

533

ASME BOILER AND PRESSURE VESSEL CODE
AN AMERICAN NATIONAL STANDARD

SECTION II
Material Specifications
**Part C — Welding Rods,
Electrodes, and Filler Metals**

1989 EDITION

JULY 1, 1989



ASME BOILER AND PRESSURE VESSEL COMMITTEE
SUBCOMMITTEE ON MATERIALS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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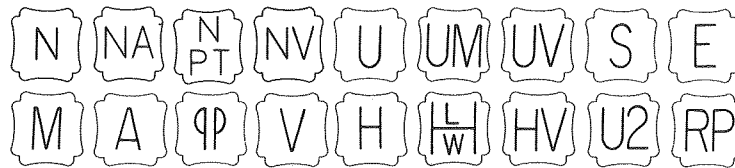
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1989 ASME BOILER AND PRESSURE VESSEL CODE

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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.

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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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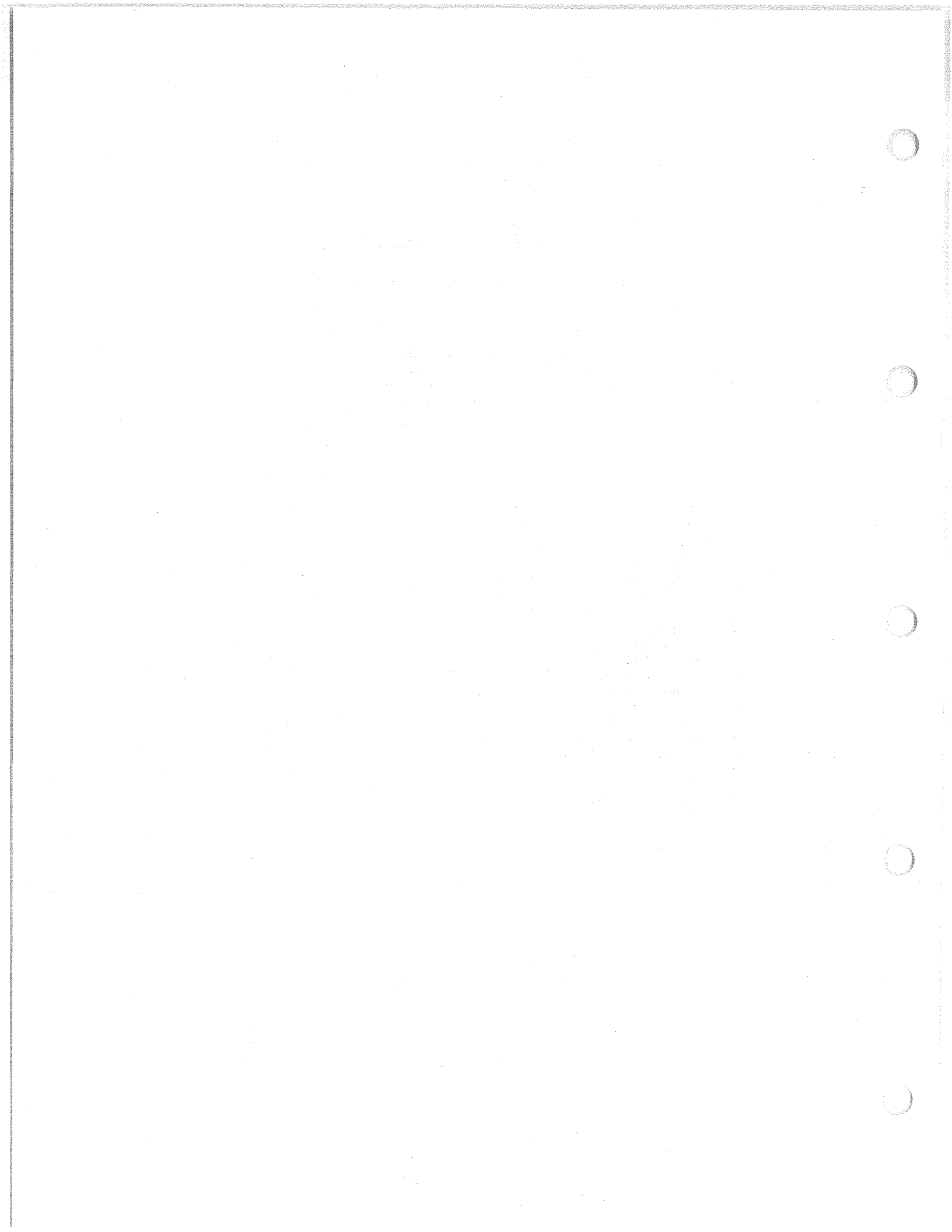
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A5O Filler Metal for Gas-Shielded Arc Welding	D. A. Fink
A5P Electroslag and Electrogas Filler Metal	D. A. Fink
A5R Carbon Arc Electrodes	D. A. Fink
A5S Shielding Gases	N. E. Larson
A5T Filler Metal Procurement Guidelines	J. Caprarola, Jr.



