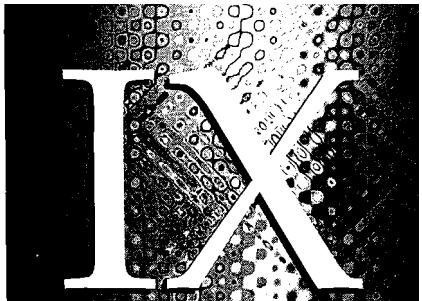
ASME BOILER AND PRESSURE VESSEL CODE
AN INTERNATIONAL CODE



QUALIFICATION STANDARD FOR WELDING AND BRAZING PROCEDURES, WELDERS, BRAZERS, AND WELDING AND BRAZING OPERATORS

2004 Edition
July 1, 2004

ASME BOILER AND PRESSURE VESSEL COMMITTEE SUBCOMMITTEE ON WELDING

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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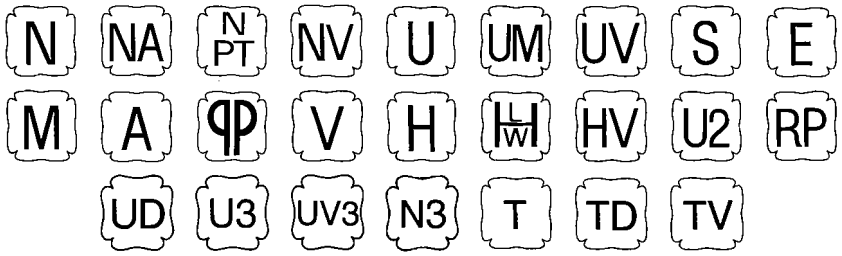
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2004 ASME
BOILER AND PRESSURE VESSEL CODE

04

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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 2007 Code. The 2004 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 2004 Code. Interpretations of Section III, Divisions 1 and 2, will be included with the update service to Subsection NCA.

Beginning with the 2004 Edition, Interpretations of the Code will be distributed annually in July with the issuance of the edition and subsequent addenda. Interpretations previously distributed in January will be posted in January at www.cstools.asme.org/interpretations and included in the July distribution.

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 2004 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 2007 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, relating only to pressure integrity, governing the construction[1] of boilers, pressure vessels, transport tanks and nuclear components, and inservice inspection for pressure integrity of nuclear components and transport tanks, and to interpret these rules when questions arise regarding their intent. This code does not address other safety issues relating to the construction of boilers, pressure vessels, transport tanks and nuclear components, and the inservice inspection of nuclear components and transport tanks. The user of the Code should refer to other pertinent codes, standards, laws, regulations, or other relevant documents. With few 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. Recognizing this, the Committee has approved a wide variety of construction rules in this Section to allow the user or his designee to select those which will provide a pressure vessel having a margin for deterioration in service so as to give a reasonably long, safe period of usefulness. Accordingly, it is not intended that this Section be used as a design handbook; rather, engineering judgment must be employed in the selection of those sets of Code rules suitable to any specific service or need.

This Code contains mandatory requirements, specific prohibitions, and nonmandatory guidance for construction activities. The Code does not address all aspects of these activities and those aspects which 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 designers 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 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 they are responsible for the application of these programs to their design.

The Code does not fully address tolerances. When dimensions, sizes, or other parameters are not specified with tolerances, the values of these parameters are considered nominal and allowable tolerances or local variances may be considered acceptable when based on engineering judgment and standard practices as determined by the designer.

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. Only the Boiler and Pressure Vessel 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 Mandatory Appendix covering preparation of technical inquiries). Proposed revisions to the Code resulting from inquiries

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

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 at *http://cstools.asme.org/wbpms/public/index.cfm?PublicReview=Revisions* 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, except for revisions to material specifications in Section II, Parts A and B, become mandatory six months after such date of issuance, except for boilers or pressure vessels contracted for prior to the end of the six-month period. Revisions to material specifications are originated by the American Society for Testing and Materials (ASTM) and other recognized national or international organizations, and are usually adopted by ASME. However, those revisions may or may not have any effect on the suitability of material, produced to earlier editions of specifications, for use in ASME construction. ASME material specifications approved for use in each construction Code are listed in the Guidelines for Acceptable ASTM Editions in Section II, Parts A and B. These Guidelines list, for each specification, the latest edition adopted by ASME, and earlier and later editions considered by ASME to be identical for ASME construction.

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.

The Code 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 ASME Boiler and Pressure Vessel Committee. ASME is to be notified should questions arise concerning improper use of an ASME Code symbol.

The specifications for materials given in Section II are identical with or similar to those of specifications published by ASTM, AWS, and other recognized national or international organizations. When reference is made in an ASME material specification to a non-ASME specification for which a companion ASME specification exists, the reference shall be interpreted as applying to the ASME material specification. Not all materials included in the 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 material specifications contained in Section II or referenced in the Guidelines for Acceptable ASTM Editions in Section II, Parts A and B, 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; Guideline for Acceptable ASTM Editions in Section II, Part A and Guideline for Acceptable ASTM Editions in Section II, Part B list editions of ASME and year dates of specifications that meet ASME requirements and which may be used in Code construction. Material produced to an acceptable specification with requirements different from the requirements of the corresponding specifications listed in the Guideline for Acceptable ASTM Editions in Part A or Part B 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 requirements of specifications listed in the Guideline for Acceptable ASTM Editions in Part A or Part B have been met. Material produced to an acceptable 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.

Either U.S. Customary units or SI units may be used for compliance with all requirements of this edition, but one system shall be used consistently throughout for all phases of construction.

