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BEFORE THE ARIZONA CORPORATION COMMISSION

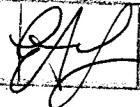
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SUSAN BITTER SMITH
Chairman
BOB STUMP
Commissioner
BOB BURNS
Commissioner
DOUG LITTLE
Commissioner
TOM FORESE
Commissioner

Arizona Corporation Commission

DOCKETED

AUG 14 2015

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RECEIVED

2015 AUG 14 P 1:02

AZ CORP COMMISSION
DOCKET CONTROL

ORIGINAL

IN THE MATTER OF COMMISSION PIPELINE
SAFETY SECTION STAFF'S COMPLAINT
AGAINST DESERT GAS, LP, FOR VIOLATIONS
OF COMMISSION RULES.

DOCKET NO. G-20923A-15-0030

STAFF'S NOTICE OF FILING
LATE FILED EXHIBITS

During the evidentiary hearing held in the above captioned complaint, Staff was directed to file as late-filed exhibits, copies of various standards incorporated by reference into the Arizona Administrative Code, as well as a confirmation regarding the operating temperature for the process piping involved in the methane compressor addition at DG's Ehrenberg facility. Staff hereby provides notice of filing the attached documents. Attachment A is a collection of screenshots of operating temperatures for the suction lines at the facility that DG provided to Staff as well as a chain of emails between Staff and a representative of DG explaining that the graphs show that the suction lines operate at temperatures in a range of approximately 58 to 98 degrees Fahrenheit. Attachment B is a photocopy of excerpted portions of the American Society of Mechanical Engineers ("ASME") Standard B31.3 (1996 Edition) sections 328.2.1 (a), 328.2.2 and 341.3.4. Attachment C is a photocopy of National Fire Protection Association ("NFPA") Code standard 59(A) (2001 Edition) Section 6.6.3.2. Attachment D is a copy of ASME Boiler Pressure Vessel Code (1995 Edition) Section IX.

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1 As was directed at the hearing, Staff is only provided the specified excerpted provisions.
2 Staff would note that the full ASME Standard B31.3 is voluminous (it is approximately 700
3 pages), and the NFPA Code standard 59(A) is approximately 60 pages. However, Staff is prepared
4 to make those available if it would be helpful to better understand the respective code provisions.

5 RESPECTFULLY SUBMITTED this 14th day of August, 2015.

6 

7
8 Charles H. Hains
9 Attorney, Legal Division
10 Arizona Corporation Commission
11 1200 West Washington Street
12 Phoenix, Arizona 85007
13 (602) 542-3402

14 The original and thirteen (13) copies
15 of the foregoing were filed this
16 14th day of August, 2015 with:

17 Docket Control
18 Arizona Corporation Commission
19 1200 West Washington Street
20 Phoenix, Arizona 85007

21 Copy of the foregoing mailed this
22 14th day of August, 2015 to:

23 Bret Bartholomey
24 Desert Gas, LP
25 1709 Utica Square - 240
26 Tulsa, OK 74114

27 Mr. Raymond Latchem, President
28 Desert Gas Services
1709 Utica Square - 240
Tulsa, OK 74114

Mr. Robert E. Marvin, Director, Safety Division
Arizona Corporation Commission
2200 North Central Avenue, Suite #300
Phoenix, AZ 85004

Jason D. Gellman
Snell & Wilmer, LLP
One Arizona Center
400 East Van Buren Street, Suite 1900
Phoenix, Arizona 85004
Attorney for Desert Gas, LP

28 

ATTACHMENT A

Charles Hains

From: Robert Miller
Sent: Friday, August 14, 2015 11:00 AM
To: Charles Hains
Subject: Fwd: MRC suction line temps

Here is a brief explanation of how to read the chart and confirmation from DGS.

Sent from my Verizon Wireless 4G LTE DROID

----- Original Message -----

Subject: FW: MRC suction line temps
From: Scott Frye <SFrye@azcc.gov>
To: Robert Miller <RMiller@azcc.gov>
CC:

Let me know if you get this.

Thank you,

Bryan Frye
Arizona Corporation Commission
Senior Pipeline Safety Inspector
2200 North Central Avenue Suite 200
Phoenix, AZ 85004
(602) 262-5601

From: Bret Bartholomy [bret@spectruming.com]
Sent: Tuesday, August 11, 2015 1:36 PM
To: Scott Frye
Cc: Robert Miller
Subject: RE: MRC suction line temps

Yes, that is correct.

-----Original Message-----

From: Scott Frye [<mailto:SFrye@azcc.gov>]
Sent: Tuesday, August 11, 2015 3:23 PM
To: Bret Bartholomy
Cc: Robert Miller
Subject: RE: MRC suction line temps

Bret,

In reviewing the charts it appears that the number in the upper right hand corner represents the temperature reflected on the line chart. If that is the case, then the operational temperature of the line in question has an range of approximately 58 to 98 degrees Fahrenheit. Would that be an accurate statement?

Thank you,

Bryan Frye

Arizona Corporation Commission
Senior Pipeline Safety Inspector
2200 North Central Avenue Suite 300
Phoenix, AZ 85004
(602) 262-5601

From: Bret Bartholomy [bret@spectrumlng.com]
Sent: Monday, August 10, 2015 6:57 AM
To: Scott Frye
Subject: MRC suction line temps

Bryan,

These screen shots show the temperatures the MRC suction lines operate at. This is 2015 data since the computer doesn't archive more than 6 months history.

The suction lines on MRC-6 you asked about were in continuous service from 7/28/14 to 9/17/14 when we removed them and performed an additional 15 xrays.

Let me know if you need anything else,
Bret

[cid:image001.png@01D0D34A.3B0D4370]

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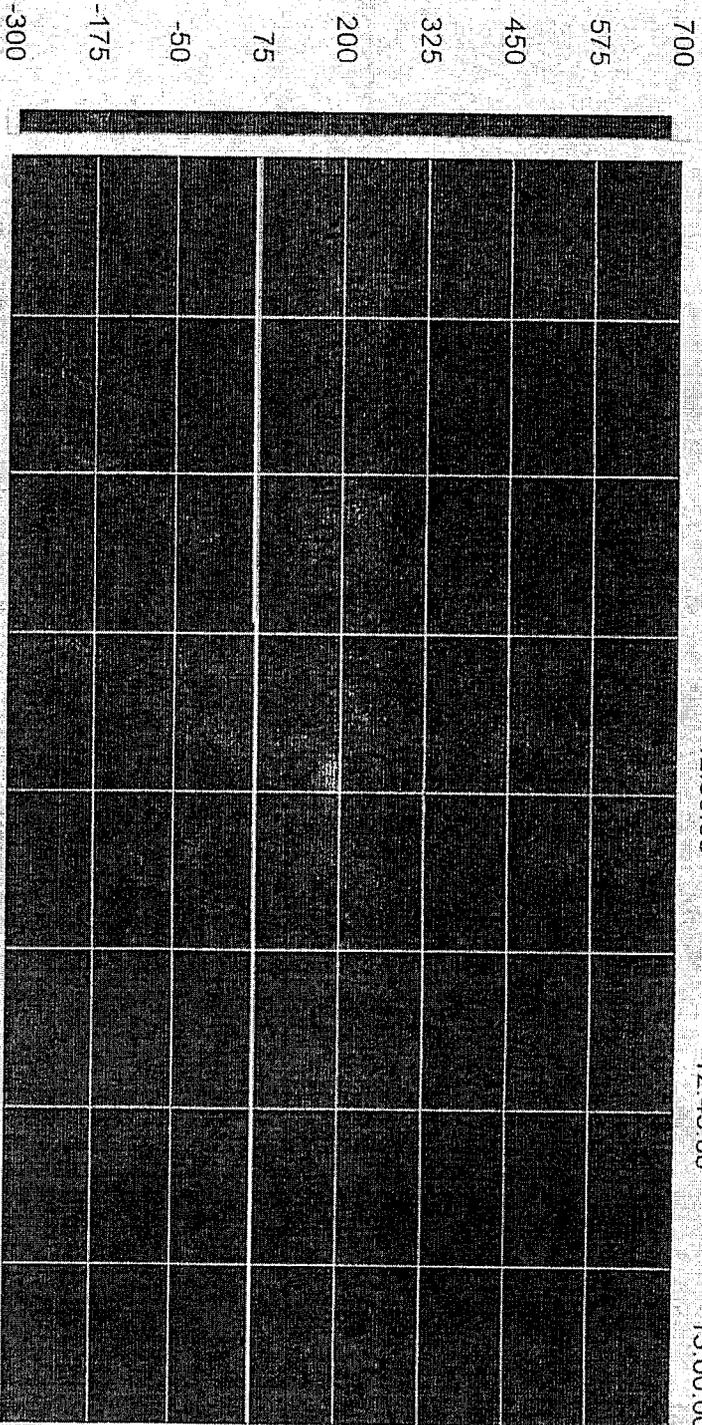
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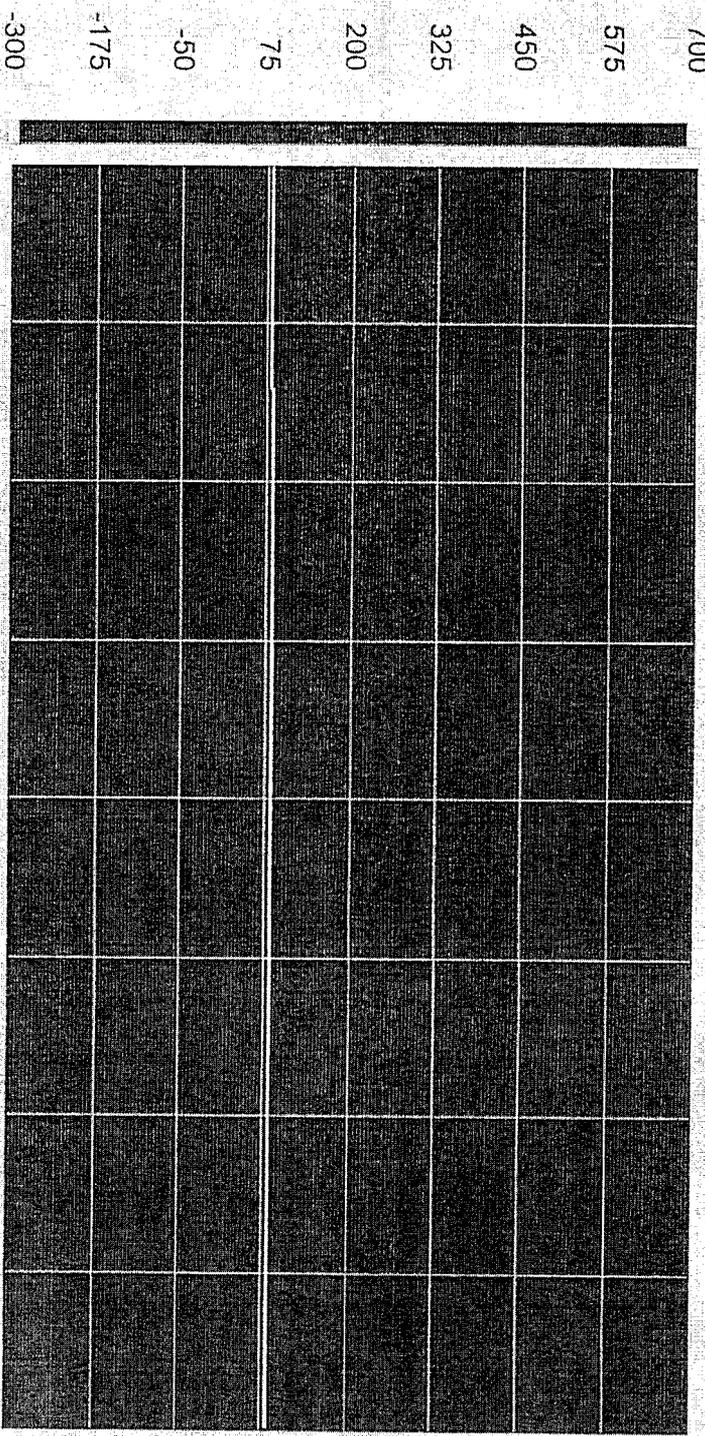
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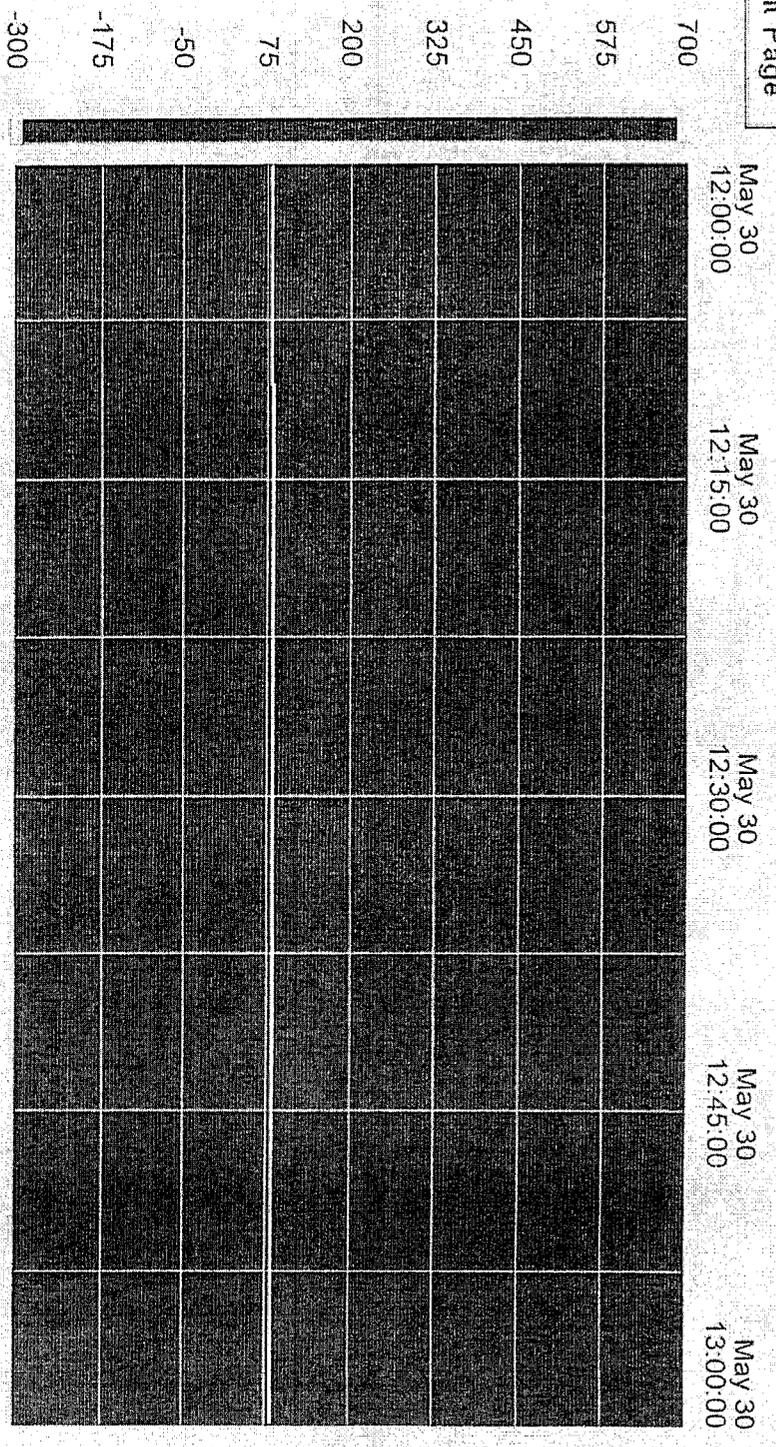
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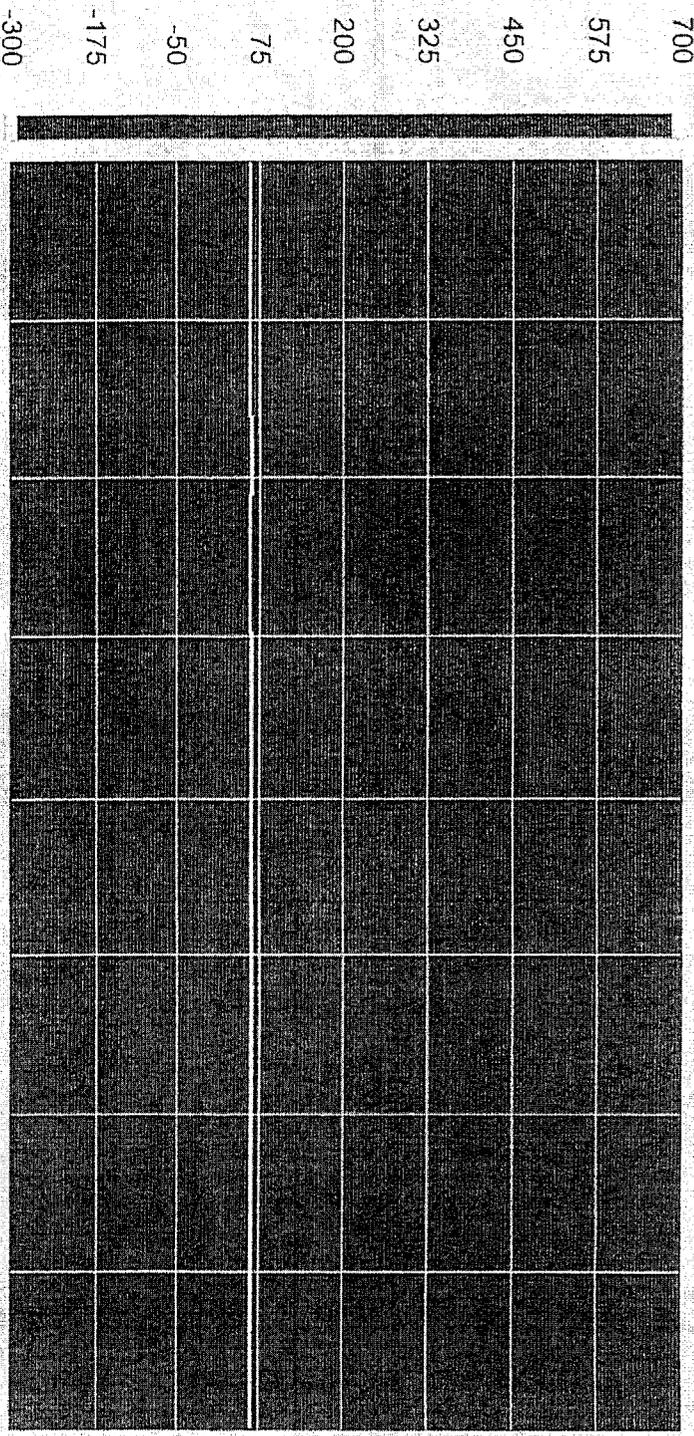
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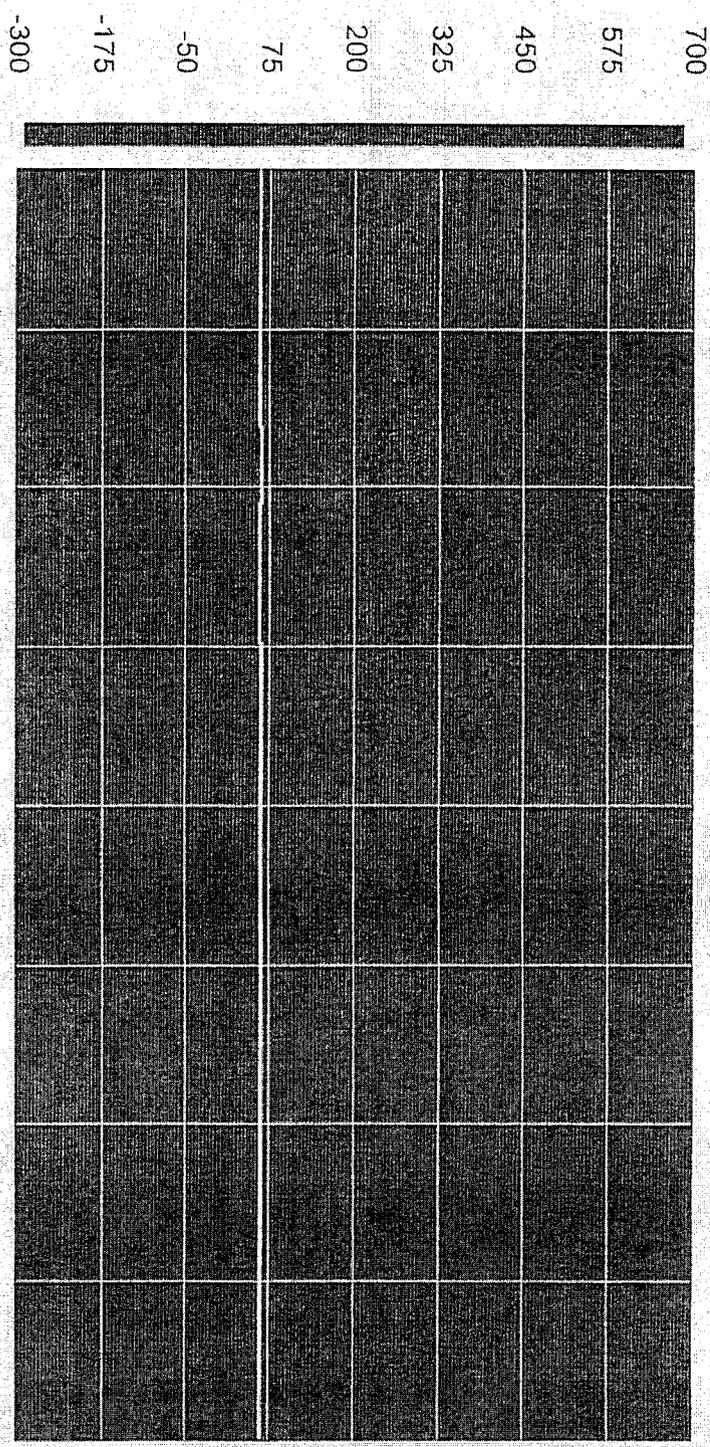
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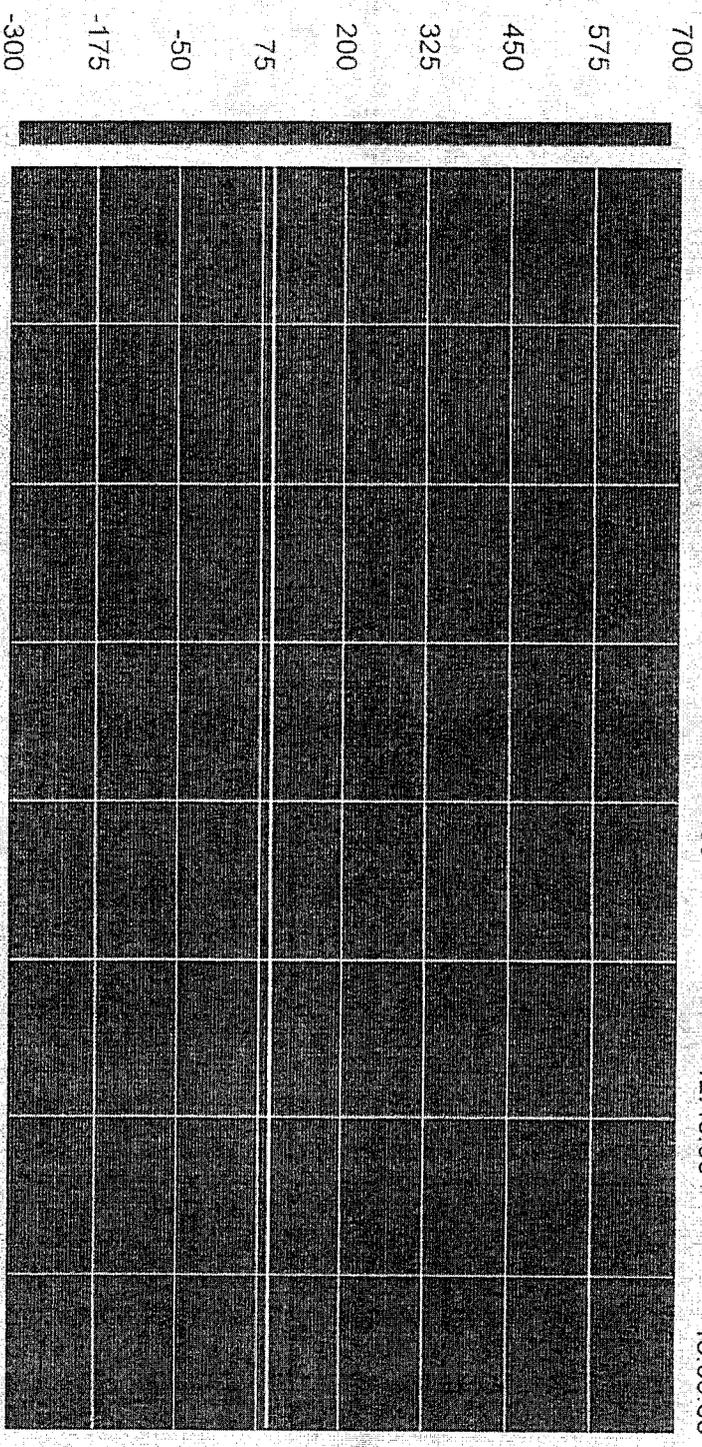
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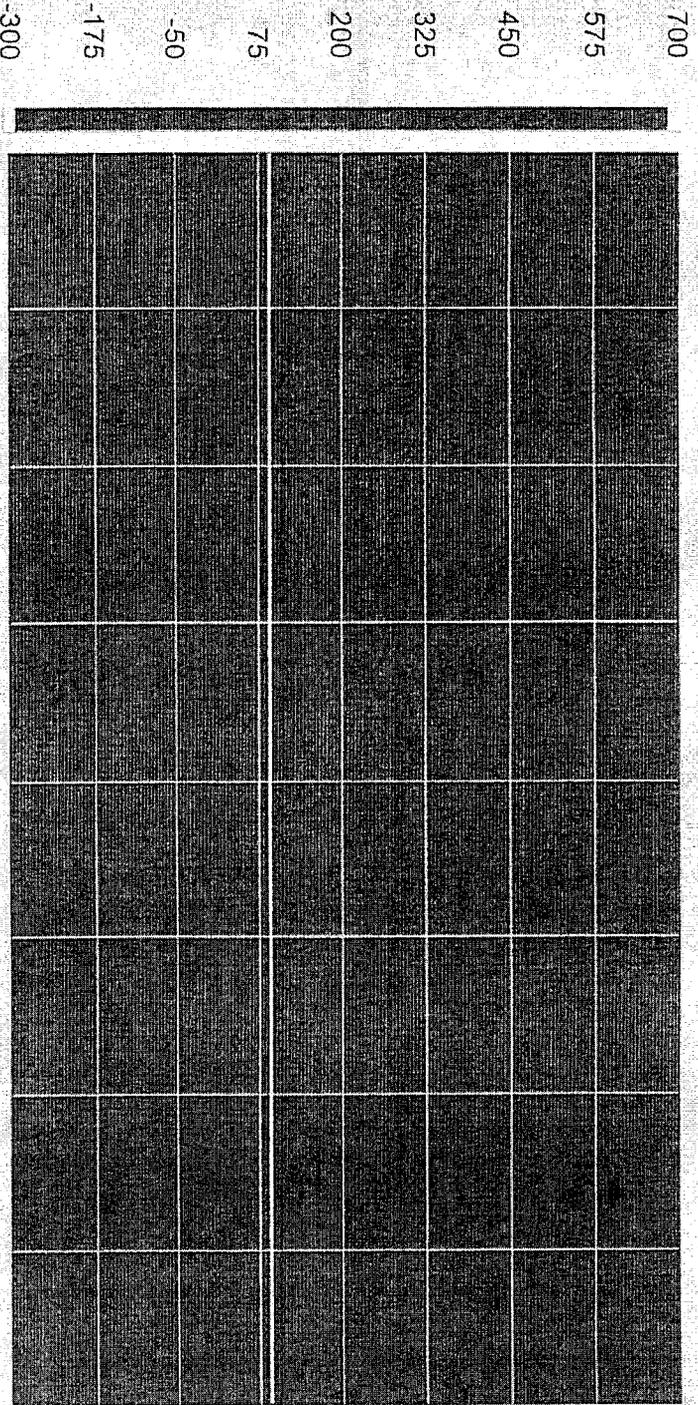
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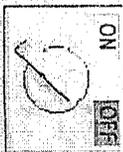
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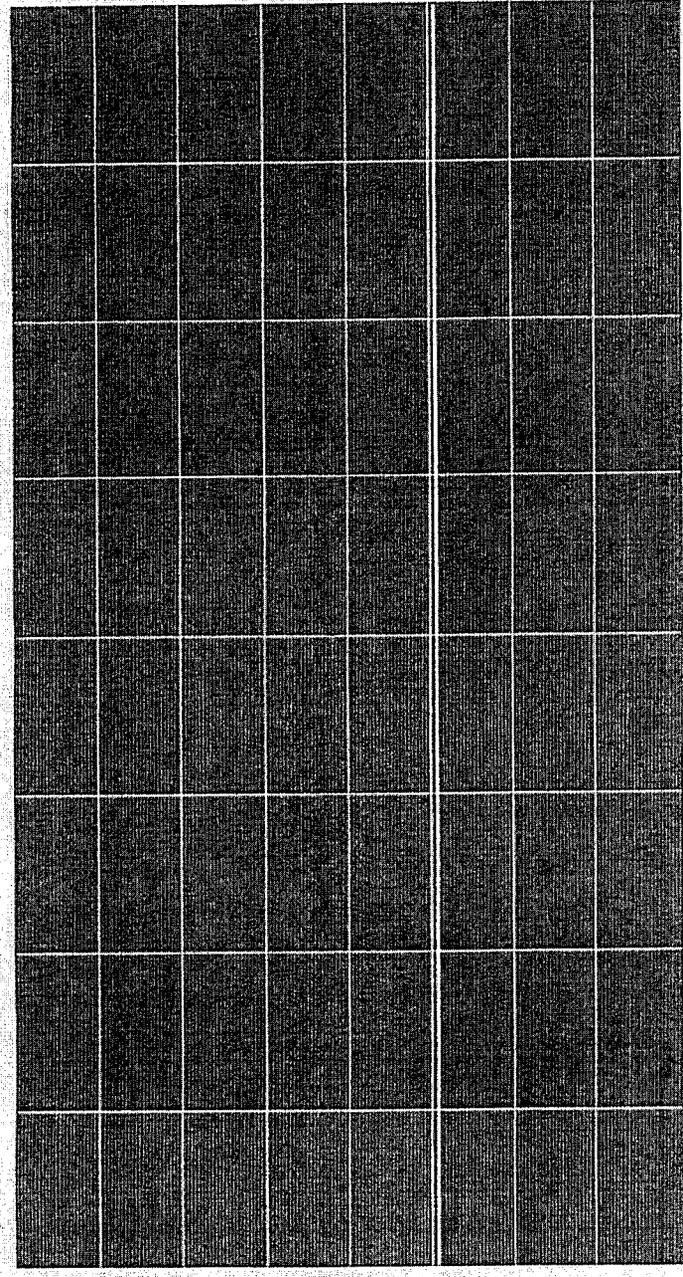
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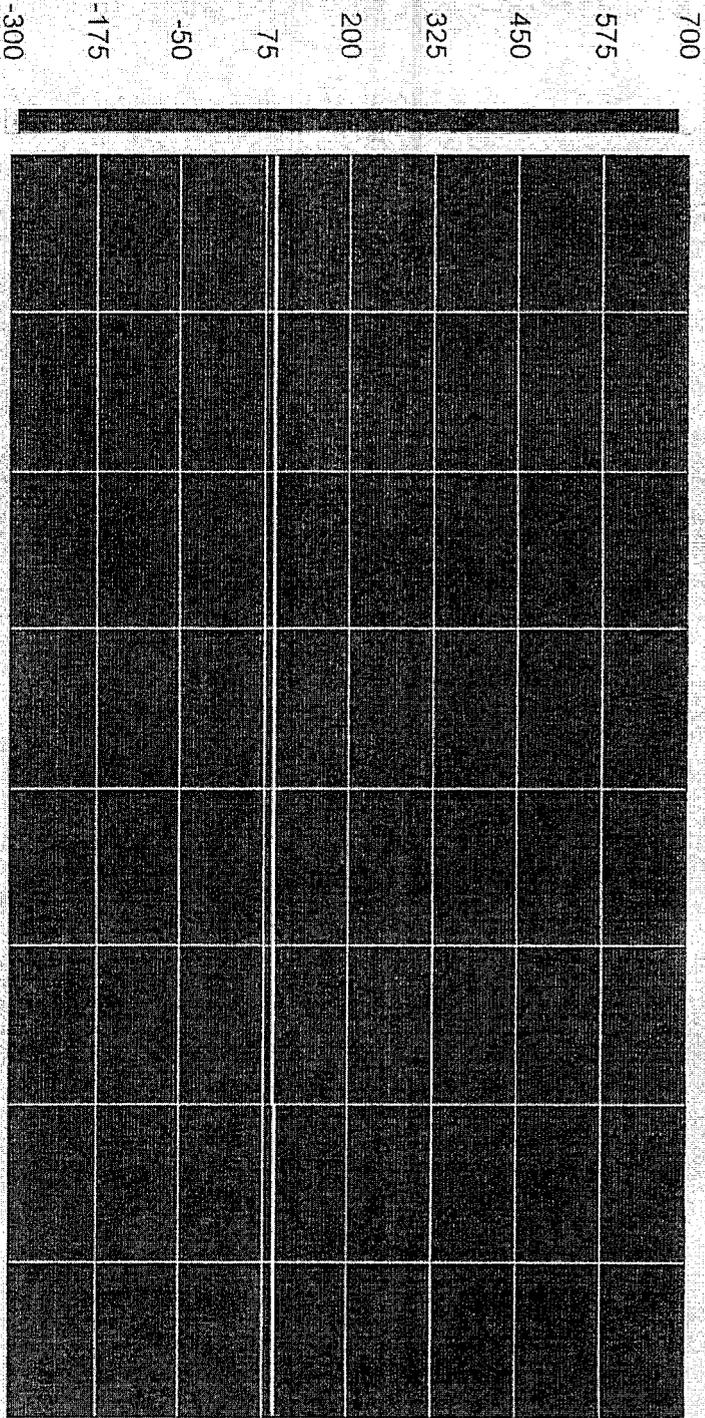
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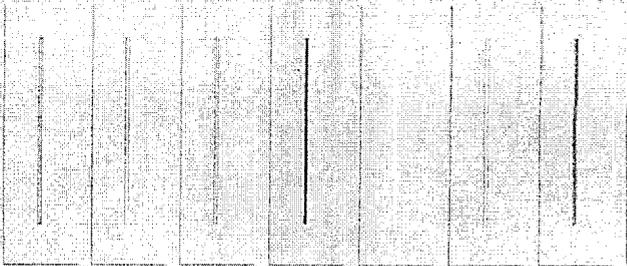


