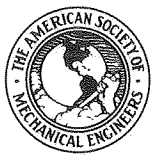
ASME BOILER AND PRESSURE VESSEL CODE
AN AMERICAN NATIONAL STANDARD

SECTION VII

Recommended Guidelines for the Care of Power Boilers

1989 EDITION

JULY 1, 1989



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SUBCOMMITTEE ON POWER BOILERS
SUBGROUP ON CARE OF POWER BOILERS (SC I)

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
United Engineering Center 345 East 47th Street New York, N.Y. 10017

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(Includes all Addenda dated December 1988 and earlier)

This code or standard was developed under procedures accredited as meeting the criteria for American National Standards. The Consensus 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 which provides an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large.

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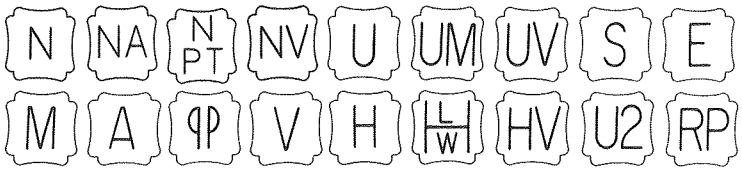

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1989 ASME
BOILER AND PRESSURE VESSEL CODE

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ADDENDA

Colored-sheet Addenda, which include additions and revisions to individual Sections of the Code, are published annually and will be sent automatically to purchasers of the applicable Sections up to the publication of the 1992 Code. The 1989 Code is available only in the loose-leaf format; accordingly, the Addenda will be issued in the loose-leaf, replacement-page format.

INTERPRETATIONS

ASME issues written replies to inquiries concerning interpretation of technical aspects of the Code. The Interpretations for each individual Section will be published separately and will be included as part of the update service to that Section. They will be issued semiannually (July and December) up to the publication of the 1992 Code. Interpretations of Section III, Divisions 1 and 2, will be included with the update service to Subsection NCA. Interpretations are not part of the Code or the Addenda.

CODE CASES

The Boiler and Pressure Vessel Committee meets 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 which have been adopted will appear in the appropriate 1989 Code Cases book: (1) Boilers and Pressure Vessels and (2) Nuclear Components. Supplements will be sent automatically to the purchasers of the Code Cases books up to the publication of the 1992 Code.

FOREWORD

The American Society of Mechanical Engineers set up a committee in 1911 for the purpose of formulating standard rules for the construction of steam boilers and other pressure vessels. This committee is now called the Boiler and Pressure Vessel Committee.

The Committee's function is to establish rules of safety governing the design, fabrication, and inspection during construction of boilers and pressure vessels, and to interpret these rules when questions arise regarding their intent. 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 so as to give a reasonably long, safe period of usefulness. Advancements in design and material and the evidence of experience have been recognized.

The Boiler and Pressure Vessel Committee deals with the care and inspection of boilers and pressure vessels in service only to the extent of providing suggested rules of good practice as an aid to owners and their inspectors.

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 Boiler and Pressure Vessel Committee meets regularly to consider revisions of the rules, new rules as dictated by technological development, Code Cases, and requests for interpretations. Requests for interpretation must be addressed to the Secretary in writing and must give full particulars in order to receive consideration and a written interpretation (see Mandatory Appendix covering preparation of technical inquiries). Proposed revisions to the Code resulting from inquiries will be presented to the Main Committee for appropriate action. The action of the Main Committee becomes effective only after confirmation by letter 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 and published in *Mechanical Engineering* to invite comments from all interested persons. After the allotted time for public review and final approval by ASME, revisions are published annually in Addenda to the Code.

Code Cases may be used in the construction of components to be stamped with the ASME Code symbol beginning with the date of their approval by ASME.

After Code revisions are approved by ASME, they may be used beginning with the date of issuance shown on the Addenda. Revisions become mandatory as minimum requirements six months after such date of issuance, except for boilers or pressure vessels contracted for prior to the end of the six-month period.

Manufacturers and users of components are cautioned against making use of revisions and Cases that are less restrictive than former requirements without having assurance that they have been accepted by the proper authorities in the jurisdiction where the component is to be installed.

Each state and municipality in the United States and each province in Canada that adopts or accepts one or more Sections of the Boiler and Pressure Vessel Code is invited to appoint a representative to act on the Conference Committee to the Boiler and Pressure Vessel Committee. Since the members of the Conference Committee are in active contact with the administration and enforcement of the rules, the requirements for inspection in this Code correspond with those in effect in their respective jurisdictions. The required qualifications for an Authorized Inspector under these rules may be obtained from the administrative authority of any state, municipality, or province which has adopted these rules.

The Boiler and Pressure Vessel Committee in the formulation of its rules and in the establishment of maximum design and operating pressures considers materials, construction, methods of fabrication, inspection, and safety devices. Permission may be granted to regulatory bodies and organizations publishing safety standards to use a complete Section of the Code

by reference. If usage of a Section, such as Section IX, involves exceptions, omissions, or changes in provisions, the intent of the Code might not be attained.

