CSD-1, and/or NFPA 85, depending on the input and boiler design. Each automatically fired steam- or vapor-system boiler is equipped with at least one automatic low-water fuel cutoff that automatically cuts off the fuel supply before the surface of the water falls to the lowest visible part of the water gauge glass. If the 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.

8.4.1.2 A low-water 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 Ys not less than NPS $^1/_2$ (DN 15) between the boiler and the 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.

8.4.1.3 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.

8.4.1.4 ASME CSD-1 requires two low-water cutoffs on steam boilers. Refer to ASME CSD-1 for applicable requirements.

8.4.2 Steam Gauges

8.4.2.1 Each steam boiler shall have a steam gauge or a compound steam gauge connected to its steam space, water column, or steam connection. The gauge or piping to the gauge shall contain a siphon or equivalent device that will develop and maintain a water seal that will prevent steam from entering the gauge tube. The piping shall be so arranged that the gauge cannot be shut off from the boiler except by a cock placed in the pipe at the gauge 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. The gauge connection boiler tapping, external siphon, or piping to the boiler shall be not less than NPS $^1/_4$ (DN 8). Where steel or wrought iron pipe or tubing is used, the boiler connection and external siphon shall be not less than NPS $^1/_2$ (DN 15). Ferrous and nonferrous tubing having inside diameters at least equal to that of nominal pipe sizes listed above may be substituted for pipe.

8.4.2.2 The scale on the dial of the steam boiler gauge shall be graduated to not less than 30 psi (200 kPa) nor more than 60 psi (400 kPa). The travel of the pointer from 0 psi to 30 psi (0 kPa to 200 kPa) pressure shall be at least 3 in. (75 mm).

8.4.3 Water Gauge Glasses

8.4.3.1 Each steam boiler shall have one or more water gauge 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 $^1/_4$ in. (6 mm) in diameter to facilitate cleaning. Gauge glass replacement shall be possible with the boiler 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) may be equipped with a water-level indicator of the glass bull's-eye type, provided the indicator is of sufficient size to show the water at both normal operating and low-water cutoff levels.

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

8.4.3.3 The lowest visible part of the water gauge 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.

8.4.3.4 In electric boilers of the submerged electrode type, the water gauge glass shall be so located to indicate the water levels both at startup and under maximum steam load conditions as established by the Manufacturer.

8.4.3.5 In electric boilers of the resistance heating element type, the lowest visible part of the water gauge glass shall not be below the top of the electric resistance heating element. Each boiler of this type shall also be equipped with an automatic low-water electrical power cutoff so located as to automatically cut off the power supply to the heating elements before the surface of the water falls below the top of the electrical resistance heating elements.

8.4.3.6 A water-level indicator using an indirect sensing method may be used in lieu of an operating water gauge glass; however, a water gauge glass must be installed and operable but may be shut off by valving. The water-level indicator may be attached to a water column or directly to the boiler by means of valved fittings not less than NPS $\frac{1}{2}$ (DN 15). The device shall be provided with a drain valve of a type having an unrestricted drain opening not less than $\frac{1}{4}$ in. (6 mm) in diameter to facilitate cleaning.

8.4.4 Water Column and Water-Level-Control Pipes

8.4.4.1 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 gauges, or apparatus that does not permit the escape of any steam or water except for manually operated blowdowns, shall be attached to the water column or the pipe connecting a water column to a boiler. If the water column, gauge 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 turn to facilitate cleaning. The water column drain pipe and valve shall be not less than NPS $\frac{3}{4}$ (DN 20).

8.4.4.2 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 centerline of the shell. For a cast iron boiler, the steam connection to the water column shall be taken from the top end of the steam header, and the water connection shall be made on an end section not less than 6 in. (150 mm) below the bottom connection to the water gauge glass.