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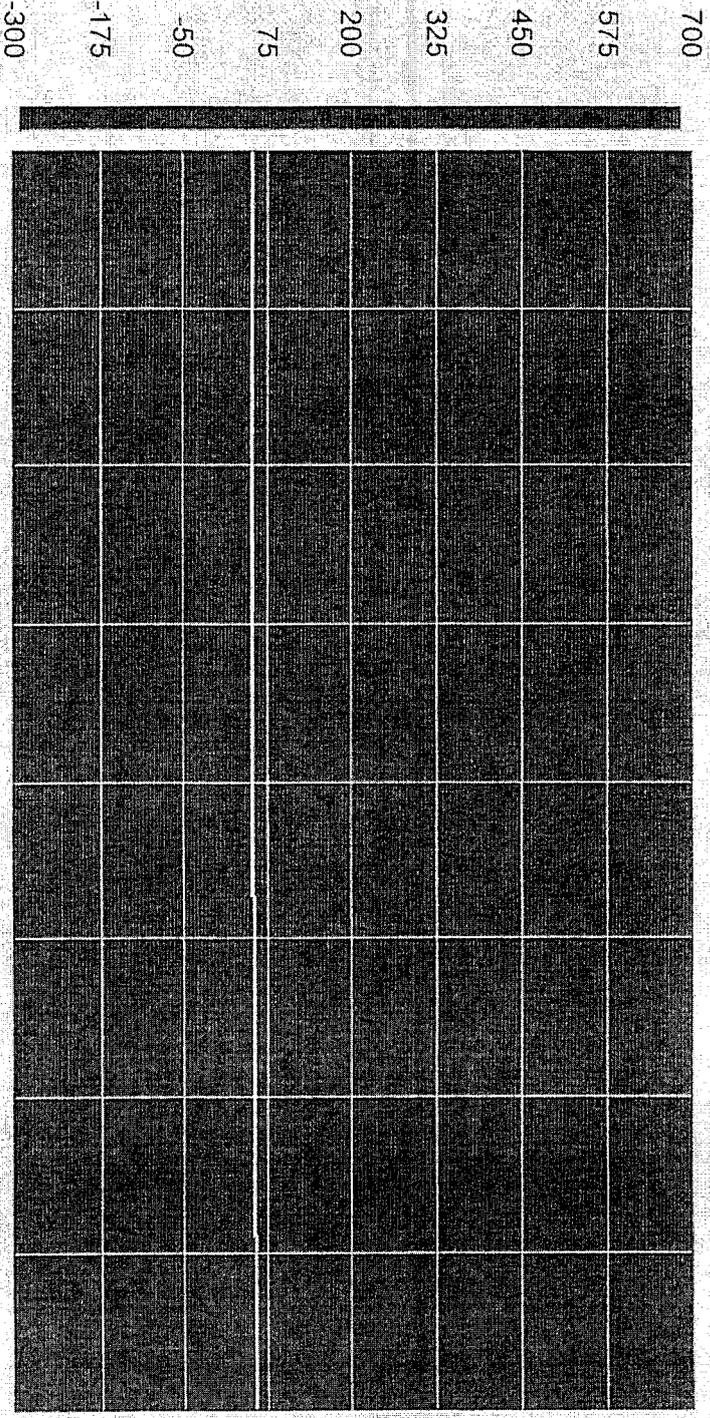


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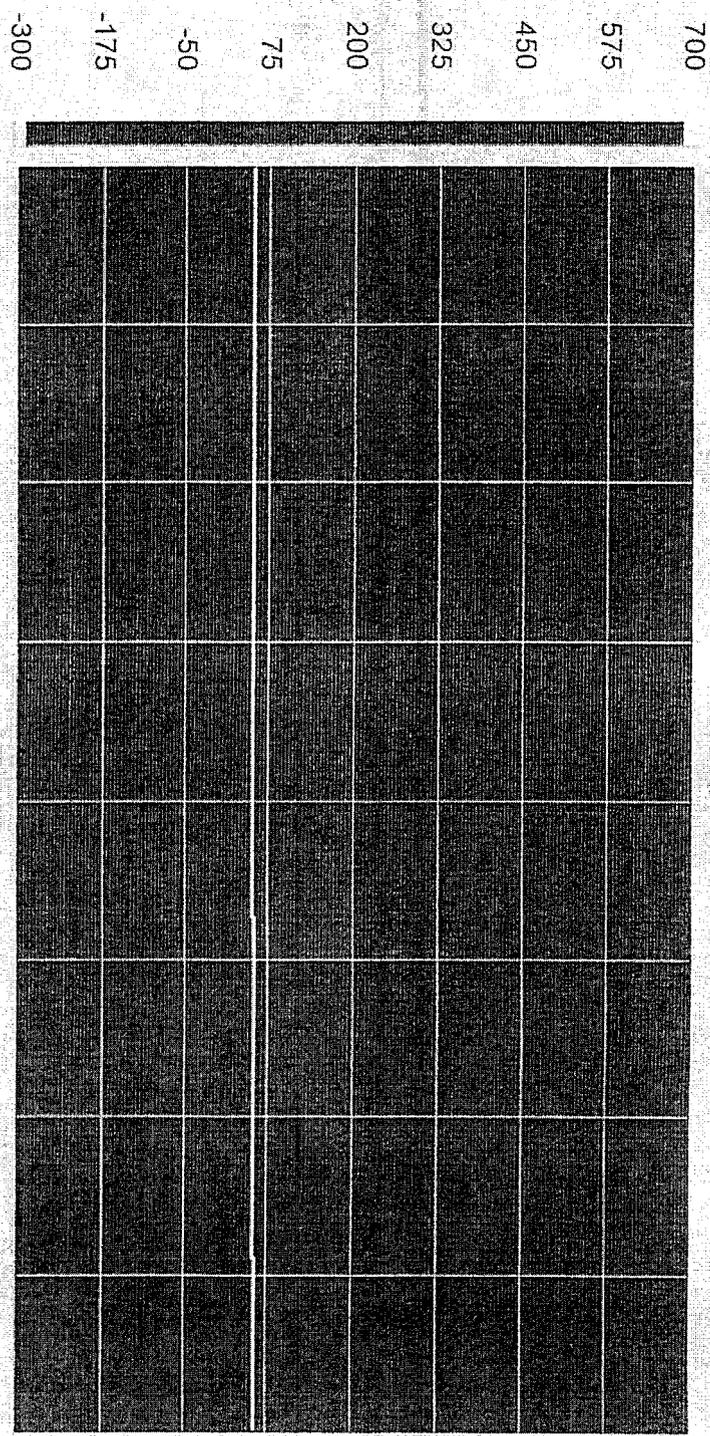
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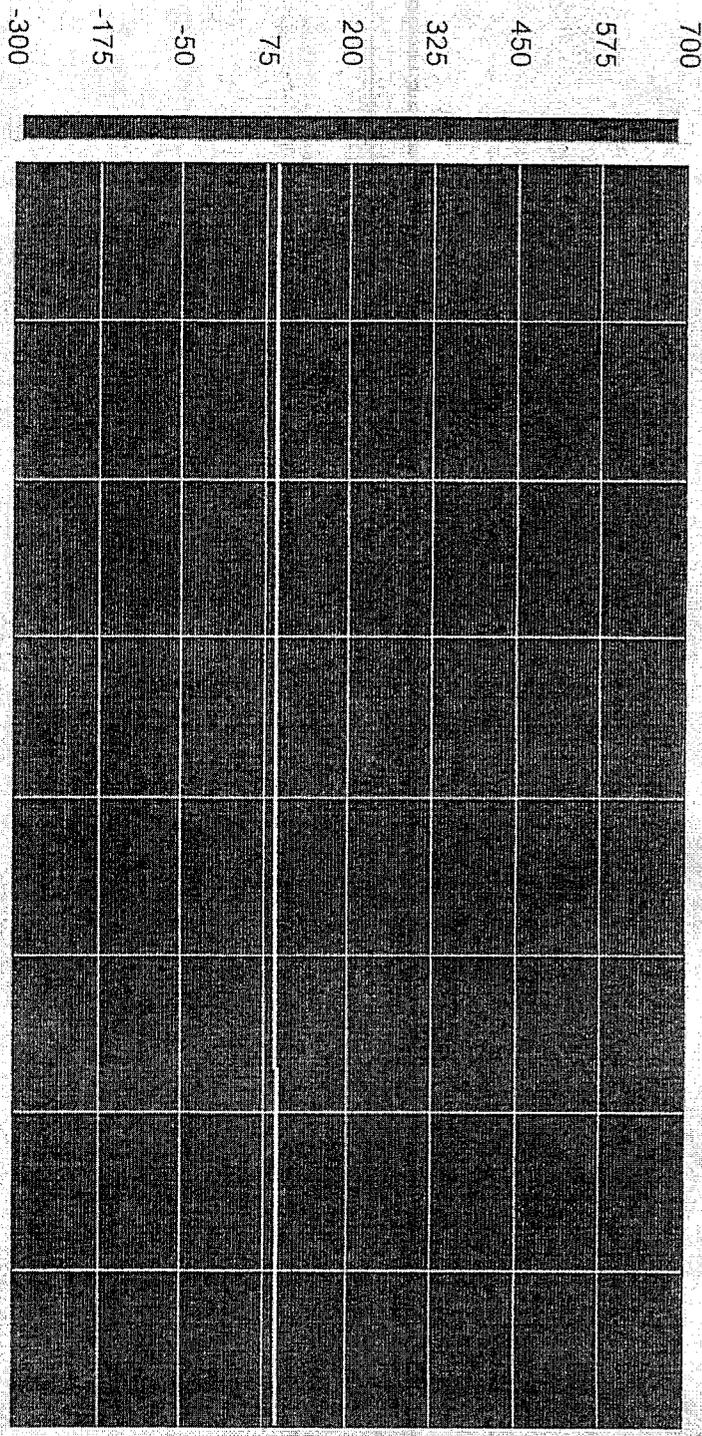
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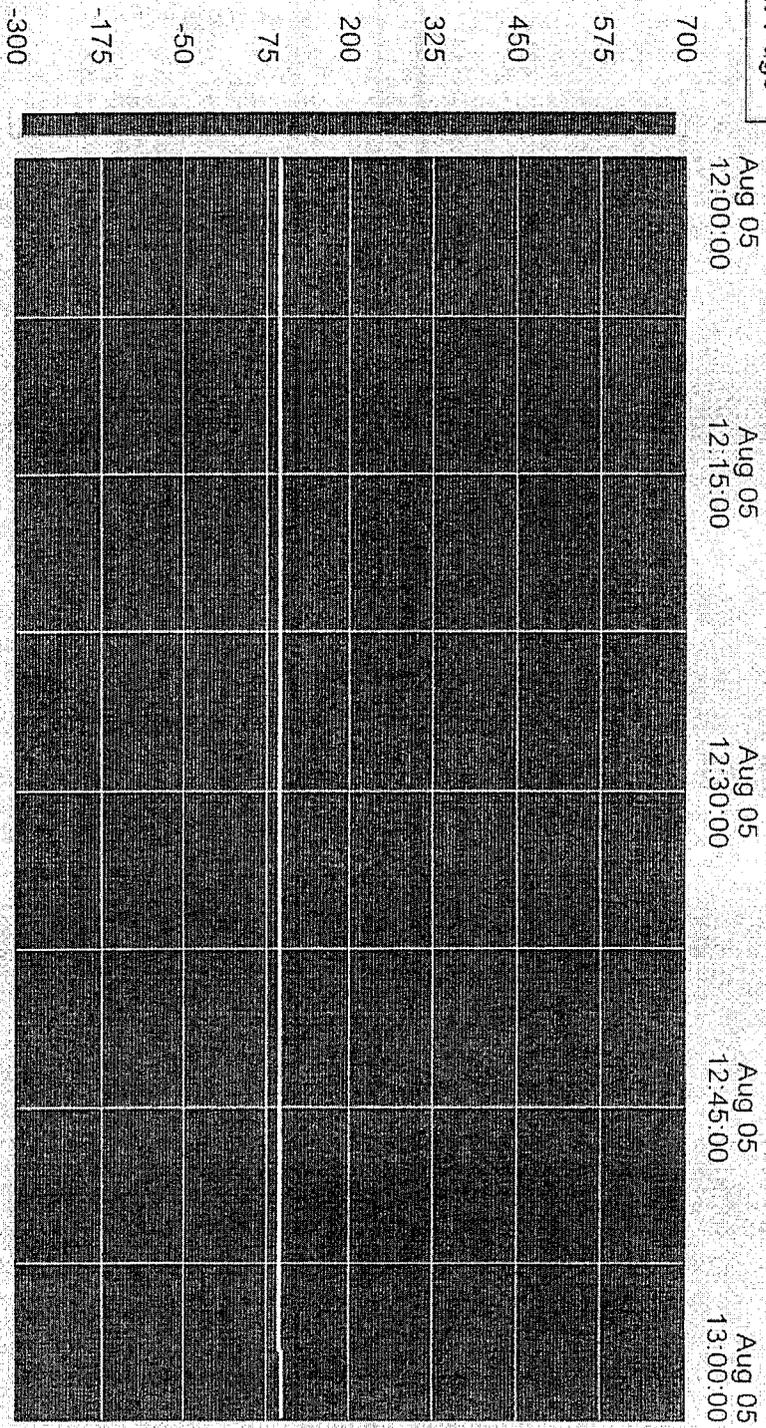
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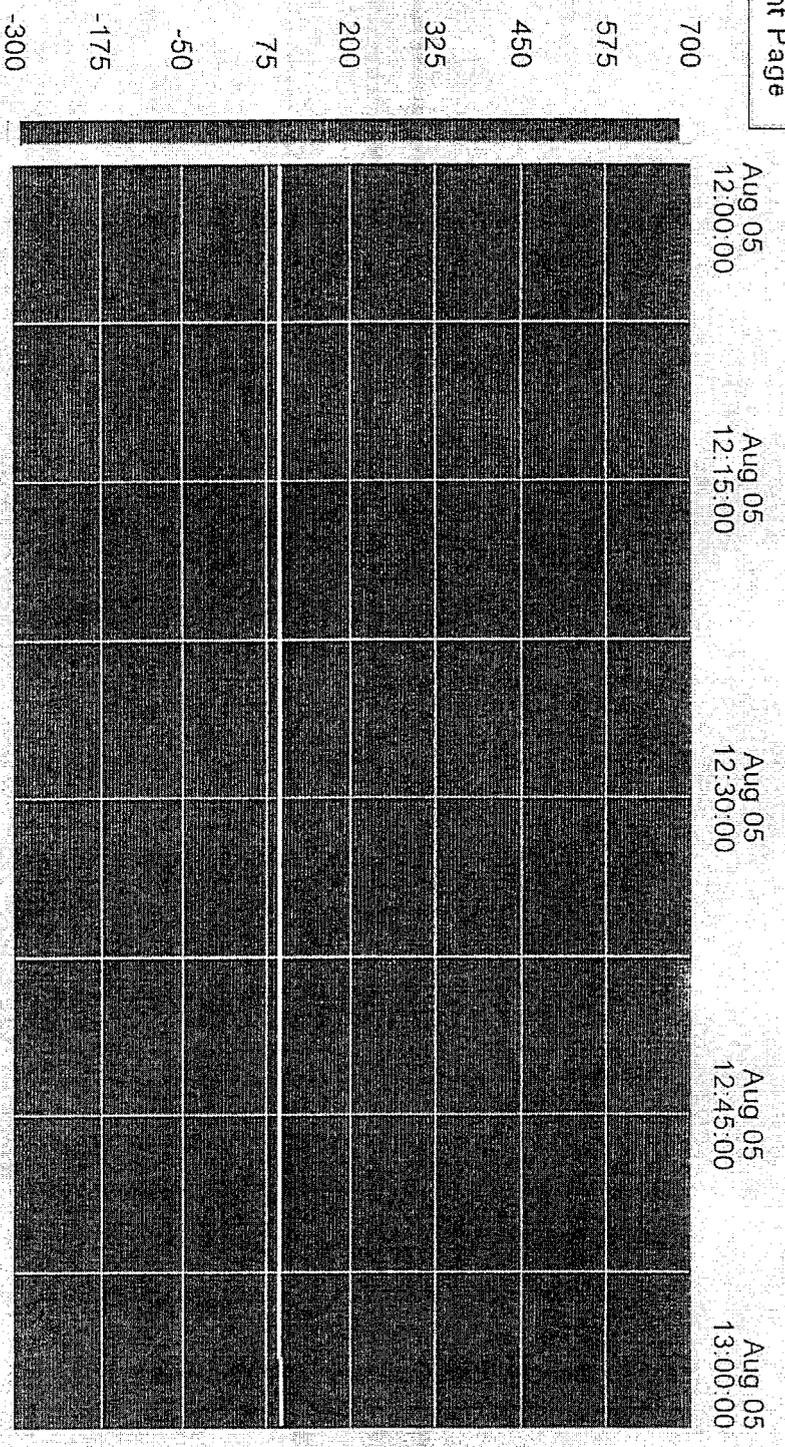
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ATTACHMENT B