Either the U.S. Customary units or SI units that are listed in Mandatory Appendix F are identified in the text, or are identified in the nomenclature for equations, shall be used consistently for all phases of construction (e.g. materials, design, fabrication, and reports). Since values in the two systems are not exact equivalents, each system shall be used independently of the other without mixing U.S. Customary units and SI units.

When SI units are selected, U.S. Customary values in referenced specifications that do not contain SI units shall be converted to SI values to at least three significant figures for use in calculations and other aspects of construction.

With the publication of the 2004 Edition, Section II, Part D is published as two separate publications. One publication contains values only in U.S. Customary units and the other contains values only in SI units. The selection of the version to use is dependent on the set of units selected for construction.

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 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 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 that 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.

The ASME logo, which is the cloverleaf with the letters ASME within, shall not be used by any organization other than ASME.

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 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.

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INTRODUCTION

The following is a brief introduction to the 2004 Edition of Section IX and cannot be considered as a substitute for the actual review of appropriate sections of the document. However, this introduction is intended to give the reader a better understanding of the purpose and organization of Section IX.

Section IX of the ASME Boiler and Pressure Vessel Code relates to the qualification of welders, welding operators, brazers, and brazing operators, and the procedures employed in welding or brazing in accordance with the ASME Boiler and Pressure Vessel Code and the ASME B31 Code for Pressure Piping. As such, this is an active document subject to constant review, interpretation, and improvement to recognize new developments and research data. Section IX is a document referenced for qualification by various construction codes such as Section I, III, IV, VIII, etc. These particular construction codes apply to specific types of fabrication and may impose additional welding requirements or exemptions to Section IX qualifications. Qualification in accordance with Section IX is not a guarantee that procedures and performance qualifications will be acceptable to a particular construction code.

Section IX establishes the basic criteria for welding and brazing which are observed in the preparation of welding and brazing requirements that affect procedure and performance. It is important that the user of the 2001 Edition of Section IX understand the basic criteria in reviewing the requirements which have been established.

Section IX does not contain rules to cover all welding and brazing conditions affecting production weld or braze properties under all circumstances. Where such welding or brazing conditions are determined by the Manufacturer to affect weld or braze properties, the Manufacturer shall address those welding or brazing conditions to ensure that the required properties are achieved in the production weldment or brazement.

The purpose of the Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR) is to determine that the weldment proposed for construction is capable of having the required properties for its intended application. It is presupposed that the welder or welding operator performing the welding procedure qualification test is a skilled workman. This also applies to the Brazing Procedure Specifications (BPS) and the brazer and brazing operator qualifications. The procedure qualification test is to establish the properties of the weldment or brazement and not the skill of the personnel performing the welding or brazing. In addition, special consideration is given when notch toughness is required by other Sections of the Code. The notch-toughness variables do not apply unless referenced by the construction codes.

In Welder or Brazer/Brazing Operator Performance Qualification, the basic criterion is to determine the ability to deposit sound weld metal, or to make a sound braze. In Welding Operator Performance Qualification, the basic criterion is to determine the mechanical ability of the welding operator to operate the equipment.

In developing the present Section IX, each welding process and brazing process that was included was reviewed with regard to those items (called variables) which have an effect upon the welding or brazing operations as applied to procedure or performance criteria.

The user of Section IX should be aware of how Section IX is organized. It is divided into two parts: welding and brazing. Each part is then divided into articles. These articles deal with the following:

(a) general requirements (Article I Welding and Article XI Brazing)

(b) procedure qualifications (Article II Welding and Article XII Brazing)

(c) performance qualifications (Article III Welding and Article XIII Brazing)

(d) data (Article IV Welding and Article XIV Brazing)

(e) standard welding procedures (Article V Welding)

These articles contain general references and guides that apply to procedure and performance qualifications such as positions, type and purpose of various mechanical tests, acceptance criteria, and the applicability of Section IX, which was in the Preamble of the 1980 Section IX (the Preamble has been deleted). The general requirement articles reference the data articles for specifics of the testing equipment and removal of the mechanical test specimens.

PROCEDURE QUALIFICATIONS 04

Each process that has been evaluated by Section IX is listed separately with the essential and nonessential

variables as they apply to that particular process. In general, the Welding Procedure Specifications (WPS) and the Brazing Procedure Specifications (BPS) are to list all essential and nonessential variables for each process that is included under that particular procedure specification. If a change is made in any essential variable, requalification of the procedure is required. If a change is made in a nonessential variable, the procedure need only be revised or amended to address the nonessential variable change. When notch toughness is required by the construction code, the supplementary essential variables become additional essential variables and a change requires requalification of the procedure.

In addition to covering various processes, there are also rules for procedure qualification of corrosion-resistant weld metal overlay and hard-facing weld metal overlay.

Beginning with the 2000 Addenda, the use of Standard Welding Procedure Specifications (SWPSs) was permitted. Article V provides the requirements and limitations that govern the use of these documents. The SWPSs approved for use are listed in Appendix E.

In the 2004 Edition, rules for temper bead welding were added.

PERFORMANCE QUALIFICATIONS

These articles list separately the various welding and brazing processes with the essential variables that apply to the performance qualifications of each process. The welder, brazer, and brazing operator qualifications are limited by essential variables.

The performance qualification articles have numerous paragraphs describing general applicable variables for all processes. QW-350 and QB-350 list additional essential variables which are applicable for specific processes. The QW-350 variables do not apply to welding operators. QW-360 lists the additional essential variables for welding operators.

Generally, a welder or welding operator may be qualified by mechanical bending tests, radiography of a test plate, or radiography of the initial production weld. Brazers or brazing operators may not be qualified by radiography.