8.4.5 Pressure Controls

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

8.4.5.2 Each automatically fired steam boiler or assembled modular steam boiler shall have a safety limit control that will cut off the fuel supply to prevent steam pressure from exceeding the 15-psi (100-kPa) maximum allowable working pressure of the boiler. Each control shall be constructed to prevent a pressure setting above 15 psi (100 kPa).

8.4.5.3 Each individual steam boiler shall have a control that will cut off the fuel supply when the pressure reaches an operating limit, which shall be less than the maximum allowable pressure.

8.4.5.4 Shutoff valves of any type shall not be placed in the steam pressure connection between the boiler and the controls described in 8.4.5.1 through 8.4.5.3. These controls shall be protected with a siphon or equivalent means of maintaining a water seal that will prevent steam from entering the control.

8.4.5.5 ASME CSD-1 requires that operation of the pressure control described in 8.4.5 shall cause a safety shutdown requiring a manual reset.

8.5 HOT WATER HEATING BOILERS

8.5.1 Low-Water Fuel Cutoff (Hot Water)

8.5.1.1 Each automatically fired hot water heating boiler with heat input greater than 400,000 Btu/hr (117 kW) shall have an automatic low-water fuel cutoff that has been 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 8.5.1.2.

8.5.1.2 As there is no normal waterline to be maintained in a hot water heating boiler, any location of the low-water fuel cutoff above the lowest safe permissible water level established by the boiler Manufacturer is satisfactory.

8.5.1.3 A coil-type boiler or a watertube boiler with heat input greater than 400,000 Btu/hr (117 kW) requiring forced circulation to prevent overheating of the coils or tubes shall have a flow-sensing device installed in the outlet piping in lieu of the low-water fuel cutoff required in 8.5.1.1 to automatically cut off the fuel supply when the circulating flow is interrupted.

8.5.1.4 A means should be provided for testing the operation of the external low-water fuel cutoff without resorting to draining the entire system. Such means should not render the device inoperable except as described 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 level handle arranged to be parallel to the pipe in which it is located when the cock is open.

8.5.1.5 ASME CSD-1 requires that operation of the low-water cutoff on a hot water boiler shall cause a safety shutdown requiring manual reset.

8.5.2 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.

(a) The thermometer shall have a minimum reading of 70°F (20°C) or less.

(b) The thermometer shall have a maximum reading at least equal to 320°F (160°C) but not more than 400°F (205°C).

(c) An electronic temperature sensor used in lieu of a thermometer shall meet the following requirements:

(1) The sensor shall be powered from the boiler power supply, and it shall have a display that remains on at all times. The sensor shall have a backup power supply.

(2) The full scale of the sensor and display must be a minimum of 70°F to 320°F (20°C to 160°C). It shall be accurate within ±1°.

(3) The sensor shall have a minimum operating temperature range of 32°F to 300°F (0°C to 150°C).

(4) The display shall have an ambient operating temperature range of 32°F to 120°F (0°C to 50°C) unless otherwise required by the application.

8.5.3 Pressure or Altitude Gauges

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

8.5.4 Temperature Controls

Each automatically fired hot water heating or hot water supply boiler shall be protected from overtemperature by two temperature-operated controls. The space thermostat used for comfort control is not considered one of the required temperature-operated controls.

8.5.4.1 Each individually automatically fired hot water heating or hot water supply boiler shall have a high-temperature limit control that will cut off the fuel supply at or below the marked maximum water temperature at the boiler outlet. This control shall be constructed to prevent a temperature setting above the maximum.

8.5.4.2 Each individual hot water heating or hot water supply boiler shall have a control that will cut off the fuel supply when the system water temperature reaches a preset operating limit that shall be less than the maximum water temperature.

8.5.4.3 ASME CSD-1 requires that the operation of the temperature control described in 8.5.4.1 and 8.5.4.2 shall cause a safety shutdown requiring manual reset.