The American Society of
Mechanical Engineers

103A

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PROCESS PIPING

ASME CODE FOR PRESSURE PIPING, B31

ASME B31.3-1996 Edition

CHAPTER V

FABRICATION, ASSEMBLY, AND ERECTION

327 GENERAL

Metallic piping materials and components are prepared for assembly and erection by one or more of the fabrication processes covered in paras. 328, 330, 331, 332, and 333. When any of these processes is used in assembly or erection, requirements are the same as for fabrication.

328 WELDING

Welding shall conform to paras. 328.1 through 328.6 in accordance with applicable requirements of para. 311.2.

328.1 Welding Responsibility

Each employer is responsible for the welding done by the personnel of his organization and, except as provided in paras. 328.2.2 and 328.2.3, shall conduct the tests required to qualify welding procedures, and to qualify and as necessary requalify welders and welding operators.

328.2 Welding Qualifications

328.2.1 Qualification Requirements

(a) Qualification of the welding procedures to be used and of the performance of welders and welding operators shall conform to the requirements of the BPV Code, Section IX except as modified herein.

(b) Where the base metal will not withstand the 180 deg. guided bend required by Section IX, a qualifying welded specimen is required to undergo the same degree of bending as the base metal, within 5 deg.

(c) The requirements for preheating in para. 330 and for heat treatment in para. 331, as well as such requirements in the engineering design, shall apply in qualifying welding procedures.

(d) When impact testing is required by the Code or the engineering design, those requirements shall be met in qualifying welding procedures.

(e) If consumable inserts [Fig. 328.3.2 sketch (d), (e), (f), or (g)] or their integrally machined equivalents, or backing rings, are used, their suitability shall be demonstrated by procedure qualification, except that a procedure qualified without use of a backing ring is also qualified for use with a backing ring in a single-welded butt joint.

(f) To reduce the number of welding procedure qualifications required, P-Numbers and Group Numbers are assigned to groupings of metals generally based on composition, weldability, and mechanical properties, insofar as practicable. The P-Numbers for most metals appear in a separate column in Table A-1.

328.2.2 Procedure Qualification by Others. Each employer is responsible for qualifying any welding procedure that personnel of the organization will use. Subject to the specific approval of the Inspector, welding procedures qualified by others may be used, provided that the following conditions are met.

(a) The Inspector shall be satisfied that:

(1) the proposed welding procedure specification (WPS) has been prepared, qualified, and executed by a responsible, recognized organization with expertise in the field of welding; and

(2) the employer has not made any change in the welding procedure.

(b) The base material P-Number is either 1, 3, 4 Gr. No. 1 (1¼ Cr max.), or 8; and impact testing is not required.

(c) The base metals to be joined are of the same P-Number, except that P-Nos. 1, 3, and 4 Gr. No. 1 may be welded to each other as permitted by Section IX.

(d) The material to be welded is not more than 19 mm (¾ in.) in thickness. Postweld heat treatment shall not be required.

(e) The design pressure does not exceed the ASME B16.5 PN 50 (Class 300) rating for the material at design temperature; and the design temperature is in the range -29°C to 399°C (-20°F to 750°F), inclusive.

(f) The welding process is SMAW or GTAW or a combination thereof.

(g) Welding electrodes for the SMAW process are selected from the following classifications.

AWS A5.1	AWS A5.4	AWS A5.5
E6010	E308-15, -16	E7010-A1
E6011	E308L-15, -16	E7018-A1
E7015	E309-15, -16	E8016-B1
E7016	E310-15, -16	E8018-B1
E7018	E-16-8-2-15, -16	E8015-B2L
	E316-15, 16	E8016-B2
	E316L-15, -16	E8018-B2
	E347-15, -16	E8018-B2L

(h) By signature, the employer accepts responsibility for both the WPS and the procedure qualification record (PQR).

(i) The employer has at least one currently employed welder or welding operator who, while in his employ, has satisfactorily passed a performance qualification test using the procedure and the P-Number material specified in the WPS. The performance bend test required by Section IX, QW-302 shall be used for this purpose. Qualification by radiography is not acceptable.

328.2.3 Performance Qualification by Others. To avoid duplication of effort, an employer may accept a performance qualification made for another employer, provided that the Inspector specifically approves. Acceptance is limited to qualification on piping using the same or equivalent procedure wherein the essential variables are within the limits in Section IX. The employer shall obtain a copy from the previous employer of the performance qualification test record, showing the name of the employer, name of the welder or welding operator, procedure identification, date of successful qualification, and the date that the individual last used the procedure on pressure piping.

328.2.4 Qualification Records. The employer shall maintain a self-certified record, available to the owner (and the owner's agent) and the Inspector, of the procedures used and the welders and welding operators employed, showing the date and results of procedure and performance qualifications, and the identification symbol assigned to each welder and welding operator.

328.3 Welding Materials

328.3.1 Filler Metal. Filler metal shall conform to the requirements of Section IX. A filler metal not yet incorporated in Section IX may be used with the owner's approval if a procedure qualification test is first successfully made.

328.3.2 Weld Backing Material. When backing rings are used, they shall conform to the following.

(a) *Ferrous Metal Backing Rings.* These shall be of weldable quality. Sulfur content shall not exceed 0.05%.

(b) If two abutting surfaces are to be welded to a third member used as a backing ring and one or two of the three members are ferritic and the other member or members are austenitic, the satisfactory use of such materials shall be demonstrated by welding procedure qualified as required by para. 328.2.

Backing rings may be of the continuous machined or split-band type. Some commonly used types are shown in Fig. 328.3.2.

(c) *Nonferrous and Nonmetallic Backing Rings.* Backing rings of nonferrous or nonmetallic material may be used, provided the designer approves their use and the welding procedure using them is qualified as required by para. 328.2.

328.3.3 Consumable Inserts. Consumable inserts may be used, provided they are of the same nominal composition as the filler metal, will not cause detrimental alloying of the weld metal, and the welding procedure using them is qualified as required by para. 328.2. Some commonly used types are shown in Fig. 328.3.2.

328.4 Preparation for Welding

328.4.1 Cleaning. Internal and external surfaces to be thermally cut or welded shall be clean and free from paint, oil, rust, scale, and other material that would be detrimental to either the weld or the base metal when heat is applied.

328.4.2 End Preparation

(a) General

(1) End preparation is acceptable only if the surface is reasonably smooth and true, and slag from oxygen or arc cutting is cleaned from thermally cut surfaces. Discoloration remaining on a thermally cut surface is not considered detrimental oxidation.

(2) End preparation for groove welds specified in ASME B16.25, or any other which meets the WPS, is acceptable. [For convenience, the basic bevel angles of ASME B16.25 and some additional J-bevel angles are shown in Fig. 328.4.2 sketches (a) and (b).]

(b) Circumferential Welds

(1) If component ends are trimmed as shown in Fig. 328.3.2 sketch (a) or (b) to fit backing rings or consumable inserts, or as shown in Fig. 328.4.3 sketch (a) or (b) to correct internal misalignment, such trimming shall not reduce the finished wall thickness below the required minimum wall thickness t_m .

341.3.1-341.4.1

ship, shall be examined in accordance with the applicable requirements of para. 341. The type and extent of any additional examination required by the engineering design, and the acceptance criteria to be applied, shall be specified. Joints not included in examinations required by para. 341.4 or by the engineering design are accepted if they pass the leak test required by para. 345.

(a) For P-Nos. 3, 4, and 5 materials, examination shall be performed after completion of any heat treatment.

(b) For a welded branch connection the examination of and any necessary repairs to the pressure containing weld shall be completed before any reinforcing pad or saddle is added.

341.3.2 Acceptance Criteria. Acceptance criteria shall be as stated in the engineering design and shall at least meet the applicable requirements stated below, in para. 344.6.2 for ultrasonic examination of welds, and elsewhere in the Code.

(a) Table 341.3.2 states acceptance criteria (limits on imperfections) for welds. See Fig. 341.3.2 for typical weld imperfections.

(b) Acceptance criteria for castings are specified in para. 302.3.3.

341.3.3 Defective Components and Workmanship. An examined item with one or more defects (imperfections of a type or magnitude exceeding the acceptance criteria of this Code) shall be repaired or replaced; and the new work shall be reexamined by the same methods, to the same extent, and by the same acceptance criteria as required for the original work.

341.3.4 Progressive Sampling for Examination. When required spot or random examination reveals a defect:

(a) two additional samples of the same kind (if welded or bonded joints, by the same welder, bonder, or operator) shall be given the same type of examination; and

(b) if the items examined as required by (a) above are acceptable, the defective item shall be repaired or replaced and reexamined as specified in para. 341.3.3, and all items represented by these two additional samples shall be accepted; but

(c) if any of the items examined as required by (a) above reveals a defect, two further samples of the same kind shall be examined for each defective item found by that sampling; and

(d) if all the items examined as required by (c) above are acceptable, the defective item(s) shall be repaired or replaced and reexamined as specified in para. 341.3.3,

and all items represented by the additional sampling shall be accepted; but

(e) if any of the items examined as required by (c) above reveals a defect, all items represented by the progressive sampling shall be either:

(1) repaired or replaced and reexamined as required; or

(2) fully examined and repaired or replaced as necessary, and reexamined as necessary to meet the requirements of this Code.

341.4 Extent of Required Examination

341.4.1 Examination Normally Required. Piping in Normal Fluid Service shall be examined to the extent specified herein or to any greater extent specified in the engineering design. Acceptance criteria are as stated in para. 341.3.2 and in Table 341.3.2, for Normal Fluid Service unless otherwise specified.

(a) *Visual Examination.* At least the following shall be examined in accordance with para. 344.2:

(1) sufficient materials and components, selected at random, to satisfy the examiner that they conform to specifications and are free from defects;

(2) at least 5% of fabrication. For welds, each welder's and welding operator's work shall be represented.

(3) 100% of fabrication for longitudinal welds, except those in components made in accordance with a listed specification. See para. 341.5.1(a) for examination of longitudinal welds required to have a joint factor E_j of 0.90.

(4) random examination of the assembly of threaded, bolted, and other joints to satisfy the examiner that they conform to the applicable requirements of para. 335. When pneumatic testing is to be performed, all threaded, bolted, and other mechanical joints shall be examined.

(5) random examination during erection of piping, including checking of alignment, supports, and cold spring;

(6) examination of erected piping for evidence of defects that would require repair or replacement, and for other evident deviations from the intent of the design.

(b) *Other Examination*

(1) Not less than 5% of circumferential butt and miter groove welds shall be examined fully by random radiography in accordance with para. 344.5 or by random ultrasonic examination in accordance with para. 344.6. The welds to be examined shall be selected to ensure that the work product of each welder or welding operator doing the production welding is included.

ATTACHMENT C

NFPA 59A

Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)

2001 Edition



NFPA, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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6.4 Pipe Supports.

6.4.1 Pipe supports, including any insulation systems used to support pipe whose stability is essential to plant safety, shall be resistant to or protected against fire exposure, escaping cold liquid, or both, if they are subject to such exposure.

6.4.2 Pipe supports for cold lines shall be designed to prevent excessive heat transfer, which can result in piping restraints caused by ice formations or embrittlement of supporting steel. The design of supporting elements shall conform to ASME B 31.3, *Process Piping*, Section 321.

6.5* Piping Identification. Piping shall be identified by color-coding, painting, or labeling. Any existing company color code scheme for the identification of piping systems shall be permitted to be used.

6.6 Inspection and Testing of Piping.

6.6.1 Pressure Testing. Pressure tests shall be conducted in accordance with ASME B 31.3, *Process Piping*, Section 345. To avoid possible brittle failure, carbon and low-alloy steel piping shall be pressure tested at metal temperatures suitably above their nil ductility transition temperature.

6.6.2 Record Keeping. Records of pressure, test medium temperature, and ambient temperature shall be maintained for the duration of each test, and these records shall be maintained for the life of the facility or until such time as a retest is conducted.

6.6.3 Welded Pipe Tests.

6.6.3.1 Longitudinal or spiral welded pipe that is subjected to service temperatures below -20°F (-29°C) shall have a design pressure of less than $\frac{2}{3}$ of the mill proof test pressure or subsequent shop or field hydrostatic test pressure.

Exception: Pipe that has been subjected to 100 percent radiographic or ultrasonic inspection of the longitudinal or spiral weld.

6.6.3.2 All circumferential butt welds shall be examined fully by radiographic or ultrasonic inspection.

*Exception No. 1: Liquid drain and vapor vent piping with an operating pressure that produces a hoop stress of less than 20 percent specified minimum yield stress shall not be required to be nondestructively tested if it has been inspected visually in accordance with ASME B 31.3, *Process Piping*, Section 344.2.*

Exception No. 2: Pressure piping operating above -20°F (-29°C) shall have 30 percent of each day's circumferentially welded pipe joints nondestructively tested over the entire circumference in accordance with ASME B 31.3.

6.6.3.3 All socket welds and fillet welds shall be examined fully by liquid penetrant or magnetic particle inspection.

6.6.3.4 All fully penetrated groove welds for branch connections (as required by ASME B 31.3, *Process Piping*, Section 328.5.4) shall be examined fully by in-process examination in accordance with ASME B 31.3, Section 344.7, as well as by liquid penetrant or magnetic particle techniques after the final pass of the weld.

Exception: If specified in the engineering design or specifically authorized by the inspector, examination by radiographic or ultrasonic techniques shall be permitted to be substituted for the examinations required by 6.6.3.4.

6.6.4 Inspection Criteria. Nondestructive examination methods, limitations on defects, the qualifications of the authorized inspector, and the personnel performing the examination

shall meet the requirements of ASME B 31.3, *Process Piping*, Sections 340 and 344.

Exception: Substitution of in-process examination for radiography or ultrasonics as permitted in ASME B 31.3, Paragraph 341.4.1, shall be prohibited.

6.6.5 Record Retention. Test records and written procedures required when conducting nondestructive examinations shall be maintained for the life of the piping system or until such time as a reexamination is conducted.

Records and certifications pertaining to materials, components, and heat treatment as required by ASME B 31.3, *Process Piping*, subparagraphs 341.4.1(c) and 341.4.3(d) and Section 346, shall be maintained for the life of the system.

6.7 Purging of Piping Systems.

6.7.1* Systems shall be purged of air or gas in a safe manner.

6.7.2 Blow-down and purge connections shall be provided to facilitate purging of all process and flammable gas piping.

6.8 Safety and Relief Valves.

6.8.1 Pressure-relieving safety devices shall be arranged so that the possibility of damage to piping or appurtenances is reduced to a minimum. The means for adjusting relief valve set pressure shall be sealed.

6.8.2 A thermal expansion relief valve shall be installed as required to prevent overpressure in any section of a liquid or cold vapor pipeline that can be isolated by valves.

6.8.2.1 A thermal expansion relief valve shall be set to discharge at or below the design pressure of the line it protects.

6.8.2.2 Discharge from such valves shall be directed to minimize hazard to personnel and other equipment.

6.9 Corrosion Control.

6.9.1* Underground and submerged piping shall be protected and maintained in accordance with the principles of NACE RP 0169, *Control of External Corrosion of Underground or Submerged Metallic Piping Systems*.

6.9.2 Austenitic stainless steels and aluminum alloys shall be protected to minimize corrosion and pitting from corrosive atmospheric and industrial substances during storage, construction, fabrication, testing, and service. Tapes or other packaging materials that are corrosive to the pipe or piping components shall not be used. Where insulation materials can cause corrosion of aluminum or stainless steels, inhibitors or waterproof barriers shall be utilized.

Chapter 7 Instrumentation and Electrical Services

7.1 Liquid Level Gauging.

7.1.1 LNG Containers.

7.1.1.1 LNG containers shall be equipped with two independent liquid level gauging devices. Density variations shall be considered in the selection of the gauging devices. These gauges shall be designed and installed so that it is possible to replace them without taking the tank out of operation.

7.1.1.2 The container shall be provided with two high-liquid-level alarms, which shall be permitted to be part of the liquid level gauging devices. They shall be independent of each

ATTACHMENT D

ASME BOILER AND PRESSURE VESSEL CODE
AN INTERNATIONALLY RECOGNIZED CODE

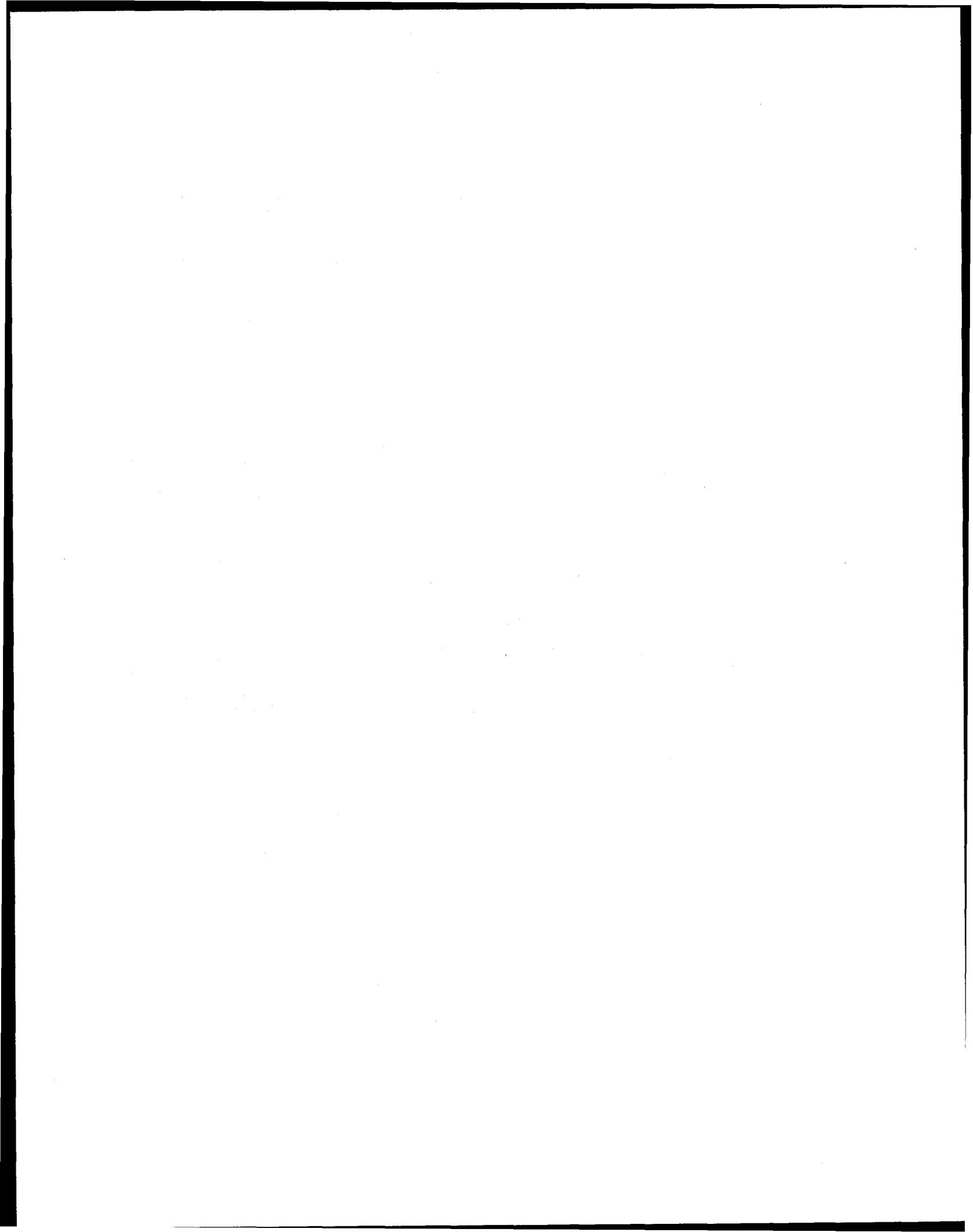
SECTION IX
Qualification Standard for Welding
and Brazing Procedures, Welders,
Brazers, and Welding
and Brazing Operators

1995 EDITION

JULY 1, 1995

ASME BOILER AND PRESSURE VESSEL COMMITTEE
SUBCOMMITTEE ON WELDING

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



1995 ASME BOILER AND PRESSURE VESSEL CODE

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- II Materials
 - Part A — Ferrous Material Specifications
 - Part B — Nonferrous Material Specifications
 - Part C — Specifications for Welding Rods, Electrodes, and Filler Metals
 - Part D — Properties
- III Subsection NCA — General Requirements for Division 1 and Division 2
- III Division 1
 - Subsection NB — Class 1 Components
 - Subsection NC — Class 2 Components
 - Subsection ND — Class 3 Components
 - Subsection NE — Class MC Components
 - Subsection NF — Supports
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- III Division 2 — Code for Concrete Reactor Vessels and Containments
- IV Rules for Construction of Heating Boilers
- V Nondestructive Examination
- VI Recommended Rules for the Care and Operation of Heating Boilers
- VII Recommended Guidelines for the Care of Power Boilers
- VIII Rules for Construction of Pressure Vessels
 - Division 1
 - Division 2 — Alternative Rules
- IX Welding and Brazing Qualifications
- X Fiber-Reinforced Plastic Pressure Vessels
- XI Rules for Inservice Inspection of Nuclear Power Plant Components

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 1998 Code. The 1995 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 1998 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 1995 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 1998 Code.