Where a state or other regulatory body, in the printing of any Section of the Boiler and Pressure Vessel Code, makes additions or omissions, it is recommended that such changes be clearly indicated.

The National Board of Boiler and Pressure Vessel Inspectors is composed of chief inspectors of states and municipalities in the United States and of provinces in Canada that have adopted the Boiler and Pressure Vessel Code. This Board, since its organization in 1919, has functioned to uniformly administer and enforce the rules of the Boiler and Pressure Vessel Code. The cooperation of that organization with the Boiler and Pressure Vessel Committee has been extremely helpful.

It should be pointed out that the state or municipality where the Boiler and Pressure Vessel Code has been made effective has definite jurisdiction over any particular installation. Inquiries dealing with problems of local character should be directed to the proper authority of such state or municipality. States, provinces, municipalities, or other regulatory bodies may, if there is any question or doubt as to the proper interpretation, refer the question to the Boiler and Pressure Vessel Committee.

The Specifications for base materials given in Section II, Parts A and B, are identical with or similar to those of The American Society for Testing and Materials. When reference is made in an ASME Material Specification to an ASTM Specification for which a companion ASME Specification exists, the reference shall be interpreted as applying to the ASME Material Specification. Specifications for welding materials given in Section II, Part C, are identical with or similar to those of the American Welding Society. Not all materials included in the ASME Material Specifications in Section II have been adopted for Code use. Usage is limited to those materials and grades adopted by at least one of the other Sections of the Code for application under rules of that Section. All materials allowed by these various Sections and used for construction within the scope of their rules shall be furnished in accordance with ASME Material Specifications contained in Section II except where otherwise provided in Code Cases or in the applicable Section of the Code. Materials covered by these Specifications are acceptable for use in items covered by the Code Sections only to the degree indicated in the applicable Section. Materials for Code use should preferably be ordered, produced, and documented on this basis; however, material produced under an ASTM Specification may be used in lieu of the corresponding ASME Specification, provided the requirements of the ASTM Specification are identical (excluding editorial differences) or more stringent than the ASME Specification for the Grade, Class, or Type produced and provided that the material is confirmed as complying with the ASTM Specification. Material produced to an ASTM specification with requirements different from the requirements of the corresponding ASME Specification may also be used in accordance with the above, provided the material manufacturer or vessel manufacturer certifies with evidence acceptable to the Authorized Inspector that the corresponding ASME Specification requirements have been met. Material produced to an ASME or ASTM Material Specification is not limited as to country of origin.

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.

Publication of the SI (Metric) Edition of the ASME Boiler and Pressure Vessel Code was discontinued with the 1986 Edition. Effective October 1, 1986, the SI Edition was withdrawn as an ASME Boiler and Pressure Vessel Code document.

STATEMENT OF POLICY ON THE USE OF CODE SYMBOLS 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 Code Symbols for marking items or constructions which 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 Code Symbols for the benefit of the users, the enforcement jurisdictions, and the holders of the symbols who comply with all requirements.

Based on these objectives, the following policy has been established on the usage in advertising of facsimiles of the symbols, 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 which might so indicate. An organization holding a Code Symbol 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."

The ASME Symbol 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 a Code Symbol who may also use the facsimile in advertising to show that clearly specified items will carry the symbol. 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 Code Symbol Stamp described in the governing Section of the Code.

Markings such as "ASME," "ASME Standard," or any other marking including "ASME" or the various Code Symbols shall not be used on any item which 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 which 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.

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CONTENTS

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PREAMBLE

The purpose of these recommended guidelines is to promote safety in the use of power boilers. These guidelines are intended for use by those directly responsible for operating, maintaining, and inspecting power boilers.

With respect to the application of these guidelines, a *power boiler* is a pressure vessel constructed in compliance with Section I in which steam is generated for use external to the boiler at a pressure exceeding 15 psig due to the application of heat. This heat may be derived from the combustion of fuel (solids, liquids, or gases), from the hot waste gases of other chemical reactions, or from the application of electrical energy. The term *power boiler* in this Section includes stationary, portable, and traction types, but does not include locomotive and high temperature water boilers (Section I), nuclear power plant boilers (Section III), heating boilers (Section IV), miniature boilers (Section I), pressure vessels (Section VIII), or marine boilers.

These guidelines apply to the boiler proper and to pipe connections up to and including the valve or valves as required by the Code. Superheaters, reheaters, economizers, or other pressure parts connected directly to the boiler without intervening valves should be considered as part of the boiler. Guidelines are also provided for operation of auxiliary equipment and appliances that affect the safe and reliable operation of power boilers.

Previous editions of these guidelines covered the full range of power boilers from small capacity, low pressure, and low temperature to once-through units. Specific references to the once-through units have been deleted. Emphasis has been placed on industrial-type boilers because of their extensive use.