WELDING AND BRAZING DATA

The welding and brazing data articles include the variables grouped into categories such as joints, base materials and filler materials, positions, preheat/postweld heat treatment, gas, electrical characteristics, and technique. They are referenced from other articles as they apply to each process.

These articles are frequently misused by selecting variables that do not apply to a particular process. Variables (QW-402 to QW-410 and QB-402 to QB-410) only apply as referenced for the applicable process in Article II or Article III for welding and Article XII or Article XIII for brazing. The user of Section IX should not try to apply any variable which is not referenced for that process in QW-250, QW-350, QW-360, QB-250, or QB-350.

These articles also include assignments of P-Numbers and F-Numbers to particular base materials and filler materials. Article IV also includes A-Number tables for reference by the manufacturer.

Beginning with the 1994 Addenda, the welding P-Numbers, brazing P-Numbers, and nonmandatory S-Numbers were consolidated into one table identified as QW/QB-422. Both the QB-422 table (brazing P-Numbers) and Appendix C table (S-Numbers) were deleted. The new QW/QB-422 table was divided into ferrous and nonferrous sections. Metals were listed in numerical order by material specification number to aid users in locating the appropriate grouping number. An abbreviated listing of metals grouped by P-Numbers, Nonmandatory Appendix D, has been included for users still wishing to locate groupings of metals by welding P-Number.

The QW-451 and QB-451 tables for procedure qualification thickness requirements and the QW-452 and QB-452 tables for performance thickness qualifications are given and may only be used as referenced by other paragraphs. Generally, the appropriate essential variables reference these tables.

Revisions to the 1980 Edition of Section IX introduced new definitions for position and added a fillet weld orientation sketch to complement the groove-weld orientation sketch. The new revision to position indicates that a welder qualifies in the 1G, 2G, 3G, etc., position and is then qualified to weld, in production, in the F, V, H, or O positions as appropriate. QW-461.9 is a revised table that summarizes these new qualifications.

The data articles also give sketches of coupon orientations, removal of test specimens, and test jig dimensions. These are referenced by Articles I and XI.

QW-470 describes etching processes and reagents.

At the end of Articles IV and XIV is a list of general definitions applicable to Section IX, welding and brazing, respectively. These may differ slightly from other welding documents.

Nonmandatory Forms for welding and brazing procedure and performance qualifications appear in Appendix B. These forms are provided for the aid of those who do not wish to design their own forms. Any form(s) that address all applicable requirements of Section IX may be used.

SUMMARY OF CHANGES

The 2004 Edition of this Code contains revisions in addition to the 2001 Edition with 2002 and 2003 Addenda. The revisions are identified with the designation **04** in the margin and, as described in the Foreword, become mandatory six months after the publication date of the 2004 Edition. To invoke these revisions before their mandatory date, use the designation "2004 Edition" in documentation required by this Code. If you choose not to invoke these revisions before their mandatory date, use the designation "2001 Edition through the 2003 Addenda" in documentation required by this Code.

Changes given below are identified on the pages by a margin note, **04**, placed next to the affected area.

Page	*Location*	*Change*
iii, iv	List of Sections	Updated to reflect 04
vii–ix	Foreword	Editorially revised
xxiii, xxiv	Introduction	Procedure Qualifications revised
13–15	QW-200.2(b)	Last paragraph revised
	QW-200.4(a)	Revised in its entirety
16	QW-202.4(b)(1)	Revised
20	QW-252	QW-404.12 revised
21	QW-252.1	QW-404.12 and QW-408.14 revised
22	QW-253	QW-404.12 and QW-404.33 revised
23	QW-253.1	(1) QW-404.12 and QW-407.6 revised (2) QW-407.9 added
24	QW-254	QW-404.33 revised
26	QW-254.1	(1) QW-404.12 and QW-407.6 revised (2) QW-407.9 added
27, 28	QW-255	(1) Title corrected by errata (2) QW-404.12, QW-404.33, and QW-407 revised
29	QW-255.1	(1) Title corrected by errata (2) QW-404.12 and QW-407.6 revised (3) QW-407.9 added
30	QW-256	QW-404.12 and QW-404.33 revised
32	QW-256.1	(1) QW-404.12 and QW-407.6 revised (2) QW-407.9 added
33	QW-257	QW-404.12 and QW-404.33 revised
35	QW-257.1	(1) QW-404.12 and QW-407.6 revised (2) QW-407.9 added
37	QW-258	QW-404.12 and QW-404.33 revised
38	QW-258.1	(1) QW-404.12 and QW-407.6 revised (2) QW-407.9 added

Page	*Location*	*Change*
39	QW-259	(1) Title corrected by errata (2) QW-404.12 and QW-404.33 revised
40	QW-260	QW-404.33 revised
44	QW-264	QW-404.33 revised
45	QW-264.1	(1) QW-404 and QW-407.6 revised (2) QW-407.9 added
47	QW-284	Penultimate sentence revised
48–50	QW-290	Added
57	QW-355	Title corrected by errata
59	QW-384	Third sentence revised
61	QW-402.23	Added
	QW-402.24	Added
63	QW-403.25	Added
	QW-403.26	Added
	QW-403.27	Added
64	QW-404.12	First two paragraphs revised
65	QW-404.33	Revised
66	QW-404.51	Added
	QW-404.52	Added
67	QW-406.8	Added
	QW-406.9	Added
	QW-406.10	Added
	QW-406.11	Added
68	QW-407.9	Added
	QW-408.9	Second line revised
69	QW-408.24	Added
70	QW-409.29	Added
	QW-410.7	Last line corrected by errata
72	QW-410.58	Added
	QW-410.59	Added
	QW-410.60	Added
	QW-410.61	Added
	QW-410.62	Added
	QW-410.63	Added
74	QW-420	Revised in its entirety
75–127	QW/QB-422	Revised