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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.

QW-100.1 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 providing 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. That is, the welding procedure qualification test establishes the properties of the weldment, not the skill of the welder or welding operator. In addition to this general requirement, special considerations for notch toughness are required by other Sections of the Code. Briefly, a WPS lists the variables, both essential and nonessential, and the acceptable ranges of these variables when using the WPS. The WPS is intended to provide direction for the welder/welding operator. The PQR lists what was used in qualifying the WPS and the test results.

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 are defined in QW-492. These are in substantial agreement with the definitions of the American Welding Society given in its document, A3.0-80, Terms and Definitions.

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

QW-103 Responsibility

QW-103.1 Welding. Each manufacturer¹ or contractor¹ 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 A.

QW-110 WELD ORIENTATION

The orientations of welds are illustrated in QW-461.1 or 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 QW-461.3 or QW-461.4 and as described in the following paragraphs, except that

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

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 QW-461.3(a).

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

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

QW-121.4 Overhead Position 4G. Plate in a horizontal plane with the weld metal deposited from underneath. Refer to QW-461.3(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 QW-461.4(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 QW-461.4(b).

QW-122.3 Multiple Position 5G. Pipe with its axis horizontal and with the welding groove in a vertical plane. Welding shall be done without rotating the pipe. Refer to QW-461.4(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 QW-461.4(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 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 QW-461.5 or 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 QW-461.5(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 QW-461.5(b).

QW-131.3 Vertical Position 3F. Plates so placed that the weld is deposited with its axis vertical. Refer to QW-461.5(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 QW-461.5(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 QW-461.6(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 QW-461.6(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 QW-461.6(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 QW-461.6(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 QW-461.6(e).

QW-140 TYPES AND PURPOSES OF TESTS AND EXAMINATIONS

QW-141 Mechanical Tests

Mechanical tests used in procedure or performance qualification are as follows.

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 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-190 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 QW-462.1 and shall meet the requirements of QW-153.

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

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

(b) For plate thickness greater than 1 in., 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 QW-462.1(b) may be used for tension tests on all thicknesses of pipe having an outside diameter greater than 3 in.

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

(b) For pipe thicknesses greater than 1 in., 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. or less, reduced-section specimens conforming to the requirements given in QW-462.1(c) may be used for tension tests.

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

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

(b) For thicknesses over 1 in., 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. apart. The centers of the specimens adjacent to the metal surfaces shall not exceed $\frac{1}{4}$ in. 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 QW-462.1(e) may be used for testing pipe with an outside diameter of 3 in. 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. 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 fusion line, 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.

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 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 QW-462.2.

Specimens of base metal thickness over 1½ in. may be cut into approximately equal strips between ¾ in. and 1½ in. 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 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 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 QW-462.3(a).

QW-161.5 Longitudinal-Bend Tests. Longitudinal-bend tests may be used in lieu of the transverse side-, face-, 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 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 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 QW-466.1 or 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 defects, 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 ¼ in. diameter wire cannot be inserted between the specimen and the die of QW-466.1, or the specimen is bottom ejected if the roller type of jig (QW-466.2) is used.

When using the wrap around jig (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 defects, if any, for side-bend specimens.

When specimens wider than 1½ in. are to be bent as permitted in QW-462.2, the test jig mandrel must be at least ¼ in. 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 defects in the weld or heat affected zone exceeding $\frac{1}{8}$ in., measured in any direction on the convex surface of the specimen after bending. Open defects 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 defects. For corrosion-resistant weld overlay cladding, no open defect exceeding $\frac{1}{16}$ in., measured in any direction, shall be permitted in the cladding, and no open defects exceeding $\frac{1}{8}$ in. shall be permitted in the bond line.

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 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 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 QW-462.4(a) or 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. 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-plate shall be cut transversely to provide five approximately equal test specimens not to exceed approximately 2 in. in length. For pipe-to-plate 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 QW-462.4(b) or QW-462.4(c). The test coupon for plate-to-plate shall be cut transversely to provide a center section approximately 4 in. long and two end sections, each approximately 1 in. 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 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. 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. performance specimen center section in QW-462.4(b) or the stem of the quarter section in 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. in QW-462.4(b) or 10% of the quarter section in QW-462.4(c).

QW-183 Macro-Examination — Procedure Specimens

One face of each cross section of the five test specimens in QW-462.4(a) or four test specimens in 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:

Visual examination of the cross sections of the weld metal and heat affected zone shall show complete fusion and freedom from cracks; and

There shall not be more than $\frac{1}{8}$ in. 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. long, in QW-462.4(b) or the cut end of

one of the pipe quarter sections in 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:

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. shall be acceptable; and

The weld shall not have a concavity or convexity greater than $\frac{1}{16}$ in.; and

There shall be not more than $\frac{1}{8}$ in. difference in the lengths of the legs of the fillet.

QW-190 VISUAL EXAMINATION— PERFORMANCE

Performance test coupons shall show complete joint penetration with complete fusion of weld metal and base metal.

QW-191 Radiographic Examination

QW-191.1 The radiographic examination in QW-142 for welders and in QW-143 for welding operators shall meet the requirements of Article 2, Section V. The acceptance standards of QW-191.2 shall be met.

QW-191.2 Radiographic Acceptance Criteria

QW-191.2.1 Terminology

Linear Indications. Cracks, incomplete fusion, inadequate penetration, and slag are represented on the radiograph as linear indications in which the length is more than three times the width.

Rounded Indications. Porosity and inclusions such as slag or tungsten are represented on the radiograph as rounded indications with a length three times the width or less. These indications may be circular, elliptical, or irregular in shape; may have tails; and may vary in density.

QW-191.2.2 **Acceptance Standards.** Welder and welding operator performance tests by radiography of welds in test assemblies shall be judged unacceptable when the radiograph exhibits any imperfections in excess of the limits specified below.

(a) *Linear Indications*

(1) any type of crack or zone of incomplete fusion or penetration;

(2) any elongated slag inclusion which has a length greater than:

- (a) 1/8 in. for t up to 3/8 in., inclusive
- (b) 1/4 in. for t over 3/8 to 2 1/4 in., inclusive
- (c) 3/4 in. for t over 2 1/4 in.

(3) any group of slag inclusions in line that have an aggregate length greater than t in a length of 12t, except when the distance between the successive imperfections exceeds 6L where L is the length of the longest imperfection in the group.

(b) Rounded Indications

(1) The maximum permissible dimension for rounded indications shall be 20% of t or 1/8 in., whichever is smaller.

(2) For welds in material less than 1/8 in. in thickness, the maximum number of acceptable rounded indications shall not exceed 12 in a 6 in. length of weld. A proportionately fewer number of rounded indications shall be permitted in welds less than 6 in. in length.

(3) For welds in material 1/8 in. or greater in thickness, the charts in Appendix I represent the maximum acceptable types of rounded indications illustrated in typically clustered, assorted, and randomly dispersed configurations. Rounded indications less than 1/32 in. in maximum diameter shall not be considered in the radiographic acceptance tests of welders and welding operators in these ranges of material thicknesses.

QW-191.2.3 Production Welds. The acceptance standard for welding operators who qualify on production welds shall be that specified in the referencing Code Section. The acceptance standard for welders who qualify on production welds as permitted by QW-304.1 shall be per QW-191.2.2.

QW-191.3 Record of Tests. The results of welder and welding operator performance tests by radiography shall be recorded in accordance with QW-301.4.

QW-192 Stud-Weld Tests — Procedure Qualification Specimens

QW-192.1 Required Tests. Ten stud-weld tests are required to qualify each procedure. The equipment used for stud welding shall be completely automatic except for manual starting.

Every other welding stud (five joints) shall be tested either by hammering over until one-fourth of its length is flat on the test piece, or by bending the stud to an angle of at least 15 deg. and returning it to its original position using a test jig and an adapter location dimension that are in accordance with QW-466.4.

The remaining five welded stud joints shall be tested in torque using a torque testing arrangement that is substantially in accordance with QW-466.5. Alternately,

where torquing is not feasible, tensile testing may be used, and the fixture for tensile testing shall be similar to that shown in QW-466.6 except that studs without heads may be gripped on the unwelded end in the jaws of the tensile testing machine.

QW-192.2 Acceptance Criteria — Bend and Hammer Tests. In order to pass the test(s), each of the five stud welds and heat affected zones shall be free of visible separation or fracture after bending and return bending or after hammering.

QW-192.3 Acceptance Criteria — Torque Tests. In order to pass the test(s), each of the five stud welds shall be subjected to the required torque shown in the following table before failure occurs.

Nominal Diameter of Stud, in.	Required Torque for Testing Threaded Carbon Steel Studs	
	Threads/in. and Series Designated	Testing Torque, ft-lb
1/4	28 UNF	5.0
1/4	20 UNC	4.2
5/16	24 UNF	9.5
5/16	18 UNC	8.6
3/8	24 UNF	17
3/8	16 UNC	15
7/16	20 UNF	27
7/16	14 UNC	24
1/2	20 UNF	42
1/2	13 UNC	37
9/16	18 UNF	60
9/16	12 UNC	54
5/8	18 UNF	84
5/8	11 UNC	74
3/4	16 UNF	147
3/4	10 UNC	132
7/8	14 UNF	234
7/8	9 UNC	212
1	12 UNF	348
1	8 UNC	318

Alternatively, where torquing to destruction is not feasible tensile testing may be used, in which case failure strength in pounds per square inch shall not be less than 35,000. The failure strength shall be based on the minor diameter of the threaded section of externally threaded studs except where the shank diameter is less than the minor diameter, or on the original cross-sectional area where failure occurs in a non-threaded, internally threaded, or reduced-diameter stud.

QW-192.4 Acceptance Criteria — Macro-Examination. In order to pass the macro-examination, each of five sectioned stud welds and the heat affected zone

shall be free of cracks when examined at a magnification of $\times 10$, which is required by QW-202.5 when studs are welded to metals other than P-No. 1.

QW-193 Stud-Weld Tests — Performance Qualification Specimens

QW-193.1 Required Tests. Five stud-weld tests are required to qualify each stud-welding operator. The equipment used for stud welding shall be completely automatic except for manual starting. The performance test shall be welded in accordance with a qualified WPS per QW-301.2.

Each stud (five joints) shall be tested either by hammering over until one-fourth of its length is flat on the test piece or by bending the stud to an angle of at least 15 deg. and returning it to its original position using a test jig and an adapter location dimension that are in accordance with QW-466.4.

QW-193.2 Acceptance Criteria — Bend and Hammer Tests. In order to pass the test(s), each of the five stud welds and heat affected zones shall be free of visible separation or fracture after bending and return bending or after hammering.

QW-195 Liquid Penetrant Examination

QW-195.1 The liquid penetrant examination in QW-214 for corrosion-resistant weld metal overlay shall meet the requirements of Article 6, Section V. The acceptance standards of QW-195.2 shall be met.

QW-195.2 Liquid Penetrant Acceptance Criteria

QW-195.2.1 Terminology

(a) *relevant indications* — indications with major dimensions greater than $\frac{1}{16}$ in.

(b) *linear indications* — an indication having a length greater than three times the width

(c) *rounded indications* — an indication of circular or elliptical shape with the length equal to or less than three times the width

QW-195.2.2 Acceptance Standards. Procedure and performance tests examined by liquid penetrant

techniques shall be judged unacceptable when the examination exhibits any indication in excess of the limits specified below:

(a) relevant linear indications;

(b) relevant rounded indications greater than $\frac{1}{16}$ in.;

(c) four or more relevant rounded indications in a line separated by $\frac{1}{16}$ in. or less (edge-to-edge).

QW-196 Resistance Weld Testing

QW-196.1 Metallographic Examination

QW-196.1.1 Welds shall be cross-sectioned, polished, and etched to reveal the weld metal. The section shall be examined at a magnification of 10 times.

QW-196.1.2 The weld nugget shall be sound for 1.25 times the thickness of the thinner member.

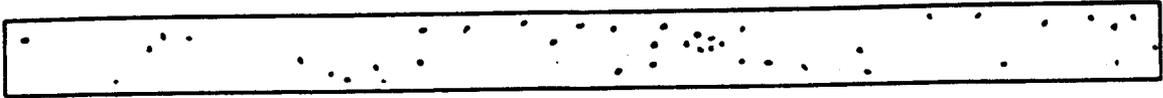
QW-196.1.3 For spot welds, the nugget size shall be measured at the interface between the sheets being joined, and it shall equal or exceed $0.9\sqrt{t}$, where t is the thickness of the thinner sheet. For projection welds, the nugget size shall not be less than the initial size of the projection. For seam welds, the width of the fused weld cut transverse to the seam shall be not less than $0.9\sqrt{t}$, where t is the thickness of the thinnest sheet.

QW-196.2 Mechanical Testing

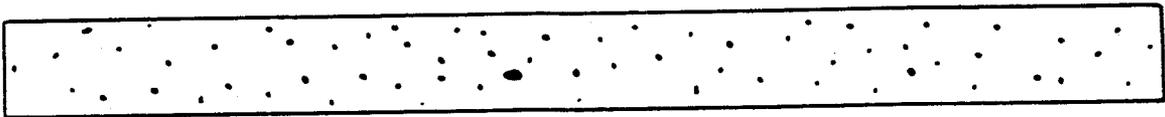
QW-196.2.1 Shear test specimens shall be prepared as shown on QW-462.9. For spot and projection welds, each test specimen shall equal or exceed the minimum strength, and the average strength specified in QW-462.10 and QW-462.11 for the appropriate material. Further, for each set, 90% shall have shear strength values between 0.9 and 1.1 times the set average value. The remaining 10% shall lie between 0.8 and 1.2 times the set average value.

QW-196.2.2 Peel test specimens shall be prepared as shown in Fig. QW-462.8. The specimens shall be peeled or separated mechanically, and fracture shall occur in the base metal by tearing out of the weld in order for the specimen to be acceptable.

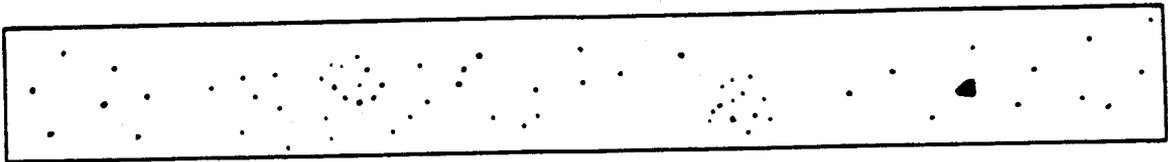
**APPENDIX I
ROUNDED INDICATION CHARTS
(See QW-191.2)**



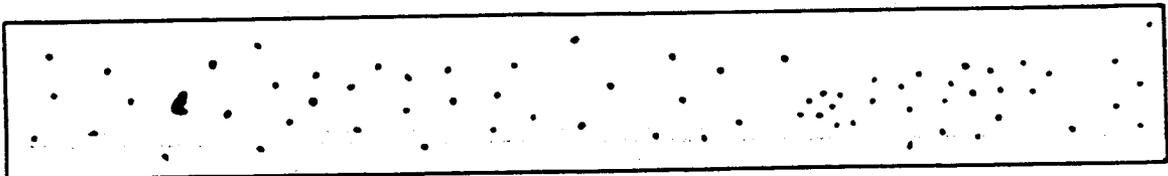
TYPICAL QUANTITY AND SIZE PERMITTED
IN 6 IN. LENGTH OF WELD
1/8 IN. TO 1/4 IN. THICKNESS



TYPICAL QUANTITY AND SIZE PERMITTED
IN 6 IN. LENGTH OF WELD
OVER 1/4 IN. TO 1/2 IN. THICKNESS



TYPICAL QUANTITY AND SIZE PERMITTED
IN 6 IN. LENGTH OF WELD
OVER 1/2 IN. TO 1 IN. THICKNESS



TYPICAL QUANTITY AND SIZE PERMITTED
IN 6 IN. LENGTH OF WELD
OVER 1 IN. THICKNESS

ARTICLE II

WELDING PROCEDURE QUALIFICATIONS

QW-200 GENERAL

QW-200.1 Each manufacturer and contractor shall prepare written Welding Procedure Specifications which are defined as follows.

(a) *Welding Procedure Specification (WPS)* A WPS is a written qualified welding procedure prepared to provide direction for making production welds to Code requirements. The WPS or other documents [see (e) below] may be used to provide direction to the welder or welding operator to assure compliance with the Code requirements.

(b) *Contents of the WPS.* The completed WPS shall describe all of the essential, nonessential, and, when required, supplementary essential variables for each welding process used in the WPS. These variables are listed in QW-250 through QW-280 and are defined in Article IV, Welding Data.

The WPS shall reference the supporting Procedure Qualification Record(s) (PQR) described in QW-200.2. The manufacturer or contractor may include any other information in the WPS that may be helpful in making a Code weldment.

(c) *Changes to the WPS.* Changes may be made in the nonessential variables of a WPS to suit production requirements without requalification provided such changes are documented with respect to the essential, nonessential, and, when required, supplementary essential variables for each process. This may be by amendment to the WPS or by use of a new WPS.

Changes in essential or supplementary essential (when required) variables require requalification of the WPS (new or additional PQRs to support the change in essential or supplementary essential variables).

(d) *Format of the WPS.* The information required to be in the WPS may be in any format, written or tabular, to fit the needs of each manufacturer or contractor, as long as every essential, nonessential, and, when required, supplementary essential variables outlined in QW-250 through QW-280 is included or referenced.

Form QW-482 (see Nonmandatory Appendix B) has been provided as a guide for the WPS. This Form includes the required data for the SMAW, SAW, GMAW, and GTAW processes. It is only a guide and does not list all required data for other processes. It also lists some variables that do not apply to all processes (e.g., listing shielding gas which is not required for SAW). The guide does not easily lend itself to multiple process procedure specification (e.g., GTAW root with SMAW fill).

(e) *Availability of the WPS.* A WPS used for Code production welding shall be available for reference and review by the Authorized Inspector (AI) at the fabrication site.

QW-200.2 Each manufacturer or contractor shall be required to prepare a procedure qualification record which is defined as follows.

(a) *Procedure Qualification Record (PQR).* A PQR is a record of the welding data used to weld a test coupon. The PQR is a record of variables recorded during the welding of the test coupons. It also contains the test results of the tested specimens. Recorded variables normally fall within a small range of the actual variables that will be used in production welding.

(b) *Contents of the PQR.* The completed PQR shall document all essential and, when required, supplementary essential variables of QW-250 through QW-280 for each welding process used during the welding of the test coupon. Nonessential or other variables used during the welding of the test coupon may be recorded at the manufacturer's or contractor's option. All variables, if recorded, shall be the actual variables (including ranges) used during the welding of the test coupon. If variables are not monitored during welding, they shall not be recorded. It is not intended that the full range or the extreme of a given range of variables to be used in production be used during qualification unless required due to a specific essential or, when required, supplementary essential variable.

The PQR shall be certified accurate by the manufacturer or contractor. The manufacturer or contractor may not subcontract the certification function. This certification is intended to be the manufacturer's or contractor's verification that the information in the PQR is a true record of the variables that were used during the welding of the test coupon and that the resulting tensile, bend, or macro (as required) test results are in compliance with Section IX.

When more than one welding process or filler metal is used to weld a test coupon, the approximate deposit weld metal thickness of each welding process and filler metal shall be recorded.

(c) *Changes to the PQR.* Changes to the PQR are not permitted except as described below. It is a record of what happened during a particular welding test. Editorial corrections or addenda to the PQR are permitted. An example of an editorial correction is an incorrect P-Number, F-Number, or A-Number that was assigned to a particular base metal or filler metal. An example of an addendum would be a change resulting from a Code change. For example, Section IX may assign a new F-Number to a filler metal or adopt a new filler metal under an established F-Number. This may permit, depending on the particular construction Code requirements, a manufacturer or contractor to use other filler metals that fall within that particular F-Number where, prior to the Code revision, the manufacturer or contractor was limited to the particular electrode classification that was used during qualification. Additional information can be incorporated into a PQR at a later date provided the information is substantiated as having been part of the original qualification condition by lab record or similar data.

All changes to a PQR require recertification (including date) by the manufacturer or contractor.

(d) *Format of the PQR.* Form QW-483 (see Nonmandatory Appendix B) has been provided as a guide for the PQR. The information required to be in the PQR may be in any format to fit the needs of each manufacturer or contractor, as long as every essential and, when required, supplementary essential variable, required by QW-250 through QW-280, is included. Also the type of tests, number of tests, and test results shall be listed in the PQR.

The QW-483 guide does not easily lend itself to cover combinations of welding processes or more than one F-Number filler metal in one test coupon. Additional sketches or information may be attached or referenced to record the required variables.

(e) *Availability of the PQR.* PQRs used to support WPSs shall be available, upon request, for review by

the Authorized Inspector (AI). The PQR need not be available to the welder or welding operator.

(f) *Multiple WPSs With One PQR/Multiple PQRs With One WPS.* Several WPSs may be prepared from the data on a single PQR (e.g., a IG plate PQR may support WPSs for the F, V, H, and O positions on plate or pipe within all other essential variables). A single WPS may cover several essential variable changes as long as a supporting PQR exists for each essential and, when required, supplementary essential variable (e.g., a single WPS may cover a thickness range from $\frac{1}{16}$ in. through $1\frac{1}{4}$ in. if PQRs exist for both the $\frac{1}{16}$ in. through $\frac{3}{16}$ in. and $\frac{3}{16}$ in. through $1\frac{1}{4}$ in. thickness ranges).

QW-200.3 To reduce the number of welding procedure qualifications required, P-Numbers are assigned to base metals dependent on characteristics such as composition, weldability, and mechanical properties, where this can logically be done; and for steel and steel alloys (QW-422.1 through QW-422.11) Group Numbers are assigned additionally to P-Numbers. These Group Numbers classify the metals within P-Numbers for the purpose of procedure qualification where notch-toughness requirements are specified. The assignments do not imply that base metals may be indiscriminately substituted for a base metal which was used in the qualification test without consideration of the compatibility from the standpoint of metallurgical properties, postweld heat treatment, design, mechanical properties, and service requirements. Where notch toughness is a consideration, it is presupposed that the base metals meet the specific requirements.

In general, notch-toughness requirements are mandatory for all P-No. 11 quenched and tempered metals, for low temperature applications of other metals as applied to Section VIII, and for various classes of construction required by Section III. Acceptance criteria for the notch-toughness tests are as established in the other Sections of the Code.

For certain materials permitted by the ASME/ANSI B31 Code for Pressure Piping or by selected Code Cases of the ASME Boiler and Pressure Vessel Code but which are not included within the ASME Boiler and Pressure Vessel Code Material Specifications (Section II), S-Number groupings are assigned in QW/QB-422. These groupings are similar to the P-Number groupings of QW-422. Qualification limits are given in QW-420.2.

QW-200.4 Combination of Welding Procedures

(a) More than one procedure having different essential or nonessential variables may be used in a single production joint. Each procedure may include one or

a combination of processes, filler metals, or other variables.

Where two or more procedures involving different processes or other essential variables are used in one joint, QW-451 shall be used to determine the range of base metal thickness qualified and the maximum thickness of deposited weld metal qualified for each process or procedure. Alternatively, qualification for root deposits only may be made in accordance with QW-200.4(b). The deposited weld metal of each process or procedure shall be included in the tension and bend specimens, and in the notch-toughness specimen (when required). One or more processes or procedures may be deleted from a qualified combination procedure. Each such process or procedure may be used separately provided:

(1) the remaining essential, nonessential, and supplementary essential variables are applied;

(2) the base metal and deposited weld metal thickness limits of QW-451 are applied.