PREFACE

On January 3, 1919, ASME participated with several other organizations in a meeting to discuss the continuation of wartime research in welding. Out of that meeting, the American Welding Society was established and since that time there has been a constant and interwoven record of development by the American Welding Society and The American Society of Mechanical Engineers of the techniques of welding. Through all of these great years of growth, many of the leaders in the field of engineering had the common interest of pressure equipment design and manufacture and the development of welding as a powerful tool in that manufacture. The evolution of this cooperative effort is contained in Professor A. M. Greene's "History of the ASME Boiler Code," which was published as a series of articles in *Mechanical Engineering* from July 1952 through August 1953 and is now available from ASME in a special bound edition. The following quotation from this history based on the minutes of the Committee notes the cooperative nature of the work done in the area of welding.

"During 1919, a number of cases involving welding were referred by the Boiler Code Committee to the Subcommittee on Welding.

"As the National Welding Council was to be discontinued, a new organization was to be formed to be known as the American Welding Society with which the American Bureau of Welding was to be affiliated. This was to be a body representing the entire industry and would eliminate commercial aspects, undertake research and standardization, and act as a judicial body providing a medium for advancing the science and art of welding."

In 1935 the AWS-ASTM Joint Committee on Filler Metal was organized to provide standard specifications for welding rods, electrodes, filler metals, and fluxes for this developing U.S. industry.

In 1969 these two sponsors agreed to dissolve this joint activity and to permit the American Welding Society to assume sole responsibility for the family of welding rods, electrodes, filler metal, and flux specifications then in being.

Section II, Part C, currently contains material specifications, most of which are identical to corresponding specifications published by AWS. The specifications prepared and copyrighted by AWS are reproduced in the Code with the permission of AWS. The ASME Committee reviews all material specifications submitted to it and if it is felt that there is any need to adapt them for Code purposes, revisions are made to them. However, there is constant liaison between ASME and AWS, and there will be continuing effort to see that the specifications as produced by AWS and those printed in the ASME Code are identical.

To assure that there will be a clear understanding on the part of the users of Section II, ASME publishes both the identical specifications and those amended for Code usage in three parts every three years, in the same page size to match the other Sections of the Code, and Addenda are issued annually to provide the latest changes in Section II specifications.

The ASME Boiler and Pressure Vessel Code has been adopted into law by 45 states and many municipalities in the United States and by all of the Canadian Provinces.



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APPENDIX 1 — MANDATORY PREPARATION OF TECHNICAL INQUIRIES TO THE BOILER AND PRESSURE VESSEL COMMITTEE

1-100 INTRODUCTION

The ASME Boiler and Pressure Vessel Committee meets regularly to consider written requests for interpretations and revisions to the Code rules, and to develop new rules as dictated by technological development. The Committee's activities in this regard are limited strictly to interpretations of the rules or to the consideration of revisions to the present rules on the basis of new data or technology. As a matter of published policy, ASME does not approve, certify, rate, or endorse any item, construction, proprietary device, or activity, and, accordingly, inquiries requiring such consideration will be returned. Moreover, ASME does not act as a consultant on specific engineering problems or on the general application or understanding of the Code rules. If, based on the inquiry information submitted, it is the opinion of the Committee that the inquirer should seek assistance, the inquiry will be returned with the recommendation that such assistance be obtained.