Page	*Location*	*Change*
128	QW-423.1	In-text table revised
	QW-424.1	In-text table revised
129–135	QW-432	Title corrected by errata
136	QW-433	In-text table revised
138	QW-451.1	Note (1) corrected by errata
139	QW-451.2	Note (1) corrected by errata
142	QW-452.4	Revised
164	QW-462.7	Right callout corrected by errata to read "Braze"
168	QW-462.12	Added
178, 179	QW-466.1	For both Customary and SI units, third entry of first column revised
184, 186, 188, 189	QW/QB-492	(1) Definition of *filler metal, brazing* corrected by errata (2) Definitions of *postweld hydrogen bakeout*; *surface temper bead reinforcing layer*; and *temper bead welding* added
210	QB-300.3	Second paragraph revised
212	QB-305	First paragraph revised
220	QB-452	Title added by errata
224	QB-462.1(c)	Revised
251	QB-484	The sentence above "Company Name" corrected by errata
252–265	Nonmandatory Appendix D	Revised
269	Mandatory Appendix F	Added
270–274	Nonmandatory Appendix G	Added

NOTE: Volume 54 of the Interpretations to Section IX of the ASME Boiler and Pressure Vessel Code follows the last page of the Edition to Section IX.

PART QW WELDING

ARTICLE I
WELDING GENERAL REQUIREMENTS

QW-100 GENERAL

Section IX of the ASME Boiler and Pressure Vessel Code relates to the qualification of welders, welding operators, brazers, and brazing operators, and the procedures that they employ in welding and brazing according to the ASME Boiler and Pressure Vessel Code and the ASME B31 Code for Pressure Piping. It is divided into two parts: Part QW gives requirements for welding and Part QB contains requirements for brazing. Other Sections of the Code may specify different requirements than those specified by this Section. Such requirements take precedence over those of this Section, and the manufacturer or contractor shall comply with them.

QW-100.1 A Welding Procedure Specification (WPS) is a written document that provides direction to the welder or welding operator for making production welds in accordance with Code requirements. Any WPSs used by a manufacturer or contractor that will have responsible operational control of production welding shall be a WPS that has been qualified by that manufacturer or contractor in accordance with Article II, or it shall be an AWS Standard Welding Procedure Specification (SWPS) listed in Appendix E and adopted by that manufacturer or contractor in accordance with Article V.

Both WPSs and SWPSs specify the conditions (including ranges, if any) under which welding must be performed. These conditions include the base metals that are permitted, the filler metals that must be used (if any), preheat and postweld heat treatment requirements, etc. Such conditions are referred to in this Section as welding "variables."

When a WPS is to be prepared by the manufacturer or contractor, it must address, as a minimum, the specific variables, both essential and nonessential, as provided in Article II for each process to be used in production welding. In addition, when other Sections of the Code require notch toughness qualification of the WPS, the applicable supplementary essential variables must be addressed in the WPS.

The purpose for qualification of a WPS is to determine that the weldment proposed for construction is capable of providing the required properties for its intended application. Welding procedure qualification establishes the properties of the weldment, not the skill of the welder or welding operator.

The Procedure Qualification Record (PQR) documents what occurred during welding the test coupon and the results of testing of the coupon. As a minimum, the PQR shall document the essential variables and other specific information identified in Article II for each process used during welding the test coupon and the results of the required testing. In addition, when notch toughness testing is required for procedure qualification, the applicable supplementary essential variables for each process shall be recorded.

QW-100.2 In performance qualification, the basic criterion established for welder qualification is to determine the welder's ability to deposit sound weld metal. The purpose of the performance qualification test for the welding operator is to determine the welding operator's mechanical ability to operate the welding equipment.

QW-100.3 Welding Procedure Specifications (WPS) written and qualified in accordance with the rules of this Section, and welders and welding operators of automatic and machine welding equipment also qualified in accordance with these rules may be used in any construction built to the requirements of the ASME Boiler and Pressure Vessel Code or the ASME B31 Code for Pressure Piping.

However, other Sections of the Code state the conditions under which Section IX requirements are mandatory, in whole or in part, and give additional requirements. The reader is advised to take these provisions into consideration when using this Section.

Welding Procedure Specifications, Procedure Qualification Records, and Welder/Welding Operator Performance Qualification made in accordance with the requirements of the 1962 Edition or any later Edition of Section IX may be used in any construction built to the ASME Boiler and Pressure Vessel Code or the ASME B31 Code for Pressure Piping.

Welding Procedure Specifications, Procedure Qualification Records, and Welder/Welding Operator Performance Qualification made in accordance with the requirements of the Editions of Section IX prior to 1962, in which all of the requirements of the 1962 Edition or later Editions are met, may also be used.

Welding Procedure Specifications and Welder/Welding Operator Performance Qualification records meeting the above requirements do not need to be amended to include any variables required by later Editions and Addenda.

Qualification of new Welding Procedure Specifications or Welders/Welding Operators and requalification of existing Welding Procedure Specifications or Welders/Welding Operators shall be in accordance with the current Edition (see Foreword) and Addenda of Section IX.

QW-101 Scope

The rules in this Section apply to the preparation of Welding Procedure Specifications and the qualification of welding procedures, welders, and welding operators for all types of manual and machine welding processes permitted in this Section. These rules may also be applied, insofar as they are applicable, to other manual or machine welding processes permitted in other Sections.

QW-102 Terms and Definitions

Some of the more common terms relating to welding and brazing are defined in QW/QB-492.

Wherever the word pipe is designated, tube shall also be applicable.