(b) For GTAW, SMAW, GMAW, PAW, and SAW, or combinations of these processes, a PQR for a process recording a test coupon that was at least $\frac{1}{2}$ in. thick may be combined with one or more other PQRs recording another welding process and any greater base metal thickness. In this case, the process recorded on the first PQR may be used to deposit the root layers using the process(es) recorded on that PQR up to 2t (for short-circuiting type of GMAW, see QW-404.32) in thickness on base metal of the maximum thickness qualified by the other PQR(s) used to support the WPS. The requirements of Note (1) of QW-451.1 and QW-451.2 shall apply.

QW-201 Manufacturer's or Contractor's Responsibility

Each manufacturer or contractor shall list the parameters applicable to welding that he performs in construction of weldments built in accordance with this Code. These parameters shall be listed in a document known as a Welding Procedure Specification (WPS).

Each manufacturer or contractor shall qualify the WPS by the welding of test coupons and the testing of specimens (as required in this Code), and the recording of the welding data and test results in a document known as a Procedure Qualification Record (PQR). The welders or welding operators used to produce weldments to be tested for qualification of procedures shall be under the full supervision and control of the manufacturer or contractor during the production of these test weldments. It is not permissible for the manufacturer or contractor to have the welding of the test weldments performed

by another organization. It is permissible, however, to subcontract any or all of the work of preparation of test metal for welding and subsequent work on preparation of test specimens from the completed weldment, performance of nondestructive examination, and mechanical tests, provided the manufacturer or contractor accepts the responsibility for any such work.

The Code recognizes a manufacturer or contractor as the organization which has responsible operational control of the production of the weldments to be made in accordance with this Code. If in an organization effective operational control of welding procedure qualification for two or more companies of different names exists, the companies involved shall describe in their Quality Control system/Quality Assurance Program, the operational control of procedure qualifications. In this case separate welding procedure qualifications are not required, provided all other requirements of Section IX are met.

A WPS may require the support of more than one PQR, while alternatively, one PQR may support a number of WPSs.

The manufacturer or contractor shall certify that he has qualified each Welding Procedure Specification, performed the procedure qualification test, and documented it with the necessary Procedure Qualification Record (PQR).

QW-202 Type of Tests Required

QW-202.1 Mechanical Tests. The type and number of test specimens which shall be tested to qualify a groove weld procedure are given in QW-451, and shall be removed in a manner similar to that shown in QW-463. If any test specimen required by QW-451 fails to meet the applicable acceptance criteria, the test coupon shall be considered as failed, and a new test coupon shall be welded. Where qualification is for fillet welds only, the requirements are given in QW-202.2(c) and (d); and where qualification is for stud welds only, the requirements are given in QW-202.5.

QW-202.2 Groove and Fillet Welds

(a) *Qualification for Groove Full Penetration Welds.* Groove-weld test coupons shall qualify the thickness ranges of both base metal and deposited weld metal to be used in production. Limits of qualification shall be in accordance with QW-451. WPS qualification for groove welds shall be made on groove welds using tension and guided-bend specimens. Notch-toughness tests shall be made when required by other Section(s) of the Code. The WPS shall be qualified for use with

groove welds within the range of essential variables listed.

(b) *Qualification for Partial Penetration Groove Welds.* Partial penetration groove welds shall be qualified in accordance with the requirements of QW-451 for both base metal and deposited weld metal thickness. Alternatively, partial penetration groove welds qualified using 1½ in. thick or thicker base metal qualify the weld metal deposit in accordance with QW-451, with no upper limit on the base metal thickness.

(c) *Qualification for Fillet Welds (Except for P-No. 11 Metals Excluding P-No. 11A Group Nos. 1 and 2).* WPS qualification for fillet welds may be made on groove-weld test coupons using test specimens specified in (a) or (b) above. Fillet-weld procedures so qualified may be used for welding all thicknesses of base metal for all sizes of fillet welds, and all diameters of pipe or tube in accordance with QW-451.4. Nonpressure-retaining fillet welds, as defined in other Sections of the Code, may as an alternate be qualified with fillet welds only. Tests shall be made in accordance with QW-180. Limits of qualification shall be in accordance with QW-451.3.

(d) *Qualification for Fillet Welds in P-No. 11 Metals (Excluding P-No. 11A Group Nos. 1 and 2).* WPS qualification for all fillet welds (including nonpressure-retaining) shall be made on:

- (1) groove-weld tests in accordance with (a) or (b) above; and
- (2) fillet-weld tests in accordance with QW-180.

QW-202.3 Weld Repair and Buildup. WPS qualified on groove welds shall be applicable for weld repairs to groove and fillet welds and for weld buildup under the following provisions.

- (a) There is no limitation on the thickness of base metal or deposited weld metal for fillet welds.
- (b) For other than fillet welds, the upper limit for base metal and deposited weld metal for each welding process shall be in accordance with QW-451, except qualification on 1½ in. thick base metal will permit welding on unlimited base metal thickness.

QW-202.4 Dissimilar Base Metal Thicknesses. WPS qualified on groove welds shall be applicable for production welds between dissimilar base metal thicknesses provided:

- (a) the thickness of the thinner member shall be within the range permitted by QW-451;
- (b) the thickness of the thicker member shall be as follows.
 - (1) For P-No. 8, P-No. 41, P-No. 42, P-No. 43, P-No. 44, P-No. 45, P-No. 46, P-No. 51, P-No. 52, P-No. 53, P-No. 61, and P-No. 62 metal in which

notch toughness is not a requirement, there shall be no limitation on the maximum thickness of the thicker production member in joints of similar P-Number materials provided qualification was made on base metal having a thickness of ¼ in. or greater.

(2) For all other metal, the thickness of the thicker member shall be within the range permitted by QW-451, except there need be no limitation on the maximum thickness of the thicker production member provided qualification was made on base metal having a thickness of 1½ in. or more.

More than one PQR may be required to qualify for some dissimilar thickness combinations.

QW-202.5 Stud Welding. Procedure qualification tests for stud welds shall be made in accordance with QW-192. The procedure qualification tests shall qualify the welding procedures for use within the range of the essential variables of QW-261. For studs welded to other than P-No. 1 metals, five additional welds shall be made and subjected to a macro-test, except that this is not required for studs used for extended heating surfaces.

QW-203 Limits of Qualified Positions for Procedures

Unless specifically required otherwise by the welding variables (QW-250), a qualification in any position qualifies the procedure for all positions. The welding process must be compatible; and the welding rods, electrodes, and filler metals such as defined in the specifications of Section II, Part C must be suitable for their use in specific positions. A welder or welding operator making and passing the WPS qualification test is thereby qualified for the position tested. See QW-301.2.

QW-210 PREPARATION OF TEST COUPON

QW-211 Base Metal and Filler Metal

The base metals and filler metals shall be one or more of those listed in the WPS. The dimensions of the test assembly shall be sufficient to provide the required test specimens.

The base metals may consist of either plate, pipe, or other product forms. Qualification in plate also qualifies for pipe welding and vice versa.

QW-212 Type and Dimensions of Groove Welds

The test coupon shall be welded using a type of welding groove proposed in the WPS for use in construction. Except as otherwise provided in QW-250, the type and dimensions of the welding groove are not essential variables.

QW-213 P-No. 11 Base Metals

For vessels or parts of vessels constructed with P-No. 11 base metals, weld grooves for thickness less than $\frac{5}{8}$ in. shall be prepared by thermal processes, when such processes are to be employed during fabrication. This groove preparation shall also include back gouging, back grooving, or removal of unsound weld metal by thermal processes, when these processes are to be employed during fabrication.

QW-214 Corrosion-Resistant Weld Metal Overlay

QW-214.1 The size of test coupons, limits of qualification, required examinations and tests, and test specimens shall be as specified in QW-453.

QW-214.2 Essential variables shall be as specified in QW-250 for the applicable welding process.

QW-215 Electron Beam Welding and Laser Beam Welding

QW-215.1 The WPS qualification test coupon shall be prepared with the joint geometry duplicating that to be used in production. If the production weld is to include a lap-over (completing the weld by rewelding over the starting area of the weld, as for a girth weld), such lap-over shall be included in the WPS qualification test coupon.

QW-215.2 The mechanical testing requirements of QW-451 shall apply.

QW-215.3 Essential variables shall be as specified in QW-260 and QW-264 for the applicable welding process.

QW-216 Hard-Facing Weld Metal Overlay

Oxyfuel Gas Welding (OFW) and Plasma-Arc Welding (PAW) both refer to a Spray Fuse Method of hard surfacing. The following requirements apply regardless of which hard-surfacing process is used.

QW-216.1 The size of test coupons, limits of qualification, required examinations and tests, and test specimens shall be as specified in QW-453.

QW-216.2 Essential variables shall be as specified in QW-250 for the applicable welding process.

QW-216.3 Oxyfuel Gas Welding (OFW) and Plasma-Arc Welding (PAW) both refer to a Spray Fuse method of hard surfacing. The test coupons for these methods shall be prepared in accordance with QW-216.1 and QW-216.2.

QW-217 Joining of Composite (Clad Metals)

The WPS for groove welds in clad metal shall be qualified as provided in (a) below when any part of the cladding thickness, as permitted by the referencing Code Section, is included in the design calculations, and as provided in either (a) or (b) below when the cladding thickness is not included in the design calculations.

(a) The essential and nonessential variables of QW-250 shall apply for each welding process used in production. The procedure qualification test coupon shall be made using the same P-Number base metal, cladding, and welding process, and filler metal combination to be used in production welding. For metal not included in QW-422, the metal used in the composite test plate shall be within the range of chemical composition of that to be used in production. The qualified thickness range for the base metal and filler metal(s) shall be based on the actual test coupon thickness for each as applied to QW-451, except that the minimum thickness of filler metal joining the cladding portion of the weldment shall be based on a chemical analysis performed in accordance with QW-453. Tensile and bend tests required in QW-451 for groove welds shall be made, and they shall contain the full thickness of cladding through the reduced section of the specimen. The bond line between the original cladding and the base metal may be disregarded when evaluating side-bend tests if the cladding was applied by a process other than fusion welding.

(b) The essential and nonessential variables of QW-250 shall apply for each welding process used in production for joining the base metal portion of the weldment. The PQRs that support this portion of the WPS need not be based on test coupons made with clad metal. The essential and nonessential variables of QW-250 shall apply for the corrosion-resistant overlay portion of the weld, and the test coupon and testing shall be in accordance with QW-453. The WPS shall limit the depth of the groove, which will receive the

corrosion-resistant overlay in order to ensure development of the full strength of the underlying weld in the base metal.

QW-218 Applied Linings

Each welding process to be used in attaching applied linings to base metal shall be qualified on a lining-attachment weld made in the form and arrangement used in the construction, and with materials that are within the range of chemical composition of the metal to be used for the base plate, the linings, and the weld metal. The other welding variables of QW-250 shall also apply. In addition, a qualification test shall be performed for each position that will be used in production. One specimen from each position to be qualified shall be sectioned, polished, and etched to show clearly the demarcation between the fusion zone and the base metal. To be acceptable, the specimen shall show complete fusion in the fusion zone and complete freedom from cracks in the fusion and heat affected zones under visual examination without magnification.

QW-250 WELDING VARIABLES

QW-251 General

QW-251.1 Types of Variables for Welding Procedure Specifications (WPS). These variables (listed for

each welding process in QW-252 through QW-265) are subdivided into essential variables, supplementary essential variables, and nonessential variables (QW-401).

QW-251.2 Essential Variables. Essential variables are those in which a change, as described in the specific variables, is considered to affect the mechanical properties of the weldment, and shall require requalification of the WPS.

Supplementary essential variables are required for metals for which other Sections specify notch-toughness tests.

QW-251.3 Nonessential Variables. Nonessential variables are those in which a change, as described in the specific variables, may be made in the WPS without requalification.

QW-251.4 Special Processes

(a) The special process essential variables for corrosion-resistant and hard-surfacing weld metal overlays are as indicated in the following tables for the specified process. Only the variables specified for special processes shall apply. A change in the corrosion-resistant or hard-surfacing welding process shall require requalification.

(b) WPS qualified for corrosion-resistant and hard-surfacing overlay welding, in accordance with other Sections when such qualification rules were included in those Sections, may be used with the same provisions as provided in QW-100.3.

QW-252
WELDING VARIABLES PROCEDURE SPECIFICATIONS (WPS)
Oxyfuel Gas Welding (OFW)

Paragraph	Brief of Variables	Essential	Supplementary Essential	Nonessential
QW-402 Joints	.1 ϕ Groove design			X
	.2 \pm Backing			X
	.3 ϕ Backing comp.			X
	.10 ϕ Root spacing			X
QW-403 Base Metals	.1 ϕ P-Number	X		
	.2 Max. T qualified	X		
	.13 ϕ P-No. 5/9/10	X		
QW-404 Filler Metals	.3 ϕ Size			X
	.4 ϕ F-Number	X		
	.5 ϕ A-Number	X		
	.12 ϕ AWS class.	X		
QW-405 Positions	.1 + Position			X
QW-406 Preheat	.1 Decrease > 100°F			X
QW-407 PWHT	.1 ϕ PWHT	X		
QW-408 Gas	.7 ϕ Type fuel gas	X		
QW-410 Technique	.1 ϕ String/weave			X
	.2 ϕ Flame characteristics			X
	.4 ϕ = Technique			X
	.5 ϕ Method cleaning			X
	.26 \pm Peening			X

Legend:
 + Addition > Increase/greater than † Uphill - Forehand ϕ Change
 - Deletion < Decrease/less than ‡ Downhill - Backhand

QW-252.1
WELDING VARIABLES PROCEDURE SPECIFICATIONS
(WPS)
Oxyfuel Gas Welding (OFW)

Paragraph	Special Process Essential Variables		
	Hardfacing Overlay (QW-216)	Corrosion-Resistant Overlay (QW-214)	Hardfacing Spray Fuse (QW-216)
QW-402 Joints	.16	< Finished t	
	.17		> Finished t
QW-403 Base Metals	.20	ϕ P-Number	ϕ P-Number
	.23	ϕ T Qualified	ϕ T Qualified
QW-404 Filler Metals	.12	ϕ AWS class.	ϕ AWS class.
	.42		ϕ > 5% Particle size range
	.46		ϕ Powder Feed rate
QW-405 Positions	.4	- Position	+ Position
QW-406 Preheat	.4	Dec. > 100° Preheat > Interpass	Dec. > 100° Preheat > Interpass
	.5		ϕ Preheat maint.
QW-407 PWHT	.6	ϕ PWHT	ϕ PWHT
	.7		ϕ PWHT after fusing
QW-408 Gas	.7	ϕ Type of fuel gas	
	.14	ϕ Torch type, tip size	
	.16		ϕ > 5% Powder feed rate
	.19		ϕ Plasma/feed gas comp.
QW-410 Technique	.38	ϕ Multi-to single layer	ϕ Multi-to single layer
	.39	ϕ Torch type, tip size	
	.44		ϕ > 15% torch to workpiece
	.45		ϕ Surface prep.
	.46		ϕ Spray torch
	.47		ϕ > 10% Fusing temp. or method

Legend:
 - Addition > Increase greater than † Uphill ← Forehand ϕ Change
 - Deletion < Decrease/less than ‡ Downhill → Backhand

QW-253
WELDING VARIABLES PROCEDURE SPECIFICATIONS (WPS)
Shielded Metal-Arc (SMAW)

Paragraph	Brief of Variables	Essential	Supplementary Essential	Nonessential
QW-402 Joints	.1 ϕ Groove design			X
	.4 - Backing			X
	.10 ϕ Root Spacing			X
	.11 \pm Retainers			X
QW-403 Base Metals	.5 ϕ Group Number		X	
	.6 T Limits impact		X	
	.7 T/t Limits > 8 in.	X		
	.8 ϕ T Qualified	X		
	.9 t Pass > 1/2 in.	X		
	.11 ϕ P-No. qualified	X		
	.13 ϕ P-No. 5/9/10	X		
QW-404 Filler Metals	.4 ϕ F-Number	X		
	.5 ϕ A-Number	X		
	.6 ϕ Diameter			X
	.7 ϕ Diam. > 3/8 in.		X	
	.12 ϕ AWS class.		X	
	.30 ϕ t	X		
QW-405 Positions	.33 ϕ AWS class.			X
	.1 + Position			X
	.2 ϕ Position		X	
QW-406 Preheat	.3 ϕ 11 Vertical welding			X
	.1 Decrease > 100°F	X		
	.2 ϕ Preheat maint.			X
	.3 Increase > 100°F (IP)		X	
QW-407 PWHT	.1 ϕ PWHT	X		
	.2 ϕ PWHT (T & T range)		X	
	.4 T Limits	X		
QW-409 Electrical Characteristics	.1 > heat input		X	
	.4 ϕ Current or polarity		X	X
	.8 ϕ I & E range			X
QW-410 Technique	.1 ϕ String/weave			X
	.5 ϕ Method cleaning			X
	.6 ϕ Method back gouge			X
	.25 ϕ Manual or automatic			X
	.26 \pm Peening			X

Legend:
 + Addition > Increase/greater than 1 Uphill - Forehand ϕ Change
 - Deletion < Decrease/less than 1 Downhill - Backhand

QW-253.1
WELDING VARIABLES PROCEDURE SPECIFICATIONS
(WPS)
Shielded Metal-Arc (SMAW)

Paragraph	Special Process Essential Variables		
		Hardfacing Overlay (QW-216)	Corrosion-Resistant Overlay (QW-214)
QW-402 Joints	.16	< finished t	< finished t
QW-403 Base Metals	.20	ϕ P-Number	ϕ P-Number
	.23	ϕ T Qualified	ϕ T Qualified
QW-404 Filler Metals	.12	ϕ AWS class.	
	.37		ϕ A-Number
	.38	ϕ Dia. (1st layer)	ϕ Dia. (1st layer)
QW-405 Positions	.4	+ Position	+ Position
QW-406 Preheat	.4	Dec. > 100°F preheat > Interpass	Dec. > 100°F preheat > Interpass
QW-407 PWHT	.6	ϕ PWHT	ϕ PWHT
QW-409 Electrical Characteristics	.4	ϕ Current or polarity	ϕ Current or polarity
	.22	Inc. > 10% 1st layer	Inc. > 10% 1st layer
QW-410 Technique	.38	ϕ Multi- to single-layer	ϕ Multi- to single-layer

Legend:

- Addition > Increase/greater than † Uphill — Forehand ϕ Change
- Deletion < Decrease/less than ‡ Downhill — Backhand

QW-256
WELDING VARIABLES PROCEDURE SPECIFICATIONS (WPS)
Gas Tungsten-Arc Welding (GTAW)

Paragraph	Brief of Variables	Essential	Supplementary Essential	Nonessential
QW-402 Joints	.1 ϕ Groove design			X
	.5 + Backing			X
	.10 ϕ Root spacing			X
	.11 \pm Retainers			X
QW-403 Base Metals	.5 ϕ Group Number		X	
	.6 T Limits		X	
	.7 T/t Limits > 8 in.	X		
	.8 ϕ T Qualified	X		
	.11 ϕ P-No. qualified	X		
	.13 ϕ P-No. 5/9/10	X		
QW-404 Filler Metals	.3 ϕ Size			X
	.4 ϕ F-Number	X		
	.5 ϕ A-Number	X		
	.12 ϕ AWS class.		X	
	.14 \pm Filler	X		
	.22 \pm Consum. insert			X
	.23 ϕ Solid or metal-cored to flux-cored	X		
	.30 ϕ t	X		
.33 ϕ AWS class.			X	
QW-405 Positions	.1 + Position			X
	.2 ϕ Position		X	
	.3 ϕ 1: Vertical welding			X
QW-406 Preheat	.1 Decrease > 100°F	X		
	.3 Increase > 100°F (IP)		X	
QW-407 PWHT	.1 ϕ PWHT	X		
	.2 ϕ PWHT (T & T range)		X	
	.4 T Limits	X		
QW-408 Gas	.1 \pm Trail or ϕ comp.			X
	.2 ϕ Single, mixture, or %	X		
	.3 ϕ Flow rate			X
	.5 \pm or ϕ Backing flow			X
	.9 - Backing or ϕ comp.	X		
	.10 ϕ Shielding or trailing	X		

QW-256 (CONT'D)
WELDING VARIABLES PROCEDURE SPECIFICATIONS (WPS)
Gas Tungsten-Arc Welding (GTAW)

Paragraph	Brief of Variables	Essential	Supplementary Essential	Nonessential
QW-409 Electrical Characteristics	.1 > Heat input		X	
	.3 \approx Pulsing I			X
	4 ϕ Current or polarity		X	X
	.8 ϕ I & E range			X
	.12 ϕ Tungsten electrode			X
QW-410 Technique	.1 ϕ String/weave			X
	.3 ϕ Orifice, cup, or nozzle size			X
	.5 ϕ Method cleaning			X
	.6 ϕ Method back gouge			X
	.7 ϕ Oscillation			X
	.9 ϕ Multi to single pass/side		X	X
	.10 ϕ Single to multi electrodes		X	X
	.11 ϕ Closed to out chamber	X		
	.15 ϕ Electrode spacing			X
	.25 ϕ Manual or automatic			X
.26 \approx Peening			X	

Legend:
 + Addition > Increase/greater than † Uphill - Forehand ϕ Change
 - Deletion < Decrease/less than ‡ Downhill - Backhand

ARTICLE III

WELDING PERFORMANCE QUALIFICATIONS

QW-300 GENERAL

QW-300.1 This Article lists the welding processes separately, with the essential variables which apply to welder and welding operator performance qualifications.

The welder qualification is limited by the essential variables given for each welding process. These variables are listed in QW-350, and are defined in Article IV Welding Data. The welding operator qualification is limited by the essential variables given in QW-360 for each type of weld.

A welder or welding operator may be qualified by radiography of a test coupon, radiography of his initial production welding, or by bend tests taken from a test coupon except as stated in QW-304 and QW-305.

QW-300.2 The basic premises of responsibility in regard to welding are contained within QW-103 and QW-301.2. These paragraphs require that each manufacturer or contractor (an assembler or an installer is to be included within this premise) shall be responsible for conducting tests to qualify the performance of welders and welding operators in accordance with qualified Welding Procedure Specifications, which his organization employs in the construction of weldments built in accordance with the Code. The purpose of this requirement is to ensure that the manufacturer or contractor has determined that his welders and welding operators using his procedures are capable of developing the minimum requirements specified for an acceptable weldment. This responsibility cannot be delegated to another organization.

The welders or welding operators used to produce such weldments shall be tested under the full supervision and control of the manufacturer, contractor, assembler, or installer during the production of these test weldments. It is not permissible for the manufacturer, contractor, assembler, or installer to have the welding performed by another organization. It is permissible, however, to subcontract any or all of the work of preparation of test materials for welding and subsequent

work on the preparation of test specimens from the completed weldments, performance of nondestructive examination and mechanical tests, provided the manufacturer, contractor, assembler, or installer accepts full responsibility for any such work.

The Code recognizes a manufacturer, contractor, assembler, or installer as the organization which has responsible operational control of the production of the weldments to be made in accordance with this Code. If in an organization effective operational control of the welder performance qualification for two or more companies of different names exists, the companies involved shall describe in the Quality Control system, the operational control of performance qualifications. In this case requalification of welders and welding operators within the companies of such an organization will not be required, provided all other requirements of Section IX are met.

QW-300.3 More than one manufacturer, contractor, assembler, or installer may simultaneously qualify one or more welders or welding operators. When simultaneous qualifications are conducted, each participating organization shall be represented by a responsible employee during welding of the test coupons.

The welding procedure specifications (WPS) which are followed during simultaneous qualifications shall be compared by the participating organizations. The WPSs shall be identical for all the essential variables, except for the preheat temperature and PWHT requirements. The qualified thickness ranges for base metal and deposited weld metal need not be identical, but these thicknesses shall be adequate to permit welding of the test coupons. Alternatively, the participating organizations shall agree upon the use of a single WPS provided each participating organization has a PQR(s) to support the WPS covering the range of variables to be followed in the performance qualification. When a single WPS is to be followed, each participating organization shall review and accept that WPS.

Each participating organization's representative shall positively identify each welder or welding operator who is being tested. Each organizational representative shall also verify marking of the test coupon with the welder's or welding operator's identification, and marking of the top of the test coupon when the orientation must be known in order to remove test specimens.

Each organization's representative shall perform a visual examination of each completed test coupon and shall examine each test specimen to determine its acceptability. Alternatively, after visual examination, when the test coupon(s) are prepared and tested by an independent laboratory, that laboratory's report may be used as the basis for accepting the test results. When the test coupon(s) is radiographically examined (QW-302.2), the radiographic testing facility's report may be used as the basis for acceptance of the radiographic test.