All inquiries that do not provide the information needed for the Committee's full understanding will be returned.

1-200 INQUIRY FORMAT

Inquiries shall be limited strictly to interpretations of the rules or to the consideration of revisions to the present rules on the basis of new data or technology. Inquiries shall be submitted in the following format.

(a) *Scope.* Involve a single rule or closely related rules. An inquiry letter concerning unrelated subjects will be returned.

(b) *Background.* State the purpose of the inquiry, which would be either to obtain an interpretation of Code rules, or to propose consideration of a revision to the present rules. Provide concisely the information needed for the Committee's understanding of the inquiry, being sure to include reference to the applicable Code Section, Division, Edition, Addenda, paragraphs, figures, and tables. If sketches are provided, they shall be limited to the scope of the inquiry.

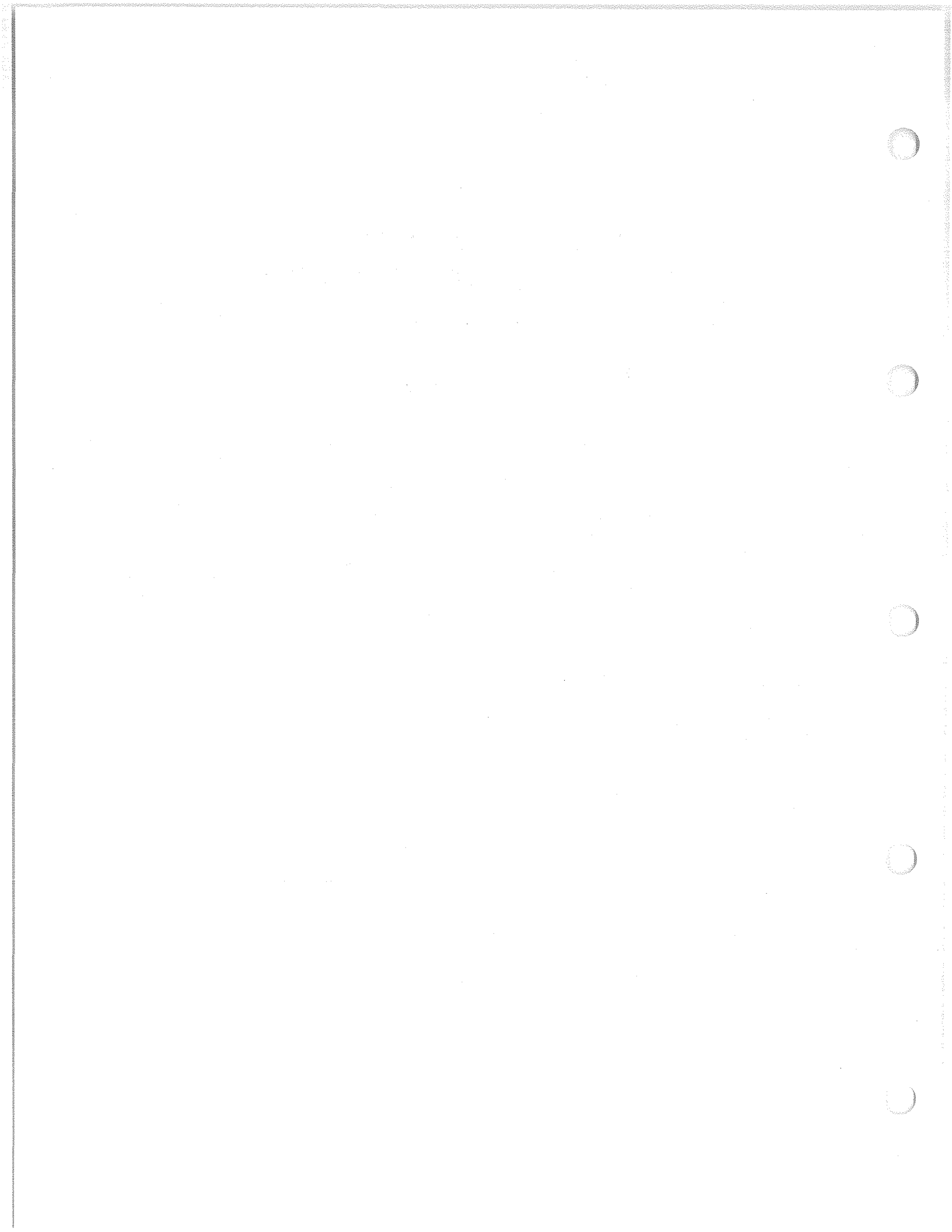
(c) *Inquiry Structure.* Prepare statements in a condensed and precise question format, omitting superfluous background information, and, where appropriate, composed in such a way that "yes" or "no" (perhaps with provisos) would be an acceptable reply. This inquiry statement should be technically and editorially correct.