QW-103 Responsibility

QW-103.1 Welding. Each manufacturer[1] or contractor[1] is responsible for the welding done by his organization and shall conduct the tests required in this Section to qualify the welding procedures he uses in the construction of the weldments built under this Code, and the performance of welders and welding operators who apply these procedures.

QW-103.2 Records. Each manufacturer or contractor shall maintain a record of the results obtained in welding procedure and welder and welding operator performance qualifications. These records shall be certified by the manufacturer or contractor and shall be accessible to the Authorized Inspector. Refer to recommended Forms in Nonmandatory Appendix B.

QW-110 WELD ORIENTATION

The orientations of welds are illustrated in figure QW-461.1 or figure QW-461.2.

QW-120 TEST POSITIONS FOR GROOVE WELDS

Groove welds may be made in test coupons oriented in any of the positions in figure QW-461.3 or figure QW-461.4 and as described in the following paragraphs, except that an angular deviation of ±15 deg from the specified horizontal and vertical planes, and an angular deviation of ±5 deg from the specified inclined plane are permitted during welding.

QW-121 Plate Positions

QW-121.1 Flat Position 1G. Plate in a horizontal plane with the weld metal deposited from above. Refer to figure QW-461.3, illustration (a).

QW-121.2 Horizontal Position 2G. Plate in a vertical plane with the axis of the weld horizontal. Refer to figure QW-461.3, illustration (b).

QW-121.3 Vertical Position 3G. Plate in a vertical plane with the axis of the weld vertical. Refer to figure QW-461.3, illustration (c).

QW-121.4 Overhead Position 4G. Plate in a horizontal plane with the weld metal deposited from underneath. Refer to figure QW-461.3, illustration (d).

QW-122 Pipe Positions

QW-122.1 Flat Position 1G. Pipe with its axis horizontal and rolled during welding so that the weld metal is deposited from above. Refer to figure QW-461.4, illustration (a).

QW-122.2 Horizontal Position 2G. Pipe with its axis vertical and the axis of the weld in a horizontal plane. Pipe shall not be rotated during welding. Refer to figure QW-461.4, illustration (b).

QW-122.3 Multiple Position 5G. Pipe with its axis horizontal and with the welding groove in a vertical plane.

[1] Wherever these words are used in Section IX, they shall include installer or assembler.

Welding shall be done without rotating the pipe. Refer to figure QW-461.4, illustration (c).

QW-122.4 Multiple Position 6G. Pipe with its axis inclined at 45 deg to horizontal. Welding shall be done without rotating the pipe. Refer to figure QW-461.4, illustration (d).

QW-123 Test Positions for Stud Welds

QW-123.1 Stud Welding. Stud welds may be made in test coupons oriented in any of the positions as described in QW-121 for plate and QW-122 for pipe (excluding QW-122.1). In all cases, the stud shall be perpendicular to the surface of the plate or pipe. See figures QW-461.7 and QW-461.8.

QW-130 TEST POSITIONS FOR FILLET WELDS

Fillet welds may be made in test coupons oriented in any of the positions of figure QW-461.5 or figure QW-461.6, and as described in the following paragraphs, except that an angular deviation of ±15 deg from the specified horizontal and vertical planes is permitted during welding.

QW-131 Plate Positions

QW-131.1 Flat Position 1F. Plates so placed that the weld is deposited with its axis horizontal and its throat vertical. Refer to figure QW-461.5, illustration (a).

QW-131.2 Horizontal Position 2F. Plates so placed that the weld is deposited with its axis horizontal on the upper side of the horizontal surface and against the vertical surface. Refer to figure QW-461.5, illustration (b).

QW-131.3 Vertical Position 3F. Plates so placed that the weld is deposited with its axis vertical. Refer to figure QW-461.5, illustration (c).

QW-131.4 Overhead Position 4F. Plates so placed that the weld is deposited with its axis horizontal on the underside of the horizontal surface and against the vertical surface. Refer to figure QW-461.5, illustration (d).

QW-132 Pipe Positions

QW-132.1 Flat Position 1F. Pipe with its axis inclined at 45 deg to horizontal and rotated during welding so that the weld metal is deposited from above and at the point of deposition the axis of the weld is horizontal and the throat vertical. Refer to figure QW-461.6, illustration (a).

QW-132.2 Horizontal Positions 2F and 2FR

(a) Position 2F. Pipe with its axis vertical so that the weld is deposited on the upper side of the horizontal surface and against the vertical surface. The axis of the weld will be horizontal and the pipe is not to be rotated during welding. Refer to figure QW-461.6, illustration (b).

(b) Position 2FR. Pipe with its axis horizontal and the axis of the deposited weld in the vertical plane. The pipe is rotated during welding. Refer to figure QW-461.6, illustration (c).

QW-132.3 Overhead Position 4F. Pipe with its axis vertical so that the weld is deposited on the underside of the horizontal surface and against the vertical surface. The axis of the weld will be horizontal and the pipe is not to be rotated during welding. Refer to figure QW-461.6, illustration (d).

QW-132.4 Multiple Position 5F. Pipe with its axis horizontal and the axis of the deposited weld in the vertical plane. The pipe is not to be rotated during welding. Refer to figure QW-461.6, illustration (e).

QW-140 TYPES AND PURPOSES OF TESTS AND EXAMINATIONS

QW-141 Mechanical Tests

Mechanical tests used in procedure or performance qualification are specified in QW-141.1 through QW-141.5.

QW-141.1 Tension Tests. Tension tests as described in QW-150 are used to determine the ultimate strength of groove-weld joints.

QW-141.2 Guided-Bend Tests. Guided-bend tests as described in QW-160 are used to determine the degree of soundness and ductility of groove-weld joints.

QW-141.3 Fillet-Weld Tests. Tests as described in QW-180 are used to determine the size, contour, and degree of soundness of fillet welds.