Each organizational representative shall complete and sign a Welder/Welding Operator Performance Qualification (WPQ) Record for each welder or welding operator. Form QW-484 (see Nonmandatory Appendix B) has been provided as a guide for the WPQ.

When a welder or welding operator changes employers, that new participating organization shall verify that the welder's continuity of qualifications has been maintained as required by QW-322 by previous employers since his qualification date. If the welder or welding operator has had his qualification withdrawn for specific reasons, the employing organization shall notify all participating organizations that the welder's or welding operator's qualification(s) has been revoked in accordance with QW-322.1(b). The new organization shall determine that the welder or welding operator can perform satisfactory work in accordance with this Section.

When a welder's or welding operator's qualifications are renewed in accordance with the provisions of QW-322.2, each renewing organization shall be represented by a responsible employee and the testing procedures shall follow the rules of this paragraph.

QW-301 Tests

QW-301.1 Intent of Tests. The performance qualification tests are intended to determine the ability of welders and welding operators to make sound welds.

QW-301.2 Qualification Tests. Each manufacturer or contractor shall qualify each welder or welding operator for each welding process to be used in production welding. The performance qualification test shall be welded in accordance with qualified Welding Procedure

Specifications (WPS), except that when performance qualification is done in accordance with a WPS that requires a preheat or postweld heat treatment, these may be omitted. Changes beyond which requalification is required are given in QW-350 for welders and in QW-360 for welding operators. Allowable visual, mechanical, and radiographic examination requirements are described in QW-304 and QW-305. Retests and renewal of qualification are given in QW-320.

The welder or welding operator who prepares the WPS qualification test coupons meeting the requirements of QW-200 is also qualified within the limits of the performance qualifications, listed in QW-304 for welders and in QW-305 for welding operators. He is qualified only within the limits for positions specified in QW-303.

The performance test may be terminated at any stage of the testing procedure, whenever it becomes apparent to the supervisor conducting the tests that the welder or welding operator does not have the required skill to produce satisfactory results.

QW-301.3 Identification of Welders and Welding Operators. Each qualified welder and welding operator shall be assigned an identifying number, letter, or symbol by the manufacturer or contractor, which shall be used to identify the work of that welder or welding operator.

QW-301.4 Record of Tests. The record of Welder/Welding Operator Performance Qualification (WPQ) tests shall include the essential variables (QW-350 or QW-360), the type of test and test results, and the ranges qualified in accordance with QW-452 for each welder and welding operator. A suggested form for these records is given in Form QW-484 (see Nonmandatory Appendix B).

QW-302 Type of Test Required

QW-302.1 Mechanical Tests. Except as may be specified for special processes (QW-380), the type and number of test specimens required for mechanical testing shall be in accordance with QW-452. Groove weld test specimens shall be removed in a manner similar to that shown in QW-463.2. Fillet weld test specimens shall be removed in a manner similar to that shown in QW-462.4 and QW-463.2(h).

All mechanical tests shall meet the requirements prescribed in QW-160 or QW-180, as applicable.

QW-302.2 Radiographic Examination. When the welder or welding operator is qualified by radiographic examination, as permitted in QW-304 for welders and

QW-305 for welding operators, the minimum length of coupon(s) to be examined shall be 6 in. and shall include the entire weld circumference for pipe(s), except that for small diameter pipe, multiple coupons may be required, but the number need not exceed four consecutively made test coupons. The radiographic technique and acceptance criteria shall be in accordance with QW-191.

QW-302.3 Test Coupons in Pipe. For test coupons made on pipe in position 1G or 2G of QW-461.4, two specimens shall be removed as shown for bend specimens in QW-463.2(d) or (e), omitting the specimens in the upper-right and lower-left quadrants, and replacing the root-bend specimen in the upper-left quadrant of QW-463.2(d) with a face-bend specimen. For test coupons made on pipe in position 5G or 6G of QW-461.4, specimens shall be removed in accordance with QW-463.2(d) or (e) and all four specimens shall pass the test. For test coupons made in both positions 2G and 5G on a single pipe test coupon, specimens shall be removed in accordance with QW-463.2(f) or (g).

QW-302.4 Visual Examination. For plate coupons all surfaces (except areas designated "discard") shall be examined visually per QW-190 before cutting of bend specimens. Pipe coupons shall be visually examined per QW-190 over the entire circumference, inside and outside.

QW-303 Limits of Qualified Positions and Diameters (See QW-461)

QW-303.1 Groove Welds — General. Welders and welding operators who pass the required tests for groove welds in the test positions of QW-461.9 shall be qualified for the positions of groove welds and fillet welds shown in QW-461.9. In addition, welders and welding operators who pass the required tests for groove welds shall also be qualified to make fillet welds in all thicknesses and pipe diameters of any size within the limits of the welding variables of QW-350 or QW-360, as applicable.

QW-303.2 Fillet Welds — General. Welders and welding operators who pass the required tests for fillet welds in the test positions of QW-461.9 shall be qualified for the positions of fillet welds shown in QW-461.9. Welders and welding operators who pass the tests for fillet welds shall be qualified to make fillet welds only in the thicknesses of material, sizes of fillet welds, and diameters of pipe and tube $2\frac{1}{8}$ in. O.D. and over, as shown in QW-452.5, within the applicable

essential variables. Welders and welding operators who make fillet welds on pipe or tube less than $2\frac{1}{8}$ in. O.D. must pass the pipe fillet weld test per QW-452.4 or the required mechanical tests in QW-304 and QW-305 as applicable.

QW-303.3 Special Positions. A fabricator who does production welding in a special orientation may make the tests for performance qualification in this specific orientation. Such qualifications are valid only for the flat position and for the special positions actually tested, except that an angular deviation of ± 15 deg. is permitted in the inclination of the weld axis and the rotation of the weld face, as defined in QW-461.1 and QW-461.2.

QW-303.4 Stud-Weld Positions. Qualification in the 4S position also qualifies for the 1S position. Qualification in the 4S and 2S positions qualifies for all positions.

QW-304 Welders

Except for the special requirements of QW-380, each welder who welds under the rules of the Code shall have passed the mechanical and visual examinations prescribed in QW-302.1 and QW-302.4 respectively. Alternatively, welders making a groove weld using SMAW, SAW, GTAW, PAW, and GMAW (except short-circuiting mode) or a combination of these processes, may be qualified by radiographic examination, except for P-No. 2X, P-No. 5X, and P-No. 6X metals. Welders making groove welds in P-No. 2X and P-No. 5X metals with the GTAW process may also be qualified by radiographic examination. The radiographic examination shall be in accordance with QW-302.2.

A welder qualified to weld in accordance with one qualified WPS is also qualified to weld in accordance with other qualified WPSs, using the same welding process, within the limits of the essential variables of QW-350.

QW-304.1 Examination. Welds made in test coupons for performance qualification may be examined by visual and mechanical examinations (QW-302.1, QW-302.4) or by radiography (QW-302.2) for the process(es) and mode of arc transfer specified in QW-304. Alternatively, a 6 in. length of the first production weld made by a welder using the process(es) and/or mode of arc transfer specified in QW-304 may be qualified by radiography.

QW-304.2 Failure to Meet Radiographic Standards. If a production weld is selected for welder performance qualification and it does not meet the radiographic standards, the welder has failed the test. In this event, the entire production weld made by this

welder shall be radiographed and repaired by a qualified welder or welding operator. Alternatively, retests may be made as permitted in QW-320.

QW-305 Welding Operators

Except for the special requirements of QW-380, each welding operator who welds under the rules of this Code shall have passed the mechanical and visual examinations prescribed in QW-302.1 and QW-302.4 respectively. Alternatively, welding operators making a groove weld using SMAW, SAW, GTAW, PAW, EGW, and GMAW (except short-circuiting mode) or a combination of these processes, may be qualified by radiographic examination, except for P-Nos. 2X, 5X, and 6X metals. Welding operators making groove welds in P-No. 2X and P-No. 5X metals with the GTAW process may also be qualified by radiographic examination. The radiographic examination shall be in accordance with QW-302.2.

A welding operator qualified to weld in accordance with one qualified WPS is also qualified to weld in accordance with other qualified WPSs within the limits of the essential variables of QW-360.

QW-305.1 Examination. Welds made in test coupons may be examined by radiography (QW-302.2) or by visual and mechanical examinations (QW-302.1, QW-302.4). Alternatively, a 3 ft length of the first production weld made entirely by the welding operator in accordance with a qualified WPS may be examined by radiography.

QW-305.2 Failure to Meet Radiographic Standards. If a portion of a production weld is selected for welding operator performance qualification, and it does not meet the radiographic standards, the welding operator has failed the test. In this event, the entire production weld made by this welding operator shall be radiographed completely and repaired by a qualified welder or welding operator. Alternatively, retests may be made as permitted in QW-320.

QW-306 Combination of Welding Processes

Each welder or welding operator shall be qualified within the limits given in QW-301 for the specific welding process(es) he will be required to use in production welding. A welder or welding operator may be qualified by making tests with each individual welding process in separate test coupons, or with a combination of welding processes in a single test coupon. Two or more welders or welding operators, each using the same or a different welding process, may be qualified in combination in a single test coupon. For

combination qualifications in a single test coupon, the limits for thicknesses of deposited weld metal, and bend and fillet testing are given in QW-452 and shall be considered individually for each welder or welding operator for each welding process or whenever there is a change in an essential variable. A welder or welding operator qualified in combination on a single test coupon is qualified to weld in production using any of his processes individually or in different combinations, provided he welds within his limits of qualification with each specific process.

Failure of any portion of a combination test in a single test coupon constitutes failure of the entire combination.

QW-310 QUALIFICATION TEST COUPONS

QW-310.1 Test Coupons. The test coupons may be plate, pipe, or other product forms. When all position qualifications for pipe are accomplished by welding one pipe assembly in both the 2G and 5G positions (QW-461.4), 6 in., 8 in., 10 in., or larger diameter pipe shall be employed to make up the test coupon as shown in QW-463.2(f) for 10 in. or larger pipe and in QW-463.2(g) for 6 in. or 8 in. diameter pipe.

QW-310.2 Welding Groove With Backing. The dimensions of the welding groove on the test coupon used in making qualification tests for double-welded groove welds or single-welded groove welds with backing shall be the same as those for any Welding Procedure Specification (WPS) qualified by the manufacturer, or shall be as shown in QW-469.1.

A single-welded groove-weld test coupon with backing or a double-welded groove-weld test coupon shall be considered welding with backing. Partial penetration groove welds and fillet welds are considered welding with backing.

QW-310.3 Welding Groove Without Backing. The dimensions of the welding groove of the test coupon used in making qualification tests for single-welded groove welds without backing shall be the same as those for any WPS qualified by the manufacturer, or as shown in QW-469.2.

QW-320 RETESTS AND RENEWAL OF QUALIFICATION

QW-321 Retests

A welder or welding operator who fails one or more of the tests prescribed in QW-304 or QW-305, as

applicable, may be retested under the following conditions.

QW-321.1 Immediate Retest Using Visual Examination. When the qualification coupon has failed the visual examination of QW-302.4, retesting shall be by visual examination before conducting the mechanical testing.

When an immediate retest is made, the welder or welding operator shall make two consecutive test coupons for each position which he has failed, all of which shall pass the visual examination requirements.

The examiner may select one of the successful test coupons from each set of retest coupons which pass the visual examination for conducting the mechanical testing.

QW-321.2 Immediate Retest Using Mechanical Testing. When the qualification coupon has failed the mechanical testing of QW-302.1, retesting shall be by mechanical testing.

When an immediate retest is made, the welder or welding operator shall make two consecutive test coupons for each position which he has failed, all of which shall pass the test requirements.

QW-321.3 Immediate Retest Using Radiography. When the qualification coupon has failed the radiographic examination of QW-302.2, the immediate retest shall be by the radiographic examination method.

(a) For welders and welding operators the retest shall be to radiographically examine two 6 in. plate coupons; for pipe, to examine two pipes for a total of 12 in. of weld, which shall include the entire weld circumference for pipe or pipes (for small diameter pipe the total number of consecutively made test coupons need not exceed eight).

(b) At the option of the manufacturer, the welder who has failed the (production weld alternative) test in QW-304.1 may be retested by radiographing an additional 12 in. length of the same production weld. If this length of weld passes the test, the welder is qualified and the area of weld on which he had previously failed the test shall be repaired by him or another qualified welder.

If this 12 in. length does not meet the radiographic standards, the welder has failed the retest and all of the production welds made by this welder shall be radiographed completely and repaired by a qualified welder or welding operator.

(c) At the option of the manufacturer, the welding operator who has failed the test in QW-305.2 may be retested by radiographing an additional 6 ft length of the same production weld. If this length of weld passes

the test, the welding operator is qualified and the area of weld on which he had previously failed the test shall be repaired by him or another qualified welder or welding operator. If this 6 ft length does not meet the radiographic standards, the welding operator has failed the retest and all of the production welds made by this welding operator shall be radiographed completely and repaired by a qualified welder or welding operator.

QW-321.4 Further Training. When the welder or the welding operator has had further training or practice, a new test shall be made for each position on which he failed to meet the requirements.

QW-322 Expiration and Renewal of Qualification

QW-322.1 Expiration of Qualification. The performance qualification of a welder or welding operator shall be affected when one of the following conditions occur:

(a) when he has not welded with a process during a period of 6 months or more, his qualifications for that process shall expire.

(b) when there is a specific reason to question his ability to make welds that meet the specification, the qualifications which support the welding he is doing shall be revoked. All other qualifications not questioned remain in effect.

QW-322.2 Renewal of Qualification

(a) Renewal of qualification expired under QW-322.1(a) above may be made for any process by welding a single test coupon of either plate or pipe, of any material, thickness or diameter, in any position, and by testing of that coupon as required by QW-301 and QW-302. A successful test renews the welder or welding operator's previous qualifications for that process for those materials, thicknesses, diameters, positions, and other variables for which he was previously qualified.

Providing the conditions of QW-304 and QW-305 are satisfied, renewal of qualification under QW-322.1(a) may be done on production work.

(b) Welders and welding operators whose qualifications have been revoked under QW-322.1(b) above shall requalify. Qualification shall utilize a test coupon appropriate to the planned production work. The coupon shall be welded and tested as required by QW-301 and QW-302. Successful test restores the qualification.

QW-350 WELDING VARIABLES FOR WELDERS

QW-351 General

A welder shall be requalified whenever a change is made in one or more of the essential variables listed for each welding process.

Where a combination of welding processes is required to make a weldment, each welder shall be qualified for the particular welding process or processes he will be required to use in production welding. A welder may be qualified by making tests with each individual welding process, or with a combination of welding processes in a single test coupon.

The limits of deposited weld metal thickness for which he will be qualified are dependent upon the thickness of the weld he deposits with each welding process. exclusive of any weld reinforcement, this thickness shall be considered the test coupon thickness as given in QW-452.

In any given production weldment, welders may not deposit a thickness greater than that permitted by QW-452 for each welding process in which they are qualified.

QW-353 SHIELDED METAL-ARC WELDING (SMAW) Essential Variables

Paragraph		Brief of Variables	
QW-402 Joints	.4	-	Backing
QW-403 Base Metals	.16	φ	Pipe Diameter
	.18	φ	P-Number
QW-404 Filler Metals	.15	φ	F-Number
	.30	φ	t Weld deposit
QW-405 Positions	.1	+	Position
	.3	φ	: : Vertical welding

QW-352 OXYFUEL GAS WELDING (OFW) Essential Variables

Paragraph		Brief of Variables	
QW-402 Joints	.7	+	Backing
QW-403 Base Metals	.2		Maximum qualified
	.18	φ	P-Number
QW-404 Filler Metals	.14	=	Filler
	.15	φ	F-Number
Filler Metals	.31	φ	t Weld deposit
QW-405 Positions	.1	+	Position
QW-408 Gas	.7	φ	Type fuel gas

QW-354 SEMIAUTOMATIC SUBMERGED-ARC WELDING (SAW) Essential Variables

Paragraph		Brief of Variables	
QW-403 Base Metals	.16	φ	Pipe diameter
	.18	φ	P-Number
QW-404 Filler Metals	.15	φ	F-Number
	.30	φ	t Weld deposit
QW-405 Positions	.1	+	Position

QW-355 SEMIAUTOMATIC GAS METAL-ARC WELDING (GMAW)
 [This Includes Flux-Cored Arc Welding (FCAW)]
 Essential Variables

Paragraph		Brief of Variables	
QW-402 Joints	.4	-	Backing
QW-403 Base Metals	.16	φ	Pipe diameter
	.18	φ	P-Number
QW-404 Filler Metals	.15	φ	F-Number
	.30	φ	t Weld deposit
	.32		t Limit (S. Cir. Arc.)
QW-405 Positions	.1	+	Position
	.3	φ	↑ ↓ Vertical welding
QW-408 Gas	.8	-	Inert backing
QW-409 Electrical	.2	φ	Transfer mode

QW-356 MANUAL AND SEMIAUTOMATIC GAS TUNGSTEN-ARC WELDING (GTAW)
 Essential Variables

Paragraph		Brief of Variables	
QW-402 Joints	.4	-	Backing
QW-403 Base Metals	.16	φ	Pipe diameter
	.18	φ	P-Number
QW-404 Filler Metals	.14	±	Filler
	.15	φ	F-Number
	.22	±	Inserts
	.30	φ	t Weld deposit
QW-405 Positions	.1	+	Position
	.3	φ	↑ ↓ Vertical welding
QW-408 Gas	.8	-	Inert backing
QW-409 Electrical	.4	φ	Current or polarity

QW-357 MANUAL AND SEMIAUTOMATIC PLASMA-ARC WELDING (PAW)
 Essential Variables

Paragraph		Brief of Variables	
QW-402 Joints	.4	-	Backing
QW-403 Base Metals	.16	φ	Pipe diameter
	.18	φ	P-Number
QW-404 Filler Metals	.14	±	Filler
	.15	φ	F-Number
	.22	±	Inserts
QW-405 Positions	.30	φ	t Weld deposit
	.1	+	Position
QW-408 Gas	.3	φ	↑ ↓ Vertical welding
	.8	-	Inert backing

Legend for QW-352 through QW-357:
 φ Change ↑ Uphill
 + Addition ↓ Downhill
 - Deletion

QW-360 WELDING VARIABLES FOR WELDING OPERATORS

QW-361 General

Except as specified in QW-362, QW-363, and for the special processes of QW-380, a welding operator shall be requalified whenever a change is made in one of the following essential variables.

QW-361.1 Essential Variables — Automatic Welding

- (a) A change from automatic to machine welding.
- (b) A change in the welding process.
- (c) For electron beam and laser welding, the addition or deletion of filler metal.
- (d) For laser welding, a change in laser type (e.g., a change from CO₂ to YAG).
- (e) For friction welding, a change from continuous drive to inertia welding or vice versa.
- (f) For electron beam welding, a change from vacuum to out-of-vacuum equipment, and vice versa.

QW-361.2 Essential Variables — Machine Welding

- (a) A change in the welding process.
- (b) A change from direct visual control to remote visual control and vice-versa.
- (c) The deletion of an automatic arc voltage control system for GTAW.

(d) The deletion of automatic joint tracking.

(e) The addition of welding positions other than those already qualified (see QW-120, QW-130, and QW-303).

(f) The deletion of consumable inserts, except that qualification with consumable inserts shall also qualify for fillet welds and welds with backing.

(g) The deletion of backing. Double-welded groove welds are considered welding with backing.

(h) A change from single pass per side to multiple passes per side but not the reverse.

QW-362 Electron Beam Welding (EBW), Laser Beam Welding (LBW), and Friction Welding (FRW)

The performance qualification test coupon shall be production parts or test coupons that have joint designs permitted by any qualified WPS. The coupon shall be mechanically tested in accordance with QW-452. Alternatively, when the part or coupon does not readily lend itself to the preparation of bend test specimens, the part may be cut so that at least two full-thickness weld cross sections are exposed. Those cross sections 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. The weld metal and heat affected zone shall exhibit complete fusion and freedom from cracks. The essential variables for welding operator qualification shall be in accordance with QW-361.

QW-363 Stud Welding

Stud welding operators shall be performance qualified in accordance with the test requirements of QW-193 and the position requirements of QW-303.4.

QW-380 SPECIAL PROCESSES

QW-381 Corrosion-Resistant Weld Metal Overlay

(a) The size of test coupons, limits of qualification, required examinations and tests, and test specimens shall be as specified in QW-453.

(b) Welders or welding operators who pass the tests for corrosion-resistant weld metal overlay cladding shall only be qualified to apply corrosion-resistant weld metal overlay portion of a groove weld joining composite clad or lined materials.

(c) The essential variables of QW-350 and QW-360 shall apply for welders and welding operators, respectively, except welders or welding operators shall

be qualified for unlimited maximum deposited thickness and as otherwise specified in QW-453.

(d) A welder or welding operator who has qualified on composite welds in clad or lined material, as provided in QW-383(c) is also qualified to deposit corrosion-resistant weld metal overlay.

QW-382 Hard-Facing Weld Metal Overlay (Wear Resistant)

(a) The size of the test coupons, limits of qualification, required examinations and tests, and test specimens shall be as specified in QW-453. Base material test coupons may be as permitted in QW-423.

(b) Welders and welding operators who pass the tests for hard-facing weld metal overlay are qualified for hard-facing overlay only.

(c) The essential variable, of QW-350 and QW-360, shall apply for welders and welding operators, respectively, except that there is no limit on the maximum thickness of hard-facing overlay that may be applied in production and as otherwise specified in QW-453.

(d) Qualification with one AWS classification within an SFA specification qualifies for all other AWS classifications in that SFA specification.

(e) A change in welding process shall require welder and welding operator requalification.

QW-383 Clad Plate or Applied Lining

(a) A welder or welding operator who has qualified on composite welds in clad or lined material as provided in (c), below, is qualified for welding the base metal and lining or cladding material separately. A welder or welding operator who has qualified using separate test coupons for both the base material and lining or cladding materials is also qualified to make a composite weld. Qualification on both base material and lining or cladding material is required only of welders or welding operators who weld both materials.

(b) The qualification test coupon shall consist of a base material not less than 6 in. long, 3 in. wide, and 1/4 in. thick, to which are clamped or bonded two strips of lining or cladding material separated by a gap left in the lining or a groove cut in the cladding as illustrated in QW-462.6(a); or the test coupon may be a base material not less than 6 in. long, 3 in. wide, and 3/8 in. thick with a 1/8 in. deep groove cut in the cladding as illustrated in QW-462.6(b).

The gap or groove shall run lengthwise of the test coupon approximately midway of the coupon width. The width of the gap shall not be less than twice the

nominal thickness of the lining or cladding and not less than the maximum gap to be used in construction, but need not be greater than $\frac{3}{4}$ in. The essential variables of QW-350 for welders and QW-360 for welding operators shall apply separately to the base material and the lining or cladding. For material not included in QW-422, the material used in the test coupon shall be within the range of chemical composition of that to be used in construction. The test weld shall be made between the edges of the joint representing lining or cladding material by the technique prescribed in a qualified WPS. Postweld heat treatment may be omitted per QW-301.2. The mechanical test shall be performed on two longitudinal face-bend test specimens that conform to the dimensions and other requirements of QW-161 and QW-462.3(b). The specimens shall be tested in accordance with and meet the requirements of QW-160.

(c) *Composite Welds.* Performance qualification tests may be made by preparing test coupons from clad

material so that the essential variables of QW-350 or QW-360 are met. Heat treatment is not required, but is permitted if the welder's or welding operator's work on construction is to be heat treated. QW-462.6(c), (d), and (e) show some acceptable composite joint details.

QW-384 Resistance Welding Operator Qualification

Each welding operator shall be tested on each machine type which he will use. Qualification testing on any P-2X metal shall qualify the operator for all materials. Qualification on any P-1 through P-11 or any P-4X metals shall qualify the operator for all P-1 through P-11 or P-4X metals. Qualification testing shall consist of making a set of 10 consecutive welds, five of which shall be subjected to mechanical shear tests or peel tests, and five to metallographic examination. Examination, testing, and acceptance criteria shall be in accordance with QW-196.