(d) *Proposed Reply.* State what it is believed that the Code requires. If in the inquirer's opinion a revision to the Code is needed, recommended wording shall be provided.

1-300 SUBMITTAL

Inquiries shall preferably be submitted in typewritten form; however, legible handwritten inquiries will also be considered. They shall include the name and mailing address of the inquirer, and be mailed to the following address:

Secretary
ASME Boiler and Pressure Vessel Committee
345 East 47th Street
New York, NY 10017



SI UNITS

The 1989 Edition of the Boiler and Pressure Vessel Code is based on U.S. Customary (ft-lb) units of measurement which are to be regarded as the standard. This supplement is provided as a convenience to the Code user and contains SI conversion factors for units contained in the Code.

LIST OF SI UNITS FOR USE WITH ASME BOILER AND PRESSURE VESSEL CODE¹

Quantity	Unit	Symbol	Other Units or Limitations
Space and Time			
plane angle	radian	rad	degree (decimalized)
length	meter	m	
area	square meter	m ²	
volume	cubic meter	m ³	liter (L) for liquid only (use without prefix other than in milliliter, mL)
time	second	s	minute (min), hour (h), day (d), week, and year
Periodic and Related Phenomena			
frequency	hertz	Hz	revolutions per second (r/s)
rotational frequency	revolutions per second	s ⁻¹	revolutions per minute (r/m)
Mechanics			
mass	kilogram	kg	
density	kilogram per cubic meter	kg/m ³	
moment of inertia	kilogram · meter ²	kg · m ²	
force	newton	N	
moment of force (torque)	newton-meter	N · m	
pressure and stress	pascal	Pa	(pascal=newton per square meter)
energy, work	joule	J	kilowatt-hour (kW · h)
power	watt	W	
impact strength	joule	J	
section modulus	meter ³	m ³	
moment of section (second moment of area)	meter ⁴	m ⁴	
fracture toughness	Pa · √m		
Heat			
temperature — thermodynamic [Note (2)]	kelvin	K	degree Celsius (°C)
temperature — other than thermodynamic	degree Celsius	°C	kelvin (K)
linear expansion coefficient	meter per meter-kelvin	K ⁻¹	°C ⁻¹
quantity of heat	joule	J	
heat flow rate	watt	W	
thermal conductivity	watt per meter-kelvin	W/(m · K)	W/(m · °C)
thermal diffusivity	square meter per second	m ² /s	
specific heat capacity	joule per kilogram-kelvin	J/(kg · K)	J/(kg · °C)
Electricity and Magnetism			
electric current	ampere	A	
electric potential	volt	V	
current density	ampere per meter ²	A/m ²	
magnetic field strength	ampere per meter	A/m	

NOTES:

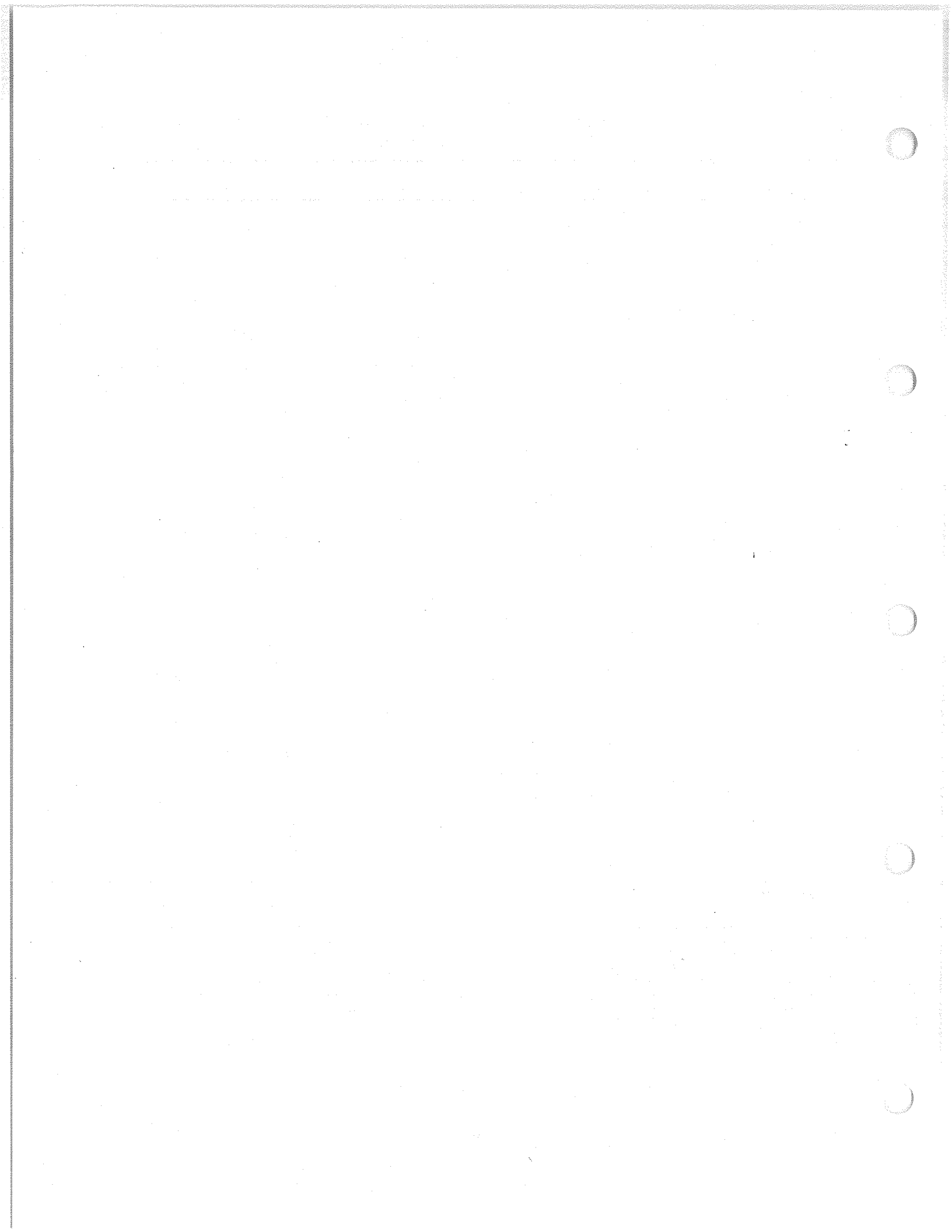
- (1) Conversion factors between SI units and U.S. customary are given in SI-1, "ASME Orientation and Guide for Use of SI (Metric) Units," and ASTM E 380.
- (2) Preferred use for temperature and temperature interval is degrees Celsius (°C), except for thermodynamic and cryogenic work where kelvins may be more suitable. For temperature interval, 1 K = 1°C exactly.

COMMONLY USED CONVERSION FACTORS
(For Others See ASTM E 380) (See Note 1)