QW-141.4 Notch-Toughness Tests. Tests as described in QW-171 and QW-172 are used to determine the notch toughness of the weldment.

QW-141.5 Stud-Weld Test. Deflection bend, hammering, torque, or tension tests as shown in figures QW-466.4, QW-466.5, and QW-466.6, and a macro-examination performed in accordance with QW-202.5, respectively, are used to determine acceptability of stud welds.

QW-142 Special Examinations for Welders

Radiographic examination may be substituted for mechanical testing of QW-141 for groove-weld performance qualification as permitted in QW-304 to prove the ability of welders to make sound welds.

QW-143 Examination for Welding Operators

An examination of a weld by radiography may be substituted for mechanical testing of QW-141 for groove weld performance qualification as permitted in QW-305 to prove the ability of welding operators to make sound welds.

QW-144 Visual Examination

Visual examination as described in QW-194 is used to determine that the final weld surfaces meet specified quality conditions.

QW-150 TENSION TESTS

QW-151 Specimens

Tension test specimens shall conform to one of the types illustrated in figures QW-462.1(a) through QW-462.1(e) and shall meet the requirements of QW-153.

QW-151.1 Reduced Section — Plate. Reduced-section specimens conforming to the requirements given in figure QW-462.1(a) may be used for tension tests on all thicknesses of plate.

(a) For thicknesses up to and including 1 in. (25 mm), a full thickness specimen shall be used for each required tension test.

(b) For plate thickness greater than 1 in. (25 mm), full thickness specimens or multiple specimens may be used, provided QW-151.1(c) and QW-151.1(d) are complied with.

(c) When multiple specimens are used, in lieu of full thickness specimens, each set shall represent a single tension test of the full plate thickness. Collectively, all of the specimens required to represent the full thickness of the weld at one location shall comprise a set.

(d) When multiple specimens are necessary, the entire thickness shall be mechanically cut into a minimum number of approximately equal strips of a size that can be tested in the available equipment. Each specimen of the set shall be tested and meet the requirements of QW-153.

QW-151.2 Reduced Section — Pipe. Reduced-section specimens conforming to the requirements given in figure QW-462.1(b) may be used for tension tests on all thicknesses of pipe having an outside diameter greater than 3 in. (75 mm).

(a) For thicknesses up to and including 1 in. (25 mm), a full thickness specimen shall be used for each required tension test.

(b) For pipe thicknesses greater than 1 in. (25 mm), full thickness specimens or multiple specimens may be used, provided QW-151.2(c) and QW-151.2(d) are complied with.

(c) When multiple specimens are used, in lieu of full thickness specimens, each set shall represent a single tension test of the full pipe thickness. Collectively, all of the specimens required to represent the full thickness of the weld at one location shall comprise a set.

(d) When multiple specimens are necessary, the entire thickness shall be mechanically cut into a minimum number of approximately equal strips of a size that can be tested in the available equipment. Each specimen of the set shall be tested and meet the requirements of QW-153.

For pipe having an outside diameter of 3 in. (75 mm) or less, reduced-section specimens conforming to the requirements given in figure QW-462.1(c) may be used for tension tests.

QW-151.3 Turned Specimens. Turned specimens conforming to the requirements given in figure QW-462.1(d) may be used for tension tests.

(a) For thicknesses up to and including 1 in. (25 mm), a single turned specimen may be used for each required tension test, which shall be a specimen of the largest diameter *D* of figure QW-462.1(d) possible for test coupon thickness [per Note (a) of figure QW-462.1(d)].

(b) For thicknesses over 1 in. (25 mm), multiple specimens shall be cut through the full thickness of the weld with their centers parallel to the metal surface and not over 1 in. (25 mm) apart. The centers of the specimens adjacent to the metal surfaces shall not exceed $\frac{5}{8}$ in. (16 mm) from the surface.

(c) When multiple specimens are used, each set shall represent a single required tension test. Collectively, all the specimens required to represent the full thickness of the weld at one location shall comprise a set.

(d) Each specimen of the set shall be tested and meet the requirements of QW-153.

QW-151.4 Full-Section Specimens for Pipe. Tension specimens conforming to the dimensions given in figure QW-462.1(e) may be used for testing pipe with an outside diameter of 3 in. (75 mm) or less.

QW-152 Tension Test Procedure

The tension test specimen shall be ruptured under tensile load. The tensile strength shall be computed by dividing the ultimate total load by the least cross-sectional area

of the specimen as calculated from actual measurements made before the load is applied.

QW-153 Acceptance Criteria — Tension Tests

QW-153.1 Tensile Strength. Minimum values for procedure qualification are provided under the column heading "Minimum Specified Tensile, ksi" of table QW/QB-422. In order to pass the tension test, the specimen shall have a tensile strength that is not less than:

(a) the minimum specified tensile strength of the base metal; or

(b) the minimum specified tensile strength of the weaker of the two, if base metals of different minimum tensile strengths are used; or

(c) the minimum specified tensile strength of the weld metal when the applicable Section provides for the use of weld metal having lower room temperature strength than the base metal;

(d) if the specimen breaks in the base metal outside of the weld or weld interface, the test shall be accepted as meeting the requirements, provided the strength is not more than 5% below the minimum specified tensile strength of the base metal.

(e) the specified minimum tensile strength is for full thickness specimens including cladding for Aluminum Alclad materials (P-No. 21 through P-No. 23) less than ½ in. (13 mm). For Aluminum Alclad materials ½ in. (13 mm) and greater, the specified minimum tensile strength is for both full thickness specimens that include cladding and specimens taken from the core.