ARTICLE IV

WELDING DATA

QW-400 VARIABLES

QW-401 General

Each welding variable described in this Article is applicable as an essential, supplemental essential, or nonessential variable for procedure qualification when referenced in QW-250 for each specific welding process. Essential variables for performance qualification are referenced in QW-350 for each specific welding process. A change from one welding process to another welding process is an essential variable and requires requalification.

QW-401.1 Essential Variable (Procedure). A change in a welding condition which will affect the mechanical properties (other than notch toughness) of the weldment (for example, change in P-Number, welding process, filler metal, electrode, preheat or postweld heat treatment, etc.).

QW-401.2 Essential Variable (Performance). A change in a welding condition which will affect the ability of a welder to deposit sound weld metal (such as a change in welding process, deletion of backing, electrode, F-Number, technique, etc.).

QW-401.3 Supplemental Essential Variable (Procedure). A change in a welding condition which will affect the notch-toughness properties of a weldment (for example, change in welding process, uphill or down vertical welding, heat input, preheat or PWHT, etc.).

When a procedure has been previously qualified to satisfy all requirements other than notch toughness, it is then necessary only to prepare an additional test coupon using the same procedure with the same essential variables, but additionally with all of the required supplementary essential variables, with the coupon long enough to provide the necessary notch-toughness specimens.

When a procedure has been previously qualified to satisfy all requirements including notch toughness, but

one or more supplementary essential variable is changed, then it is only necessary to prepare an additional test coupon using the same welding procedure and the new supplementary essential variable(s), with the coupon long enough to provide the necessary notch-toughness specimens. If a previously qualified weld procedure has satisfactory notch-toughness values in the weld metal, then it is necessary only to test notch-toughness specimens from the heat affected zone when such are required.

QW-401.4 Nonessential Variable (Procedure). A change in a welding condition which will *not* affect the mechanical properties of a weldment (such as joint design, method of back gouging or cleaning, etc.).

QW-401.5 The welding data includes the welding variables grouped as joints, base metals, filler metals, position, preheat, postweld heat treatment, gas, electrical characteristics, and technique. For convenience, variables for each welding process are summarized in QW-415 for procedure qualification and QW-416 for performance qualification.

QW-402 Joints

QW-402.1 A change in the type of groove (Vee-groove, U-groove, single-bevel, double-bevel, etc.).

QW-402.2 The addition or deletion of a backing.

QW-402.3 A change in the nominal composition of the backing.

QW-402.4 The deletion of the backing in single-welded groove welds. Double-welded groove welds are considered welding with backing.

QW-402.5 The addition of a backing or a change in its nominal composition.

QW-402.6 An increase in the fit-up gap, beyond that initially qualified.

QW-402.7 The addition of backing.

QW-402.8 A change in nominal size or shape of the stud at the section to be welded.

QW-402.9 In stud welding, a change in shielding as a result of ferrule or flux type.

QW-402.10 A change in the specified root spacing.

QW-402.11 The addition or deletion of nonmetallic retainers or nonfusing metal retainers.

QW-402.12 The welding procedure qualification test shall duplicate the joint configuration to be used in production within the limits listed, except that pipe or tube to pipe or tube may be used for qualification of a pipe or tube to other shapes, and solid round to solid round may be used for qualification of a solid round to other shapes:

(a) any change exceeding ± 10 deg. in the angle measured for the plane of either face to be joined, to the axis of rotation;

(b) a change in cross-sectional area of the weld joint greater than 10%;

(c) a change in the outside diameter of the cylindrical weld interface of the assembly greater than $\pm 10\%$;

(d) a change from solid to tubular cross section at the joint or vice versa regardless of (b) above.

QW-402.13 A change in the joint from spot to projection to seam or vice versa.

QW-402.14 A decrease in the center-to-center distance when the welds overlap. An increase or decrease of more than 10% in the spacing of the welds when they are within two diameters of each other.

QW-402.15 A change in the size or shape of the projection in projection welding.

QW-402.16 A decrease in the distance between the weld fusion line and the final surface of the production corrosion-resistant or hard-facing weld metal overlay below the minimum thickness qualified as shown in QW-462.5. There is no limit on the maximum thickness for corrosion-resistant or hard-facing weld metal overlay that may be used in production.

QW-402.17 An increase in the thickness of the production spray fuse hard-facing deposit above the thickness deposited on the procedure qualification test coupon.

QW-403 Base Metals

QW-403.1 A change from a base metal listed under one P-Number in QW-422 to a metal listed under

another P-Number or to any other base metal. When joints are made between two base metals that have different P-Numbers, a procedure qualification shall be made for the applicable combination of P-Numbers, even though qualification tests have been made for each of the two base metals welded to itself.

QW-403.2 The maximum thickness qualified is the thickness of the test coupon.

QW-403.3 Where the measurement of penetration can be made by visual or mechanical means, requalification is required where the base metal thickness differs by 20% from that of the test coupon thickness when the test coupon thickness is 1 in. and under, and 10% when the test coupon thickness is over 1 in. Where the measurement of penetration cannot be made, requalification is required where the base metal thickness differs by 10% from that of the test coupon when the test coupon thickness is 1 in. and under, and 5% when the test coupon thickness is over 1 in.

QW-403.4 Welding procedure qualifications shall be made using a base metal of the same type or grade or another base metal listed in the same group (see QW-422) as the base metal to be used in production welding. When joints are to be made between base metals from two different groups, a procedure qualification must be made for the applicable combination of base metals, even though procedure qualification tests have been made for each of the two base metals welded to itself.

QW-403.5 Welding procedure qualifications shall be made using a base metal of the same type or grade or another base metal listed in the same P-Number and Group Number (see QW-422) as the base metal to be used in production welding. A procedure qualification shall be made for each P-Number and Group Number combination of base metals, even though procedure qualification tests have been made for each of the two base metals welded to itself. If, however, the procedure specification for welding the combination of base metals specifies the same essential variables, including electrode or filler metal, as both specifications for welding each base metal to itself, such that base metals is the only change, then the procedure specification for welding the combination of base metals is also qualified. In addition, when base metals of two different P-Number Group Number combinations are qualified using a single test coupon, that coupon qualifies the welding of those two P-Number Group Numbers to themselves as well as to each other using the variables qualified.

QW-403.6 The minimum base metal thickness qualified is the thickness of the test coupon T or $\frac{3}{8}$ in., whichever is less. However, where T is less than $\frac{1}{4}$ in., the minimum thickness qualified is $\frac{1}{2}T$. This limitation does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.

QW-403.7 For the multipass processes of shielded metal-arc, submerged-arc, gas tungsten-arc, and gas metal-arc, the maximum thickness qualified for $1\frac{1}{2}$ in. and over thickness T of the test coupon of QW-451.1 shall be 8 in. for the conditions shown in QW-451.1. For thicknesses greater than 8 in., the procedure test coupon thickness of the joint to be welded in production divided by 1.33, and the maximum thickness of base metal and deposited weld metal qualified is $1.33T$ or $1.33t$, as applicable.

QW-403.8 A change in base metal thickness beyond the range qualified in QW-451, except as otherwise permitted by QW-202.4(b).

QW-403.9 For single-pass or multipass welding in which any pass is greater than $\frac{1}{2}$ in. thick, an increase in base metal thickness beyond 1.1 times that of the qualification test coupon.

QW-403.10 For the short-circuiting transfer mode of the gas metal-arc process, when the qualification test coupon thickness is less than $\frac{1}{2}$ in., an increase in thickness beyond 1.1 times that of the qualification test coupon. For thicknesses of $\frac{1}{2}$ in. and greater, use QW-451.1 or QW-451.2, as applicable.

QW-403.11 Base metals specified in the WPS shall be qualified by a procedure qualification test which was made using base metals in accordance with QW-424.

QW-403.12 A change from a base metal listed under one P-Number of QW-422 to a base metal listed under another P-Number. When joints are made between two base metals that have different P-Numbers, requalification is required even though the two base metals have been independently qualified using the same procedure. When the melt-in technique is used for joining P-No. 1, P-No. 3, P-No. 4, and P-No. 5A, a procedure qualification test with one P-Number metal shall also qualify for that P-Number metal welded to each of the lower P-Number metals, but not vice versa.

QW-403.13 A change from one P-No. 5 to any other P-No. 5 (viz P-No. 5A to P-No. 5B or P-No. 5C or vice versa). A change from P-No. 9A to P-No.

9B but not vice versa. A change from one P-No. 10 to any other P-No. 10 (viz P-No. 10A to P-No. 10B or P-No. 10C, etc., or vice versa).

QW-403.15 Welding procedure qualifications for laser beam welding and electron beam welding shall be made using a base metal of the same type or grade or another base metal listed in the same P-Number (and the same group where given — see QW-422) as the base metal to be used in production welding. When joints are to be made between base metals from two different P-Numbers (or two different groups), a procedure qualification must be made for the applicable combination of base metals even though procedure qualification tests have been made for each of the two base metals welded to itself.

QW-403.16 A change in the pipe diameter beyond the range qualified in QW-452, except as otherwise permitted in QW-303.1, QW-303.2, or when welding corrosion-resistant weld metal overlay is performed parallel to the axis of the pipe.

QW-403.17 In stud welding, a change in combination of base metal listed under one P-Number in QW-422 and stud metal P-Number (as defined in Note below), or to any other base metal/stud metal combination.

NOTE: Stud metal shall be classified by nominal chemical composition and can be assigned a P-Number when it meets the nominal composition of any one of the P-Number metals.

QW-403.18 A change from one P-Number to any other P-Number or to a base metal not listed in QW-422, except as permitted in QW-423, and in QW-420.2.

QW-403.19 A change to another base material type or grade (type or grade are materials of the same nominal chemical analysis and mechanical property range, even though of different product form), or to any other base material type or grade. When joints are made between two different types or grades of base material, a procedure qualification must be made for the applicable combinations of materials, even though procedure qualification tests have been made for each of the two base materials welded to itself.

QW-403.20 A change from a base metal, listed under one P-Number in QW-422, to a metal listed under another P-Number or to any other base metal; from a base metal of one subgroup to any other grouping in P-No. 10 or 11.

QW-403.21 The addition or deletion of a coating, plating or cladding, or a change in the nominal chemical analysis or thickness range of the plating or cladding, or a change in type of coating as specified in the WPS.

QW-403.22 A change in the nominal base metal thickness exceeding 5% of any outer sheet thickness or 10% of the nominal thickness of the total joint from that qualified.

QW-403.23 A change in base metal thickness beyond the range qualified in QW-453.

QW-404 Filler Metals

QW-404.1 A change in the cross-sectional area of the filler metal added (excluding buttering) or in the wire-feed speed greater than $\pm 10\%$ beyond that qualified.

QW-404.2 A decrease in the thickness or change in nominal specified chemical analysis of weld metal buttering beyond that qualified. (Buttering or surfacing is the deposition of weld metal on one or both faces of the joint prior to preparation of the joint for final electron beam welding.)

QW-404.3 A change in the size of the filler metal.

QW-404.4 A change from one F-Number in QW-432 to any other F-Number or to any other filler metal not listed in QW-432.

QW-404.5 (Applicable only to ferrous metals.) A change in the chemical composition of the weld deposit from one A-Number to any other A-Number in QW-442. Qualification with A-No. 1 shall qualify for A-No. 2 and vice versa.

The weld metal chemical composition may be determined by any of the following.

(a) For all welding processes — from the chemical analysis of the weld deposit taken from the procedure qualification test coupon.

(b) For SMAW, GTAW, and PAW — from the chemical analysis of the weld deposit prepared according to the filler metal specification, or from the chemical composition as reported either in the filler metal specification or the manufacturer's or supplier's certificate of compliance.

(c) For GMAW and EGW — from the chemical analysis of the weld deposit prepared according to the filler metal specification or the manufacturer's or supplier's certificate of compliance when the shielding gas used was the same as that used to weld the procedure qualification test coupon.

(d) For SAW — from the chemical analysis of the weld deposit prepared according to the filler metal specification or the manufacturer's or supplier's certificate of compliance when the flux used was the same

as that used to weld the procedure qualification test coupon.

In lieu of an A-Number designation, the nominal chemical composition of the weld deposit shall be indicated on the WPS and on the PQR. Designation of nominal chemical composition may also be by reference to the AWS classification (where such exists), the manufacturer's trade designation, or other established procurement documents.

QW-404.6 A change in the nominal size of the electrode or electrodes specified in the WPS.

QW-404.7 A change in the nominal diameter of the electrode to over $\frac{1}{4}$ in. This limitation does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.

QW-404.8 Addition or deletion, or a change in nominal amount or composition of supplementary deoxidation material (in addition to filler metal) beyond that qualified. (Such supplementary metal may be required for weld metal deoxidation for some metals being welded.)

QW-404.9

(a) A change in the indicator for minimum tensile strength (e.g., the 7 in F7A2-EM12K) when the flux wire combination is classified in Section II, Part C.

(b) A change in either the flux trade name or wire trade name when neither the flux nor the wire is classified in Section II, Part C.

(c) A change in the flux trade name when the wire is classified in Section II, Part C but the flux is not classified. A change in the wire classification within the requirements of QW-404.5 does not require requalification.

(d) A change in the flux trade name for A-No. 8 deposits.

QW-404.10 Where the alloy content of the weld metal is largely dependent upon the composition of the flux used, any change in any part of the welding procedure which would result in the important alloying elements in the weld metal being outside of the specification range of chemistry given in the Welding Procedure Specification. If there is evidence that the production welds are not being made in accordance with the procedure specification, the authorized inspector may require that a check be made on the chemical composition of the weld metal. Such a check shall preferably be made on a production weld.

QW-404.12 A change in the SFA specification filler metal classification or to a filler metal not covered by

an SFA specification, or from one filler metal not covered by an SFA specification to another which is not covered by an SFA specification.

When a filler metal conforms to an SFA specification classification, requalification is not required if a change is made in any of the following:

(a) from a filler metal which is designated as moisture-resistant to one which is not designated as moisture-resistant and vice-versa (i.e., from E7018R to E7018);

(b) from one diffusible hydrogen level to another (i.e., from E7018-H8 to E7018-H16);

(c) for carbon, low alloy, and stainless steel filler metals having the same minimum tensile strength and the same nominal chemical composition, a change from one low hydrogen coating type to another low hydrogen coating type (i.e., a change among EXX15, 16, or 18 or EXXX15, 16, or 17 classifications);

(d) from one position-usability designation to another for flux cored electrodes (i.e., a change from E70T-1 to E71T-1 or vice versa);

(e) from a classification which requires impact testing to the same classification which has a suffix which indicates that impact testing was performed at a lower temperature or exhibited greater toughness at the required temperature or both, as compared to the classification which was used during procedure qualification (i.e., a change from E7018 to E7018-1).

QW-404.14 The deletion or addition of filler metal.

QW-404.15 A change from one F-Number in QW-432 to any other F-Number or to any other filler metal, except as permitted in QW-433.

QW-404.17 A change in the type of flux or composition of the flux.

QW-404.18 A change from wire to plate electrodes, and vice versa.

QW-404.19 A change from consumable guide to nonconsumable guide, and vice versa.

QW-404.20 Any change in the method by which filler metal is added, such as preplaced shim, top strip, wire, wire feed, or prior weld metal buttering of one or both joint faces.

QW-404.21 For filler metal additions, any change from the nominal specified analysis of the filler metal qualified.

QW-404.22 The omission or addition of consumable inserts. Qualification in a single-welded butt joint, with or without consumable inserts, qualifies for fillet welds and single-welded butt joints with backing or double-welded butt joints. Consumable inserts that conform to

SFA-5.30, except that the chemical analysis of the insert conforms to an analysis for any bare wire given in any SFA specification or AWS Classification, shall be considered as having the same F-Number as that bare wire as given in QW-432.

QW-404.23 A change in the filler metal from bare (solid) or metal cored to flux cored, or vice versa.

QW-404.24 The addition or deletion of supplementary filler metal.

QW-404.25 The addition or deletion of supplementary powdered filler metal.

QW-404.26 An increase in the amount of supplementary powdered filler metal.

QW-404.27 Where the alloy content of the weld metal is largely dependent upon the composition of the supplementary powdered filler metal, any change in any part of the welding procedure which would result in the important alloying elements in the weld metal being outside of the specification range of chemistry given in the Welding Procedure Specification.

QW-404.29 A change in the flux trade name and designation.

QW-404.30 A change in deposited weld metal thickness beyond the range qualified in QW-451 for procedure qualification or QW-452 for performance qualification, except as otherwise permitted in QW-303.1 and QW-303.2. When a welder is qualified using radiography, the thickness ranges of QW-452.1 apply.

QW-404.31 The maximum thickness qualified is the thickness of the test coupon.

QW-404.32 For the low voltage short-circuiting type of gas metal-arc process when the deposited weld metal thickness is less than 1/2 in., an increase in deposited weld metal thickness beyond 1.1 times that of the qualification test deposited weld metal thickness. For weld metal thicknesses of 1/2 in. and greater, use QW-451.1 or QW-451.2, or QW-452.1 or QW-452.2, as applicable.

QW-404.33 A change in the SFA specification filler metal classification, or, if not conforming to an AWS filler metal classification, a change in the manufacturer's trade name for the electrode or filler metal. When optional supplemental designators, such as those which indicate moisture resistance (i.e., XXXXR), diffusible hydrogen (i.e., XXXX H16, H8, etc.), and supplemental impact testing (i.e., XXXX-1 or EXXXXM), are specified on the WPS, only filler metals which conform

to the classification with the optional supplemental designator(s) specified on the WPS shall be used.

QW-404.34 A change in flux type (i.e., neutral to active or vice versa) for multilayer deposits in P-No. 1 materials.

QW-404.35 A change in the flux/wire classification or a change in either the electrode or flux trade name when not classified in an SFA specification. Requalification is not required when a wire/flux combination conforms to an SFA specification and a change is made from one diffusible hydrogen level to another (i.e., a change from F7A2-EA1-A1H4 to F7A2-EA1-A1H16).

QW-404.36 Where flux from recrushed slag is used, it shall be tested in accordance with Section II, Part C by either the manufacturer or user, or qualified as an unclassified flux in accordance with QW-404.9.

QW-404.37 A change in the composition of the deposited weld metal from one A-Number in QW-442 to any other A-Number, or to an analysis not listed in the table. Each AWS classification of A-No. 8 or A-No. 9 analysis of QW-442, or each nonferrous alloy in QW-432, shall require separate WPS qualification. A-Numbers may be determined in accordance with QW-404.5.

QW-404.38 A change in the nominal electrode diameter used for the first layer of deposit.

QW-404.39 For submerged-arc welding and electroslag welding, a change in the nominal composition or type of flux used. Requalification is not required for a change in flux particle size.

QW-404.40 A change in the nominal cross-sectional area of the electrodes or supplementary filler metal of more than 10%.

QW-404.41 A change of more than 10% in the powdered metal feed rate recorded on the PQR.

QW-404.42 A change of more than 5% in the particle size range of the powder.

QW-404.43 A change in the powdered metal particle size range recorded on the PQR.

QW-404.44 A change from a homogeneous powdered metal to a mechanical mixed powdered metal or vice versa.

QW-404.45 A change in the form of filler metal from solid to fabricated wire, flux-cored wire, powdered metal, or vice versa.

QW-404.46 A change in the powder feed rate range qualified.

QW-405 Positions

QW-405.1 The addition of other welding positions than those already qualified. See QW-120, QW-130, and QW-303.

QW-405.2 A change from any position to the vertical position uphill progression. Vertical-uphill progression (e.g., 3G, 5G, or 6G position) qualifies for all positions. In uphill progression, a change from stringer bead to weave bead. This limitation does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.

QW-405.3 A change from upward to downward, or from downward to upward, in the progression specified for any pass of a vertical weld, except that the cover or wash pass may be up or down. The root pass may also be run either up or down when the root pass is removed to sound weld metal in the preparation for welding the second side.

QW-405.4 Except as specified below, the addition of other welding positions than already qualified.

(a) Qualification in the horizontal, vertical, or overhead position shall also qualify for the flat position. Qualification in the horizontal fixed position, 5G, shall qualify for the flat, vertical, and overhead positions. Qualification in the horizontal, vertical, and overhead positions shall qualify for all positions. Qualification in the inclined fixed position, 6G, shall qualify for all positions.

(b) A fabricator who does production welding in a particular orientation may make the tests for procedure qualification in this particular orientation. Such qualifications are valid only for the positions actually tested, except that an angular deviation of ± 15 deg. is permitted in the inclination of the weld axis and the rotation of the weld face as defined in QW-461.1. A test specimen shall be taken from the test coupon in each special orientation.

(c) In the vertical position, a change in the progression of travel from uphill to downhill, or vice versa.

QW-406 Preheat

QW-406.1 A decrease of more than 100°F in the preheat temperature qualified. The minimum temperature for welding shall be specified in the WPS.

QW-406.2 A change in the maintenance or reduction of preheat upon completion of welding prior to any required postweld heat treatment.

QW-406.3 An increase of more than 100°F in the maximum interpass temperature recorded on the PQR. This limitation does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.

QW-406.4 A decrease of more than 100°F in the preheat temperature qualified or an increase in the maximum interpass temperature recorded on the PQR. The minimum temperature for welding shall be specified in the WPS.

QW-406.5 A change in the maintenance or reduction of preheat upon completion of spraying and prior to fusing.

QW-406.6 A change of more than 10% in the amplitude or number of preheating cycles from that qualified.

QW-407 Postweld Heat Treatment

QW-407.1 A separate PQR is required for each of the following conditions.

(a) For P-No. 1, P-No. 3, P-No. 4, P-No. 5, P-No. 6, P-No. 9, P-No. 10, and P-No. 11 materials, the following postweld heat treatment conditions apply:

- (1) No PWHT;
- (2) PWHT below the lower transformation temperature;
- (3) PWHT above the upper transformation temperature (e.g., normalizing);
- (4) PWHT above the upper transformation temperature followed by heat treatment below the lower transformation temperature (e.g., normalizing or quenching followed by tempering);
- (5) PWHT between the upper and lower transformation temperatures.

(b) For all other materials, the following postweld heat treatment conditions apply:

- (1) No PWHT;
- (2) PWHT within a specified temperature range.

QW-407.2 A change in the postweld heat treatment (see QW-407.1) temperature and time range requires a PQR.

The procedure qualification test shall be subjected to PWHT essentially equivalent to that encountered in the fabrication of production welds, including at least 80% of the aggregate times at temperature(s). The

PWHT total time(s) at temperature(s) may be applied in one heating cycle.

QW-407.4 For test coupon (PQR) receiving a postweld heat treatment in which the upper transformation temperature is exceeded, the maximum qualified thickness for production welds is 1.1 times the thickness of the test coupon.

QW-407.5 A separate PQR is required for each of the following conditions:

- (a) No PWHT;
- (b) A change of more than 10% in the number of post heating cycles following the welding interval;
- (c) PWHT within a specified temperature and time range if heat treatment is performed separately from the welding operation.

QW-407.6 A change in postweld heat treatment condition in QW-407.1 or an increase of 25% or more in total time at postweld heat treating temperature.

QW-407.7 A change in the heat treatment temperature range qualified if heat treatment is applied after fusing.

QW-408 Gas

QW-408.1 The addition or deletion of trailing shielding gas and/or a change in its composition.

QW-408.2 A change from a single shielding gas to any other single shielding gas or to a mixture of shielding gases, or a change in specified percentage composition of shielding gas mixture, or omission of shielding gas.

QW-408.3 A change in the specified flow rate range of the shielding gas or mixture of gases.

QW-408.4 A change in composition and flow rates of orifice gas and shielding gas.

QW-408.5 The addition or deletion of gas backing, a change in backing gas composition, or a change in the specified flow rate range of the backing gas.

QW-408.6 Any change of environment shielding such as from vacuum to an inert gas, or vice versa.

QW-408.7 A change in the type of fuel gas.

QW-408.8 The omission of inert gas backing except that requalification is not required when welding a single-welded butt joint with a backing strip or a double-welded butt joint or a fillet weld. This exception does not apply to P-No. 5X, P-No. 6X, and P-No. 10I metals.

QW-408.9 For groove welds in P-No. 4X and all welds of P-No. 5X, P-No. 6X, P-No. 10I, P-No. 10J, and P-No. 10K metals, the deletion of backing gas or a change in the nominal composition of the backing gas from an inert to a mixture including non-inert gas(es).