8.5.5 Differential Temperature Controls

Some forced circulation water boilers incorporate differential temperature controls to help protect the boiler from damage caused by inadequate water flow while the boiler is firing. Differential temperature controls are typically operated by the boiler's primary safety control, which receives information from temperature sensors on the inlet and outlet water connections of the boilers. The controls compare the difference in the inlet and outlet water temperature when the burner is firing. If the temperature rise or rate of rise is too large, indicating potential overheating of the boiler heat exchanger, the controls will either reduce the heat input rate or shut off the burner to protect the heat exchanger.

8.5.6 Air for Pneumatically Operated Controls

Determine that compressed air for pneumatically operated controls is clean, dry, and available at adequate pressure.

ARTICLE 9
OPERATION AND MAINTENANCE OF STEAM BOILERS

9.1 STARTING A NEW BOILER AND HEATING SYSTEM

A new boiler should be cleaned and filled as detailed in 9.1.1 through 9.1.5.

9.1.1 Examination for Foreign Objects

Prior to starting a new boiler, an examination should be made to ensure that no foreign matter, such as tools, equipment, and rags, has been left in the boiler.

9.1.2 Checks Before Filling

Before putting water into a new boiler, make certain that the firing equipment is in operating condition to the extent that this is possible without actually lighting a fire in the empty boiler. This is necessary because raw water must be boiled [or heated to at least 180°F (82°C)] promptly after it is introduced into the boiler in order to drive off the dissolved gases that might otherwise corrode the boiler.

9.1.3 Operation to Clean the System

Fill the boiler to the proper waterline and operate the boiler with steam in the entire system for a few days to bring the oil and dirt back from the system to the boiler. This is not necessary if the condensate is to be temporarily wasted to the sewer, in which case the system should be operated until the condensate runs clear.

9.1.4 Boiling Out

The oils and greases that accumulate in a new boiler can usually be washed out by boiling. A qualified chemical water treatment specialist should be consulted for instructions regarding appropriate chemical compounds and concentrations that are compatible with local environmental regulations governing disposal of the boil-out solutions.

Proceed as follows:

Step 1. Fill the boiler to the normal waterline.

Step 2. Remove the plug from the tapping on the highest point on the boiler. If no other opening is available, the safety valve(s) may be removed, in which case the valve must be handled with extreme care to avoid damaging it.

Step 3. Add an appropriate boil-out compound through the prepared opening.

Step 4. Replace the plug or the safety valve(s).

Step 5. Start the firing equipment and check operating, limit, and safety controls. Review Manufacturer's recommendations for boiler and burner startup.

Step 6. Boil the water for at least 5 hr.

Step 7. Stop the firing equipment.

Step 8. Drain the boiler in a manner and to a location that allow the hot water to be discharged safely.

Step 9. Wash the boiler thoroughly using a high-pressure water stream.

Step 10. Fill the boiler to the normal waterline.

Step 11. Add boiler water treatment compound as needed.

Step 12. Promptly boil the water or heat it to at least 180°F (82°C).

The boiler is now ready to be put into service or on standby.

9.1.5 Second Boil-Out for Stubborn Cases

In stubborn cases, the simple boil-out described in 9.1.4 may not remove all the oil and grease and another boil-out using a surface blowoff may be necessary. For this type of cleaning, proceed as follows:

Step 1. Prepare the boiler for cleaning by running a temporary pipeline from the surface blowoff connection to an open drain or some other location where hot water may be discharged safely. If no such tapping is available, use the safety valve tapping, but run the pipe full size and as short a length as possible. Do not install a valve or any other obstruction in this line. Handle the safety valve carefully and protect it against damage while it is out of the boiler.

Step 2. Fill the boiler until water reaches the top of the water gauge glass.

Step 3. Add a boil-out compound.

Step 4. Start the firing equipment and operate sufficiently to boil the water without producing steam pressure.

Step 5. Boil for about 5 hr.

Step 6. Open the boiler feed pipe sufficiently to permit a steady trickle of water to run out the overflow pipe.

Step 7. Continue this slow boiling and trickle of overflow for several hours until the water coming from the overflow is clear.