Quantity	To Convert From	To	Multiply by [Note (2)]	
plane angle	degree	rad	1.745 329	E-02
length	in	m	2.54*	E-02
	ft	m	3.048*	E-01
	yd	m	9.144*	E-01
area	in ²	m ²	6.451 6*	E-04
	ft ²	m ²	9.290 304*	E-02
	yd ²	m ²	8.361 274	E-01
volume	in ³	m ³	1.638 706	E-05
	ft ³	m ³	2.831 685	E-02
	US gallon	m ³	3.785 412	E-03
	Imperial gallon	m ³	4.546 09	E-03
	liter	m ³	1.0*	E-03
mass	lbn	kg	4.535 924	E-01
	ton (metric) (mass)	kg	1.000 00*	E+03
	ton (short 2000 lbn)	kg	9.071 847	E+02
force	kgf	N	9.806 65*	E+00
	lbf	N	4.448 222	E+00
bending, torque	kgf · m	N · m	9.806 65*	E+00
	lbf · in	N · m	1.129 848	E-01
	lbf · ft	N · m	1.355 818	E+00
pressure, stress	kgf/m ²	Pa	9.806 65*	E+00
	lbf/ft ²	Pa	4.788 026	E+01
	lbf/in ² (psi)	Pa	6.894 757	E+03
	kips/in ²	Pa	6.894 757	E+06
	bar	Pa.	1.0*	E+05
energy, work	Btu (IT) [Note (3)]	J	1.055 056	E+03
	ft · lbf	J	1.355 818	E+00
power	hp (550 ft · lbf/s)	W	7.456 999	E+02
fracture toughness	ksi $\sqrt{\text{in}}$	Pa · $\sqrt{\text{m}}$	1.098 843	E+06
temperature	°C	K	$t_K = t_C + 273.15$	
	°F	K	$t_K = (t_F + 459.67)/1.8$	
	°F	°C	$t_C = (t_F - 32)/1.8$	
temperature interval	°C	K	1.0*	E+00
	°F	K or °C	5.555 555	E-01

NOTES:

- (1) Care should be taken when converting formulas or equations that contain constant terms or factors. The value of these terms must be understood and may also require conversion.
- (2)(a) Relationships that are exact in terms of the base units are followed by a single asterisk.
 (b) The factors are written as a number greater than 1 and less than 10 with 6 or less decimal places. The number is followed by the letter E (for exponent), a plus or minus symbol, and two digits which indicate the power of 10 by which the number must be multiplied to obtain the correct value. For example: 3.523 907 E-02 is $3.523\ 907 \times 10^{-2}$ or 0.035 239 07.
- (3) International Table



SPECIFICATION FOR COVERED CARBON STEEL ARC WELDING ELECTRODES

SFA-5.1



(Identical with AWS Specification A5.1-81)



Scope

This specification prescribes requirements for the classification of covered carbon steel electrodes for shielded metal arc welding.

Note: The values stated in U.S. customary units are to be regarded as the standard. The SI units are given as equivalent values to the U.S. customary units. The standard sizes and dimensions in the two systems are not identical and, for this reason, conversion from a standard size or dimension in one system will not always coincide with a standard size or dimension in the other. Suitable conversions, encompassing standard sizes of both can be made, however, if appropriate tolerances are applied in each case.

Section A — GENERAL REQUIREMENTS

1.0 Classification

The welding materials covered by this specification are classified according to the following criteria:

- (1) Type of current (see Table 1).
- (2) Type of covering (see Table 1).
- (3) Welding position of the electrode (see Table 1).
- (4) Chemical composition of the weld metal (see Table 2).
- (5) Mechanical properties of the weld metal in the as-welded condition (see Tables 3 and 4).

Materials classified under one classification shall not be classified under any other classification of this specification.

2.0 Acceptance

Acceptance of the material shall be in accordance with the provisions of Section 3 of AWS A5.01, Filler Metal Procurement Guidelines.

3.0 Certification

For all material furnished under this specification, the manufacturer certifies, by affixing the marking required in 6.0, that the material, or representative material, has passed the tests required for classification by this specification.

4.0 Retests

If any test fails to meet its requirement, that test must be repeated twice. The results of both tests shall meet the requirements. Specimens for retest may be taken from the original test assembly, or from one or two new test assemblies.

5.0 Method of Manufacture

The welding materials classified by this specification may be made by any method yielding product conforming to the requirements of this specification.

6.0 Marking

6.1 The following information shall be legibly marked so as to be visible from the outside of each unit package:

6.1.1 AWS specification and classification numbers.

6.1.2 Supplier's name and trade designation.

6.1.3 Standard size and net weight.

6.1.4 Lot, control, or heat number.

6.2 Marking of any overpacking of unit packages with items listed in 6.1 shall be optional with the manufacturer.