QW-160 GUIDED-BEND TESTS

QW-161 Specimens

Guided-bend test specimens shall be prepared by cutting the test plate or pipe to form specimens of approximately rectangular cross section. The cut surfaces shall be designated the sides of the specimen. The other two surfaces shall be called the face and root surfaces, the face surface having the greater width of weld. The specimen thickness and bend radius are shown in figures QW-466.1, QW-466.2, and QW-466.3. Guided-bend specimens are of five types, depending on whether the axis of the weld is transverse or parallel to the longitudinal axis of the specimen, and which surface (side, face, or root) is on the convex (outer) side of bent specimen. The five types are defined as follows.

QW-161.1 Transverse Side Bend. The weld is transverse to the longitudinal axis of the specimen, which is bent so that one of the side surfaces becomes the convex surface of the bent specimen. Transverse side-bend test specimens shall conform to the dimensions shown in figure QW-462.2.

Specimens of base metal thickness over 1½ in. (38 mm) may be cut into approximately equal strips between ¾ in. (19 mm) and 1½ in. (38 mm) wide for testing, or the specimens may be bent at full width (see requirements on jig width in QW-466). If multiple specimens are used, one complete set shall be made for each required test. Each specimen shall be tested and meet the requirements in QW-163.

QW-161.2 Transverse Face Bend. The weld is transverse to the longitudinal axis of the specimen, which is bent so that the face surface becomes the convex surface of the bent specimen. Transverse face-bend test specimens shall conform to the dimensions shown in figure QW-462.3(a). For subsize transverse face bends, see QW-161.4.

QW-161.3 Transverse Root Bend. The weld is transverse to the longitudinal axis of the specimen, which is bent so that the root surface becomes the convex surface of the bent specimen. Transverse root-bend test specimens shall conform to the dimensions shown in figure QW-462.3(a). For subsize transverse root bends, see QW-161.4.

QW-161.4 Subsize Transverse Face and Root Bends. See Note (2) of figure QW-462.3(a).

QW-161.5 Longitudinal-Bend Tests. Longitudinal-bend tests may be used in lieu of the transverse side-bend, face-bend, and root-bend tests for testing weld metal or base metal combinations, which differ markedly in bending properties between

(a) the two base metals; or

(b) the weld metal and the base metal.

QW-161.6 Longitudinal Face Bend. The weld is parallel to the longitudinal axis of the specimen, which is bent so that the face surface becomes the convex surface of the bent specimen. Longitudinal face-bend test specimens shall conform to the dimensions shown in figure QW-462.3(b).

QW-161.7 Longitudinal Root Bend. The weld is parallel to the longitudinal axis of the specimen, which is bent so that the root surface becomes the convex side of the bent specimen. Longitudinal root-bend test specimens shall conform to the dimensions shown in figure QW-462.3(b).

QW-162 Guided-Bend Test Procedure

QW-162.1 Jigs. Guided-bend specimens shall be bent in test jigs that are in substantial accordance with QW-466. When using the jigs illustrated in figure QW-466.1

or figure QW-466.2, the side of the specimen turned toward the gap of the jig shall be the face for face-bend specimens, the root for root-bend specimens, and the side with the greater discontinuities, if any, for side-bend specimens. The specimen shall be forced into the die by applying load on the plunger until the curvature of the specimen is such that a $\frac{1}{8}$ in. (3 mm) diameter wire cannot be inserted between the specimen and the die of figure QW-466.1, or the specimen is bottom ejected if the roller type of jig (figure QW-466.2) is used.

When using the wrap around jig (figure QW-466.3), the side of the specimen turned toward the roller shall be the face for face-bend specimens, the root for root-bend specimens, and the side with the greater discontinuities, if any, for side-bend specimens.

When specimens wider than $1\frac{1}{2}$ in. (38 mm) are to be bent as permitted in figure QW-462.2, the test jig mandrel must be at least $\frac{1}{4}$ in. (6 mm) wider than the specimen width.

QW-163 Acceptance Criteria — Bend Tests

The weld and heat-affected zone of a transverse weld-bend specimen shall be completely within the bent portion of the specimen after testing.

The guided-bend specimens shall have no open discontinuity in the weld or heat-affected zone exceeding $\frac{1}{8}$ in. (3 mm), measured in any direction on the convex surface of the specimen after bending. Open discontinuities occurring on the corners of the specimen during testing shall not be considered unless there is definite evidence that they result from lack of fusion, slag inclusions, or other internal discontinuities. For corrosion-resistant weld overlay cladding, no open discontinuity exceeding $\frac{1}{16}$ in. (1.5 mm), measured in any direction, shall be permitted in the cladding, and no open discontinuity exceeding $\frac{1}{8}$ in. (3 mm) shall be permitted along the approximate weld interface.

QW-170 NOTCH-TOUGHNESS TESTS

QW-171 Notch-Toughness Tests — Charpy V-Notch

QW-171.1 General. Charpy V-notch impact tests shall be made when required by other Sections.

Test procedures and apparatus shall conform to the requirements of SA-370.

QW-171.2 Acceptance. The acceptance criteria shall be in accordance with that Section specifying impact requirements.

QW-171.3 Location and Orientation of Test Specimen. The impact test specimen and notch location and orientation shall be as given in the Section requiring such tests.

When qualifying pipe in the 5G or 6G position, the notch-toughness specimens shall be removed from the shaded portion of figure QW-463.1(f).

QW-172 Notch-Toughness Tests — Drop Weight

QW-172.1 General. Drop weight tests shall be made when required by other Sections.

Test procedures and apparatus shall conform to the requirements of ASTM Specification E 208.

QW-172.2 Acceptance. The acceptance criteria shall be in accordance with that Section requiring drop weight tests.