The difficulty in formulating a set of guidelines that may be applied to all sites and types of plants is recognized; therefore, it may be advisable to depart from them in specific cases. Manufacturer's operating instructions should always be adhered to. Other recommended procedures such as National Fire Protection Association's Codes covering prevention of furnace explosions are suggested for additional guidance.

DESCRIPTION OF GUIDELINES

C1 *Fundamentals* — a general description of boiler fundamentals including steam generation, combustion, and types of boilers

C2 *Boiler Operation* — guidelines for routine boiler operation including startup, normal operation, and shutdown as well as operator training for safe and reliable operation

C3 *Boiler Auxiliaries* — guidelines for normal and emergency operation of fuel handling equipment, boiler feedpumps, fans, and other auxiliaries commonly used in the operation of boilers. Emphasis is placed on operating the auxiliaries to avoid an unsafe condition in the boilers.

C4 *Appurtenances* — operating guidelines and descriptions for frequently used boiler appurtenances such as safety valves, safety relief valves, pressure gages, feedwater regulator valves, blowdown systems, and soot blowers

C5 *Instrumentation, Controls, and Interlocks* — brief description of recommended instrumentation for monitoring boiler status, controls for boiler operation, and interlocks to prevent unsafe conditions

C6 *Inspection* — guidelines for inspection of boilers to ensure that the boiler is capable of safe and reliable operation. These guidelines apply only to those who are responsible for the inspection and operation of boiler plants and must not be considered as applying to the state, municipal, or insurance companies' inspectors. Consideration should be given to the importance of continual inspection as compared with periodic inspection. These guidelines are not intended to define or limit the extent of inspection by the Authorized Inspector.

C7 *Repairs, Alterations, and Maintenance* — guidelines for making boiler repairs and alterations; recommended routine maintenance programs to improve boiler availability and keep power boilers in a safe operating condition

C8 *Control of Internal Chemical Conditions* — guidelines address internal cleaning, laying up, deposits, corrosion, steam contamination, water chemistry, and fire side conditions

C9 *Preventing Boiler Failures* — guidelines for operation of protective equipment and precautions to prevent causes of boiler failures, such as overpressure, weakening of structure, explosions, and implosions

SUBSECTION C1
FUNDAMENTALS

SUBSECTION C1
FUNDAMENTALS

C1.100 STEAM GENERATION

The primary function of a boiler is to generate steam. This is done by applying heat to the water in the boiler. This can be done electrically or by burning fuel in a furnace, allowing the heat of combustion to be conducted through the metal to the water.

In the electric boiler, steam is generated by resistance heaters immersed in the boiler water or by passing current between electrodes immersed in the boiler water. The resistance heater method is typically used by small capacity heating boilers operating at low pressures. The electrode method is used with capacities exceeding 100,000 lb/hr and pressures up to 125 psig.

In the fuel burning method, the heat generated by the burning of fuel is conducted through the metal of the boiler or boiler tubes to the water on the other side.

C1.200 BOILER TYPES

There are three basic types of boilers: firetube, watertube, and electric.

C1.210 Firetube Boilers

In the firetube boiler, gases of combustion pass through the inside of the tubes with water surrounding the outside of the tubes. The advantages of a firetube boiler are its simple construction and less rigid water treatment requirements. The disadvantages are the excessive weight per pound of steam generated, excessive time required to raise steam pressure because of the relatively large volume of water, and the inability of the firetube boiler to respond quickly to load changes, again due to the large water volume. These boilers are commonly used for small capacity, low pressure applications in industrial process plants. Steam capacity ranges up to 200,000 lb/hr and design pressures usually fall below 1000 psig.

Circulation in a firetube boiler is established when steam bubbles are formed on the outside of the tubes and break away from the hot metal to rise to the surface. Water replaces these bubbles and circulation begins.

C1.220 Watertube Boilers

In the watertube boiler, the water is inside the tubes and gases of combustion pass around the outside of the tubes. The advantages of a watertube boiler are a lower unit weight per pound of steam generated, less time required to raise steam pressure, a greater flexibility for responding to load changes, and a greater ability to operate at high rates of steam generation. (This is due to the better circulation of water that carries heat away from the heating surfaces.)

Steam bubbles that are lighter than the water are formed inside the tubes. Breaking away from the hot metal, they rise to the surface. This is the same principle as in the firetube boiler, except that the tubes in a watertube boiler provide a path that accommodates this natural tendency.

The natural circulation of water through a watertube boiler depends solely on the difference in weight of the steam and water mixture in the generating or heated tubes, compared to the weight of water in the downcomers. As the water is heated in the generating tubes, steam bubbles are formed and the heated mixture of steam and water rises as the weight of the denser water in the downcomers forces the heated mixture up the tubes, establishing circulation. To ensure that this circulation continues unimpaired, it is essential that the required level of water be maintained in the steam drum at all times.

In operation, the function of the steam drum is to separate the steam from the mixture of water and steam entering the drum (see Figs. C1.2-1 and C1.2-2). A considerable variety of drum internals (baffles, moisture separators, screens, dryers) may be used to aid