Step 8. Stop the firing equipment.

Step 9. Drain the boiler in a manner and to a location that allow the hot water to be discharged safely.

Step 10. Remove covers and plugs from all washout openings and wash the water side of the boiler thoroughly using a high-pressure water stream.

Step 11. Refill the boiler until 1 in. (25 mm) of water shows in the gauge glass. If water in the gauge glass does not appear to be clear, repeat Steps 2 through 11 and boil out the boiler for a longer time.

Step 12. Remove temporary piping.

Step 13. Add a charge of boiler water treatment compound.

Step 14. Close the boiler.

Step 15. Replace the safety valve.

Step 16. Promptly boil the water or heat it to at least 180°F (82°C).

The boiler is now ready to be put into service or on standby.

9.2 STARTING A BOILER AFTER LAYUP (SINGLE-BOILER INSTALLATION)

9.2.1 Procedure

When starting a boiler after layup, proceed as follows:

Step 1. Review Manufacturer's instructions for startup of the burner and boiler.

Step 2. Set the control switch to the "Off" position.

Step 3. Make sure fresh air to the boiler room is unobstructed.

Step 4. Check availability of fuel.

Step 5. Check the water level in the gauge glass. Make sure the gauge glass valves are open.

Step 6. Use the try cocks, if provided, to double-check the water level.

Step 7. Vent the combustion chamber to remove unburned gases.

Step 8. Clean the glass on the fire scanner, if provided.

Step 9. Set the main steam shutoff valve to the open position.

Step 10. Open the cold water supply valve to the water feeder, if provided. Open suction and discharge valves on vacuum or condensate pumps, and set electrical switches for desired operation. Vent the boiler to remove air when necessary.

Step 11. Check the operating-pressure setting of the boiler.

Step 12. Check the manual reset, if provided, on the low-water fuel cutoff and high-limit pressure control to determine if they are properly set.

Step 13. Set the manual fuel oil supply or manual gas valve to the open position.

Step 14. Place the circuit breaker or fused disconnect switch in the "On" position.

Step 15. Place all boiler emergency switches in the "On" position.

Step 16. Place the boiler control starting switch in the "On" or "Start" position.

CAUTION: Do not stand in front of boiler access or cleanout doors. This is a precautionary measure to protect personnel should a combustion explosion occur.

Step 17. Bring pressure and temperature up slowly. Stand by the boiler until it reaches the established cutout point to make sure the operating control shuts off the burner.

Step 18. During the pressure buildup period, walk around the boiler frequently to observe that all associated equipment and piping are functioning properly.

Step 19. Check for proper over-the-fire draft and breech pressure. Verify and log burner combustion parameters.

Step 20. Immediately after the burner shuts off, examine the water column and open each try cock (if provided) individually to determine the true water level.

Step 21. In the logbook, enter the following:

(a) date and time of startup

(b) any irregularities observed and corrective action taken

(c) time when controls shut off the burner at established pressure, tests performed, etc.

(d) signature of operator

Step 22. Check the safety valve for evidence of simmering. Perform try-lever test.

9.2.2 Action in Case of Abnormal Conditions

If any abnormal conditions occur during light-off or pressure buildup, immediately open the emergency switch and lock out the equipment. (Do not attempt to restart the unit until difficulties have been identified and corrected.)

9.3 CONDENSATION

Following a cold start, condensation (sweating) may occur in a gas-fired boiler to such an extent that it appears that the boiler is leaking. This condensation can be expected to stop after the boiler is hot.

9.4 CUTTING IN AN ADDITIONAL BOILER

When placing a boiler on the line with other boilers that are already in service, first start the boiler using the procedures in 9.1 and 9.2 but have its supply stop valve and the return stop valve closed. If one is provided, open the drain valve between the stop valve at the boiler outlet and the steam main. When the pressure within the boiler is approximately the same as the pressure in the steam main, open the stop valve very slightly. If there is no unusual disturbance, such as noise or vibration, continue