QW-172.3 Location and Orientation of Test Specimen. The drop weight test specimen, the crack starter location, and the orientation shall be as given in the Section requiring such tests.

When qualifying pipe in the 5G or 6G position, the notch-toughness specimens shall be removed from the shaded portion of figure QW-463.1(f).

QW-180 FILLET-WELD TESTS

QW-181 Procedure and Performance Qualification Specimens

QW-181.1 Procedure. The dimensions and preparation of the fillet-weld test coupon for procedure qualification as required in QW-202 shall conform to the requirements in figure QW-462.4(a) or figure QW-462.4(d). The test coupon for plate-to-plate shall be cut transversely to provide five test specimen sections, each approximately 2 in. (50 mm) long. For pipe-to-plate or pipe-to-pipe, the test coupon shall be cut transversely to provide four approximately equal test specimen sections. The test specimens shall be macro-examined to the requirements of QW-183.

QW-181.1.1 Production Assembly Mockups. Production assembly mockups may be used in lieu of QW-181.1. The mockups for plate-to-shape shall be cut transversely to provide five approximately equal test specimens not to exceed approximately 2 in. (50 mm) in length. For pipe-to-shape mockups, the mockup shall be cut transversely to provide four approximately equal test specimens. For small mockups, multiple mockups may be required to obtain the required number of test specimens. The test specimens shall be macro-examined to the requirements of QW-183.

QW-181.2 Performance. The dimensions and the preparation of the fillet-weld test coupon for performance

qualification shall conform to the requirements in figure QW-462.4(b) or figure QW-462.4(c). The test coupon for plate-to-plate shall be cut transversely to provide a center section approximately 4 in. (100 mm) long and two end sections, each approximately 1 in. (25 mm) long. For pipe-to-plate or pipe-to-pipe, the test coupon shall be cut to provide two quarter sections test specimens opposite to each other. One of the test specimens shall be fracture tested in accordance with QW-182 and the other macro-examined to the requirements of QW-184. When qualifying pipe-to-plate or pipe-to-pipe in the 5F position, the test specimens shall be removed as indicated in figure QW-463.2(h).

QW-181.2.1 Production Assembly Mockups. Production assembly mockups may be used in lieu of the fillet-weld test coupon requirements of QW-181.2.

(a) Plate-to-shape

(1) The mockup for plate-to-shape shall be cut transversely to provide three approximately equal test specimens not to exceed approximately 2 in. (50 mm) in length. The test specimen that contains the start and stop of the weld shall be fracture tested in accordance with QW-182. A cut end of one of the remaining test specimens shall be macro-examined in accordance with QW-184.

(b) Pipe-to-shape

(1) The mockup for pipe-to-shape shall be cut transversely to provide two quarter sections approximately opposite to each other. The test specimen that contains the start and stop of the weld shall be fracture tested in accordance with QW-182. A cut end of the other quarter section shall be macro-examined in accordance with QW-184. When qualifying pipe-to-shape in the 5F position, the fracture specimen shall be removed from the lower 90 deg section of the mockup.

QW-182 Fracture Tests

The stem of the 4 in. (100 mm) performance specimen center section in figure QW-462.4(b) or the stem of the quarter section in figure QW-462.4(c), as applicable, shall be loaded laterally in such a way that the root of the weld is in tension. The load shall be steadily increased until the specimen fractures or bends flat upon itself.

If the specimen fractures, the fractured surface shall show no evidence of cracks or incomplete root fusion, and the sum of the lengths of inclusions and porosity visible on the fractured surface shall not exceed $\frac{3}{8}$ in. (10 mm) in figure QW-462.4(b) or 10% of the quarter section in figure QW-462.4(c).

QW-183 Macro-Examination — Procedure Specimens

One face of each cross section of the five test specimens in figure QW-462.4(a) or four test specimens in figure QW-462.4(d), as applicable shall be smoothed and etched with a suitable etchant (see QW-470) to give a clear definition to the weld metal and heat affected zone. The examination of the cross sections shall include only one side of the test specimen at the area where the plate or pipe is divided into sections i.e., adjacent faces at the cut shall not be used. In order to pass the test

(a) visual examination of the cross sections of the weld metal and heat-affected zone shall show complete fusion and freedom from cracks

(b) there shall be not more than $\frac{1}{8}$ in. (3 mm) difference in the length of the legs of the fillet

QW-184 Macro-Examination — Performance Specimens

The cut end of one of the end plate sections, approximately 1 in. (25 mm) long, in figure QW-462.4(b) or the cut end of one of the pipe quarter sections in figure QW-462.4(c), as applicable, shall be smoothed and etched with a suitable etchant (see QW-470) to give a clear definition of the weld metal and heat affected zone. In order to pass the test

(a) visual examination of the cross section of the weld metal and heat-affected zone shall show complete fusion and freedom from cracks, except that linear indications at the root not exceeding $\frac{1}{32}$ in. (0.8 mm) shall be acceptable

(b) the weld shall not have a concavity or convexity greater than $\frac{1}{16}$ in. (1.5 mm)

(c) there shall be not more than $\frac{1}{8}$ in. (3 mm) difference in the lengths of the legs of the fillet

QW-190 OTHER TESTS AND EXAMINATIONS

QW-191 Radiographic Examination

QW-191.1 Method. The radiographic examination in QW-142 for welders and in QW-143 for welding operators shall meet the requirements of Article 2, Section V, except as follows:

(a) A written radiographic examination procedure is not required. Demonstration of density and penetrameter image requirements on production or technique radiographs shall be considered satisfactory evidence of compliance with Article 2 of Section V.

(b) The requirements of T-285 of Article 2 of Section V are to be used only as a guide. Final acceptance of