QW-408.10 For P-No. 10I, P-No. 5X, and P-No. 6X metals, the deletion of trailing shielding gas, a change in the trailing gas composition, or a decrease of 10% or more in the trailing gas flow rate.

QW-408.11 The addition or deletion of one or more of the following: shielding gas, trailing shielding gas, backing gas, or plasma-removing gas.

QW-408.12 A change of more than 5% in the flow rate of one or more of the following: shielding gas, trailer shielding gas, backing gas, and plasma-removing gas.

QW-408.13 A change in the position or orientation of plasma-removing gas jet relative to the workpiece (e.g., coaxial transverse to beam).

QW-408.14 A change in the oxygen or fuel gas pressure beyond the range qualified.

QW-408.15 In gas metal-arc welding and gas tungsten-arc welding: a change from a single gas to any other single gas or to a mixture of gases, or vice versa; a change in specified percentage composition of gas mixture or omission of shielding gas; a decrease of 10% or more in the rate of flow of shielding gas or mixture.

QW-408.16 A change of more than 5% in the flow rate of the plasma-arc gas or powdered metal feed gas recorded on the PQR.

QW-408.17 A change in the plasma-arc gas, shielding gas, or powdered metal feed gas from a single gas to any other single gas, or to a mixture of gases, or vice versa.

QW-408.18 A change of more than 10% in the gas mixture composition of the plasma-arc gas, shielding gas, or powdered metal feed gas recorded on the PQR.

QW-408.19 A change in the nominal composition of the powder feed gas or (plasma-arc spray) plasma gas qualified.

QW-408.20 A change of more than 5% in the plasma gas flow rate range qualified.

QW-409 Electrical Characteristics

QW-409.1 An increase in heat input, or an increase in volume of weld metal deposited per unit length of weld, over that qualified. The increase may be measured by either of the following:

(a) Heat input (J/in.)

$$= \frac{\text{Voltage} \times \text{Amperage} \times 60}{\text{Travel Speed (in./min)}}$$

(b) Volume of Weld Metal = an increase in bead size or a decrease in length of weld bead per unit length of electrode.

The requirement for measuring the heat input or volume of deposited weld metal does not apply when the WPS is qualified with a PWHT above the upper transformation temperature or a solution anneal after welding austenitic materials.

QW-409.2 A change from spray arc, globular arc, or pulsating arc to short circuiting arc, or vice versa.

QW-409.3 The addition or deletion of pulsing current to dc power source.

QW-409.4 A change from ac to dc, or vice versa; and in dc welding, a change from straight polarity to reverse polarity, or vice versa.

QW-409.5 A change of $\pm 15\%$ from the amperage or voltage ranges in the qualified WPS.

QW-409.6 A change in the beam current of more than $\pm 5\%$, voltage of more than $\pm 2\%$, welding speed of more than $\pm 2\%$, beam focus current of more than $\pm 5\%$, gun-to-work distance of more than $\pm 5\%$, or a change in oscillation length or width of more than $\pm 20\%$ from those previously qualified.

QW-409.7 Any change in the beam pulsing frequency duration from that qualified.

QW-409.8 A change in the range of amperage, or except for SMAW and GTAW welding, a change in the range of voltage. A change in the range of electrode wire feed speed may be used as an alternative to amperage.

QW-409.9 A change in the arc timing of more than $\pm \frac{1}{10}$ sec.

QW-409.10 A change in amperage of more than $\pm 10\%$.

QW-409.11 A change in the power source from one model to another.

QW-409.12 A change in type or size of tungsten electrode.

QW-409.13 A change in the shape or dimensions of the welding electrode; a change from one RWMA (Resistance Welding Manufacturer's Association) class electrode material to another.

QW-409.14 Addition or deletion of upslope or downslope current control, or a change of more than 10% in the slope current time or amplitude.

QW-409.15 A change of more than 5% in the electrode pressure, the welding current, or the welding time cycle from that qualified, except that requalification is not required if there is a change of not more than 10% in either the electrode pressure or the welding current or the welding time cycle, provided the remaining two variables remain at the values qualified. A change from ac to dc or vice versa. The addition or deletion of pulsing current to a dc power source. When using pulsing dc current, a change of more than 5% in the pulse amplitude, width, or number of pulses per cycle from that qualified.

QW-409.16 A change from synchronous to asynchronous timing.

QW-409.17 A change in the power supply primary voltage or frequency, or in the transformer turns ratio, tap setting, choke position, secondary open circuit voltage or phase control setting.

QW-409.18 A change in the procedure or frequency of tip cleaning.

QW-409.19 Any change in the beam pulsing frequency and pulse duration from that qualified.

QW-409.20 Any change in the following variables: mode of operation (from pulsed to continuous or vice versa), energy distribution across the beam (i.e., multimode or gaussian), lens focal length, and lens focal distance.

QW-409.21 Any change in the following variables: wattage of more than 2%, welding speed of more than 2%, spot size of more than 2%, and lens to work distance of more than 5%.

QW-409.22 An increase of more than 10% in the amperage used in application for the first layer.

QW-409.23 A change of more than 10% in the ranges of amperage or voltage qualified.

QW-409.24 A change of more than 10% in the filler wire wattage recorded on the PQR. Wattage is a function of current voltage, and stickout dimension.

QW-409.25 A change of more than 10% in the plasma-arc current or voltage recorded on the PQR.

QW-409.26 For the first layer only, an increase in heat input of more than 10% or an increase in volume of weld metal deposited per unit length of weld of more than 10% over that qualified. The increase may be measured by either of the following:

(a) Heat input (J/in.)

$$= \frac{\text{Voltage} \times \text{Amperage} \times 60}{\text{Travel Speed (in./min)}}$$

(b) Volume of Weld Metal = an increase in bead size or a decrease in length of weld bead per unit length of electrode.

QW-410 Technique

QW-410.1 A change from the stringer bead technique to the weave bead technique, or vice versa.

QW-410.2 A change in the nature of the flame, oxidizing to reducing, or vice versa.

QW-410.3 A change in the orifice, cup, or nozzle size.

QW-410.4 A change in the welding technique, fore-hand to backhand, or vice versa.

QW-410.5 A change in the method of initial and interpass cleaning (brushing, grinding, etc.)

QW-410.6 A change in the method of back gouging.

QW-410.7 A change in width, frequency, or dwell time of oscillation, for machine or automatic welding only.

QW-410.8 A change in the contact tube to work distance.

QW-410.9 A change from multipass per side to single pass per side. This limitation does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.

QW-410.10 A change from single electrode to multi-electrode, or vice versa, for machine or automatic welding only. This limitation does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.

QW-410.11 A change from closed chamber to out-of-chamber conventional torch welding in P-No. 5X metals, but not vice versa.

QW-410.12 A change from the melt-in technique to the keyhole technique of welding, or vice versa, or the inclusion of both techniques though each has been individually qualified.

QW-410.14 A change in the angle of the axis of the beam relative to the workpiece.

QW-410.15 A change in the spacing of multiple electrodes for machine or automatic welding.

QW-410.17 A change in the type or model of the welding equipment.

QW-410.18 An increase in the absolute pressure of the vacuum welding environment beyond that qualified.

QW-410.19 Any change in filament type, size, or shape.

QW-410.20 The addition of a wash pass.

QW-410.21 A change of welding from one side to welding from both sides, or vice versa.

QW-410.22 A change in either of the following stud welding parameters: a change of stud gun model; a change in the lift more than $\pm \frac{1}{32}$ in.

QW-410.25 A change from manual or semiautomatic to machine or automatic welding and vice versa.

QW-410.26 The addition or deletion of peening.

QW-410.27 A change in the rotational speed producing a change in the outside surface velocity (ft/min) greater than $\pm 10\%$ of the outside surface velocity qualified.

QW-410.28 A change in the thrust load (lb) greater than $\pm 10\%$ of the thrust load qualified.

QW-410.29 A change in the rotational energy (lb-ft²) greater than $\pm 10\%$ of the rotational energy qualified.

QW-410.30 Any change in upset dimension (overall loss in length of parts being joined) greater than $\pm 10\%$ of the upset qualified.

QW-410.31 A change in the method of preparing the base metal prior to welding (e.g., changing from mechanical cleaning to chemical cleaning or to abrasive cleaning, or vice versa).

QW-410.32 A change of more than 10% in the holding pressure prior to or after welding. A change of more than 10% in the electrode holding time.

QW-410.33 A change from one welding type to another, or modification of equipment, including Manufacturer, control panel, model number, electrical rating or capacity, type of electrical energy source, or method of applying pressure.

QW-410.34 Addition or deletion of an electrode cooling medium and where it is used.

QW-410.35 A change in the distance between arms or a change in the throat depth.

QW-410.37 A change from single to multiple pass or vice versa.

QW-410.38 A change from multiple-layer to single layer cladding/hardsurfacing, or vice versa.

QW-410.39 A change in the torch type or tip size.

QW-410.40 For submerged-arc welding and electroslag welding, the deletion of a supplementary device for controlling the magnetic field acting on the weld puddle.

QW-410.41 A change of more than 15% in the travel speed range recorded on the PQR.

QW-410.42 The addition or elimination of oscillation of the plasma torch or filler wires; a change from simple harmonic to constant velocity oscillating motion or vice versa; a change of more than 10% in oscillation displacement recorded on the PQR; however, a procedure qualified using a minimum oscillation displacement and a procedure qualified using a maximum oscillation displacement shall qualify for all weld bead oscillations in between, with all other essential variables remaining the same.

QW-410.43 For the torch or workpiece, a change of more than 10% in the travel speed range qualified.

QW-410.44 A change of more than 15% in the spray-torch to workpiece distance qualified.

QW-410.45 A change in the method of surface preparation of the base metal to be hard-faced (example: sandblasting versus chemical cleaning).

QW-410.46 A change in the spray-torch model or tip orifice size.

QW-410.47 A change of more than 10% in the fusing temperature range qualified. A change in the rate of cooling from the fusing temperature of more than 50°F/hr, a change in the fusing method (example: torch, furnace, induction).

QW-410.48 A change in the constricted arc from transferable to nontransferable or vice versa.

QW-410.49 A change in the diameter of the plasma torch-arc constricting orifice.

QW-410.50 A change in the number of electrodes acting on the same welding puddle.

QW-410.51 The addition or elimination of oscillation of the electrode or electrodes.

QW-410.52 A change in the method of delivering the filler metal to the molten pool, such as from the leading or trailing edge of the torch, the sides of the torch, or through the torch.

**QW-416
WELDING VARIABLES
Welder Performance**

Paragraph ¹	Brief of Variables	Essential <i>VARIABLE RETEST</i>					
		OFW QW-352	SMAW QW-353	SAW QW-354	GMAW ² QW-355	GTAW QW-356	PAW QW-357
Joints QW-402	.4 - Backing		X		X	X	X
	.7 + Backing	X					
Base Metal QW-403	.2 Maximum qualified	X					
	.16 ϕ Pipe diameter		X	X	X	X	X
	.18 ϕ P-Number	X	X	X	X	X	X
Filler Metals QW-404	.14 \pm Filler	X				X	X
	.15 ϕ F-Number	X	X	X	X	X	X
	.22 \pm Inserts					X	X
	.30 ϕ t Weld deposit		X	X	X	X	X
	.31 ϕ t Weld deposit	X					
	.32 t Limit (s. cir. arc)				X		
Positions QW-405	.1 + Position	X	X	X	X	X	X
	.3 ϕ t ; Vert. welding		X		X	X	X
Gas QW-408	.7 ϕ Type fuel gas	X					
	.8 - Inert backing				X	X	X
Electrical QW-409	.2 ϕ Transfer mode				X		
	.4 ϕ Current or polarity					X	

Welding Processes:

FGW	Gas welding (fuel gas welding)
SMAW	Shielded metal-arc welding
SAW	Submerged-arc welding
GMAW	Gas metal-arc welding
GTAW	Gas tungsten-arc welding
PAW	Plasma-arc welding

Legend:

ϕ Change	t Thickness
+ Addition	↑ Uphill
- Deletion	↓ Downhill

NOTES:

- (1) For description, see Section IV.
- (2) Flux-cored arc welding as shown in QW-355, with or without additional shielding from an externally supplied gas or gas mixture, is included.

QW-420 Material Groupings**QW-420.1 P-Numbers**

To reduce the number of welding and brazing procedure qualifications required, base metals have been assigned P-Numbers, and for ferrous base metals which have specified impact test requirements, Group Numbers within P-Numbers. These assignments are based essentially on comparable base metal characteristics, such as composition, weldability, brazeability, and mechanical properties, where this can logically be done. These assignments do not imply that base metals may be indiscriminately substituted for a base metal which was used in the qualification test without consideration of compatibility from the standpoint of metallurgical properties, postweld heat treatment, design, mechanical properties, and service requirements. Where notch toughness is a consideration, it is presupposed that the base metals meet the specific requirements.

Base Metal	Welding	Brazing
Steel and steel alloys	P-No. 1 through P-No. 11 incl. P-No. 5A, 5B, and 5C	P-No. 101 through P-No. 103
Aluminum and aluminum-base alloys	P-No. 21 through P-No. 25	P-No. 104 and P-No. 105
Copper and copper-base alloys	P-No. 31 through P-No. 35	P-No. 107 and P-No. 108
Nickel and nickel-base alloys	P-No. 41 through P-No. 47	P-No. 110 through P-No. 112
Titanium and titanium-base alloys	P-No. 51 through P-No. 53	P-No. 115
Zirconium and zirconium-base alloys	P-No. 61 through P-No. 62	P-No. 117

When a base metal with a UNS number designation is assigned a P-Number, then a base metal listed in a different ASME material specification with the same UNS number shall be considered that P-Number. For example, SB-163, UNS N08800 is P-Number 45; therefore, all ASME specifications listing a base metal with the UNS N08800 designation shall be considered P-Number 45 (i.e., SB-407, SB-408, SB-514, etc.) whether or not these specifications are listed in QW-422. Since a minimum tensile value is required for procedure

qualification, only base metals listed in QW-422 may be used for test coupons as defined in QW-424.

In those instances where materials in the 1971 Edition of this Section have been given different P-Numbers or assigned to Subgroups within a P-Number in the 1974 Edition of this Section, those procedure and performance qualifications will continue to be valid based on the new P-Number designation.

In the column heading "Minimum Specified Tensile, ksi" of QW-422, the values given are those of the base metal specification, except as otherwise identified in the table notes. These are also the acceptance values for the room temperature tensile tests of the welding procedure qualification, except as otherwise allowed in QW-153.

QW-420.2 S-Numbers (Non-Mandatory)

S-Numbers are a listing of materials which are acceptable for use by the ASME B31 Code for Pressure Piping, or by selected Boiler and Pressure Vessel Code Cases, but which are not included within ASME Boiler and Pressure Code Material Specifications (Section II). These materials are grouped in S-Number groupings similar to the P-Number groupings. There is no mandatory requirement that S-Numbers be used.

Brazing or Welding Procedure Qualification with a base metal in one P-Number, or P-Number plus Group Number, qualifies for all other base metals in the same S-Number grouping. Qualifications for S-Number materials do not qualify corresponding P-Number materials. Base metals not assigned an S-Number or a P-Number shall require individual procedure qualification.

However, if a base metal with a UNS number designation is assigned an S-Number, then a base metal listed in a different material specification with the same UNS number shall be considered that S-Number. Since a minimum tensile value is required for procedure qualification, only base metals listed in QW/QB-422 may be used for test coupons.

For Performance Qualification of brazers, welders, brazing operators, and welding operators, the requirements for P-Numbers of base metals shall also be applied to the same S-Numbers of base metals. Qualification with P-Numbers in accordance with QB-310.3 and QB-403.18 qualifies for corresponding S-Numbers and vice versa.

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding			Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	P. No.	S. No.		
SA-36	...	K02500	58	1	1	...	...	...	C-Mn-Si	Plate
SA-53	Type F	...	45	1	1	...	101	...	C	Furnace welded pipe
SA-53	Type S, Gr. A	K02504	48	1	1	...	101	...	C	Smls. pipe
SA-53	Type E, Gr. A	K02504	48	1	1	...	101	...	C	Resistance welded pipe
SA-53	Type E, Gr. B	K03005	60	1	1	...	101	...	C-Mn	Resistance welded pipe
SA-53	Type S, Gr. B	K03005	60	1	1	...	101	...	C-Mn	Smls. pipe
SA-105	...	K03504	70	1	2	...	101	...	C-Si	Pipe flange
SA-106	A	K02501	48	1	1	...	101	...	C-Si	Smls. pipe
SA-106	B	K03006	60	1	1	...	101	...	C-Si	Smls. pipe
SA-106	C	K03501	70	1	2	...	101	...	C-Si	Smls. pipe
A 108	1015 CW	G10150	60	...	...	...	...	101	C	Bar
A 108	1018 CW	G10180	60	...	...	...	...	101	C	Bar
A 108	1020 CW	G10200	60	...	...	...	...	101	C	Bar
A 134	A283A	...	45	...	...	...	...	101	C	Weilded pipe
A 134	A285A	K01700	45	...	...	...	...	101	C	Weilded pipe
A 134	A283B	...	50	...	...	...	...	101	C	Weilded pipe
A 134	A285B	K02200	50	...	...	...	...	101	C	Weilded pipe
A 134	A283C	...	55	...	...	...	...	101	C	Weilded pipe
A 134	A285C	K02801	55	...	...	...	...	101	C	Weilded pipe
A 134	A283D	...	60	...	...	...	...	101	C	Weilded pipe
SA-134	...	...	—	1	1	...	101	...	C	Weilded pipe
SA-135	A	...	47	1	1	...	...	...	C	ERW pipe
SA-135	B	...	48	1	1	...	...	...	C	ERW pipe
A 139	A	...	48	...	...	...	...	101	C	Weilded pipe
A 139	B	K03003	60	...	...	...	...	101	C	Weilded pipe
A 148	90-60	...	90	...	...	...	...	103	...	Castings
SA-178	A	K01200	47	1	1	...	101	...	C	E.R.W. tube
SA-178	C	K03503	60	1	1	...	...	...	C	E.R.W. tube

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
 Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding				Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	Group No.	P. No.	S. No.		
SA-178	D	...	70	1	2	...	...	101	...	C-Mn-Si	Smls. tube
SA-179	...	K01200	47(2)	1	1	...	...	101	...	C	Pipe flange Pipe flange
SA-181	Cl. 60	K03502	60	1	1	...	...	101	...	C-Si	Forgings
SA-181	Cl. 70	K03502	70	1	2	...	...	...	...	C-Si	Forgings
SA-182	F12, Cl. 1	K11562	60	4	1	...	...	102	...	1Cr-0.5Mo	Forgings
SA-182	F12, Cl. 2	K11564	70	4	1	...	...	102	...	1Cr-0.5Mo	Forgings
SA-182	F11, Cl. 2	K11572	70	4	1	...	...	102	...	1.25Cr-0.5Mo-Si	Forgings
SA-182	F11, Cl. 3	K11572	75	4	1	...	...	102	...	1.25Cr-0.5Mo-Si	Forgings
SA-182	F11, Cl. 1	K11597	60	4	1	...	...	102	...	1.25Cr-0.5Mo-Si	Forgings
SA-182	F2	K12122	70	3	2	...	...	101	...	0.5Cr-0.5Mo	Forgings
SA-182	F1	K12822	70	3	2	...	...	101	...	C-0.5Mo	Forgings
SA-182	F22, Cl. 1	K21590	60	5A	1	...	...	102	...	2.25Cr-1Mo	Forgings
SA-182	F22, Cl. 3	K21590	75	5A	1	...	...	102	...	2.25Cr-1Mo	Forgings
SA-182	FR	K22035	63	9A	1	...	...	...	...	2Ni-1Cu	Forgings
SA-182	F21	K31545	75	5A	1	...	...	102	...	3Cr-1Mo	Forgings
SA-182	F3V	K31830	85	5C	1	...	...	...	...	3Cr-1Mo-0.25V	Forgings
SA-182	F5	K41545	70	5B	1	...	...	102	...	5Cr-0.5Mo	Forgings
SA-182	F5a	K42544	90	5B	1	...	...	102	...	5Cr-0.5Mo	Forgings
SA-182	F9	K90941	85	5B	1	...	...	102	...	9Cr-1Mo	Forgings
SA-182	F91	...	85	5B	2	...	...	...	...	9Cr-1Mo-V	Forgings
SA-182	F6a, Cl. 1	K91151	70	6	1	...	...	102	...	13Cr	Forgings
SA-182	F6a, Cl. 2	K91151	85	6	3	...	...	...	...	13Cr	Forgings
SA-182	FXM-19	S20910	100	8	3	...	...	...	...	22Cr-13Ni-5Mn	Forgings
SA-182	FXM-11	S21904	90	8	3	...	...	...	...	21Cr-6Ni-9Mn	Forgings
SA-182	F304	S30400	70	8	1	...	...	102	...	18Cr-8Ni	Forgings > 5 in.
SA-182	F304	S30400	75	8	1	...	...	102	...	18Cr-8Ni	Forgings
SA-182	F304L	S30403	65	8	1	...	...	102	...	18Cr-8Ni	Forgings > 5 in.
SA-182	F304L	S30403	70	8	1	...	...	102	...	18Cr-8Ni	Forgings
SA-182	F304H	S30409	70	8	1	...	...	102	...	18Cr-8Ni	Forgings > 5 in.
SA-182	F304H	S30409	75	8	1	...	...	102	...	18Cr-8Ni	Forgings

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi (Note (1))	Welding			Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	P. No.	S. No.		
SA-182	F304N	S30451	80	8	1	...	102	...	18Cr-8Ni-N	Forgings > 5 in.
SA-182	F304LN	S30453	70	8	1	...	102	...	18Cr-8Ni-N	Forgings
SA-182	F304LN	S30453	75	8	1	...	102	...	18Cr-8Ni-N	Forgings
SA-182	S30600	S30600	78	8	1	...	...	...	18Cr-15Ni-4Si	Forgings
SA-182	F45	S30815	87	8	2	...	...	...	21Cr-11Ni-N	Forgings
SA-182	F310	S31000	70	8	2	...	...	...	25Cr-20Ni	Forgings > 5 in.
SA-182	F310	S31000	75	8	2	...	...	...	25Cr-20Ni	Forgings
SA-182	F50	S31200	100	10H	1	...	...	...	25Cr-6Ni-Mo-N	Forgings
SA-182	F44	S31254	94	8	4	...	...	...	20Cr-18Ni-6Mo	Forgings
SA-182	F316	S31600	70	8	1	...	102	...	16Cr-12Ni-2Mo	Forgings > 5 in.
SA-182	F316	S31600	75	8	1	...	102	...	16Cr-12Ni-2Mo	Forgings
SA-182	F316L	S31603	65	8	1	...	102	...	16Cr-12Ni-2Mo	Forgings > 5 in.
SA-182	F316L	S31603	70	8	1	...	102	...	16Cr-12Ni-2Mo	Forgings
SA-182	F316H	S31609	70	8	1	...	102	...	16Cr-12Ni-2Mo	Forgings > 5 in.
SA-182	F316H	S31609	75	8	1	...	102	...	16Cr-12Ni-2Mo	Forgings
SA-182	F316N	S31651	80	8	1	...	102	...	16Cr-12Ni-2Mo-N	Forgings
SA-182	F316LN	S31653	70	8	1	...	102	...	16Cr-12Ni-2Mo-N	Forgings > 5 in.
SA-182	F316LN	S31653	75	8	1	...	102	...	16Cr-12Ni-2Mo-N	Forgings
SA-182	F317	S31700	70	8	1	...	...	...	18Cr-13Ni-3Mo	Forgings > 5 in.
SA-182	F317	S31700	75	8	1	...	...	...	18Cr-13Ni-3Mo	Forgings
SA-182	F317L	S31703	65	8	1	...	...	...	18Cr-13Ni-3Mo	Forgings > 5 in.
SA-182	F317L	S31703	70	8	1	...	...	...	18Cr-13Ni-3Mo	Forgings
SA-182	F51	S31803	90	10H	1	...	...	...	22Cr-5.5Ni-N	Forgings
SA-182	F321	S32100	70	8	1	...	102	...	18Cr-10Ni-Ti	Forgings > 5 in.
SA-182	F321	S32100	75	8	1	...	102	...	18Cr-10Ni-Ti	Forgings
SA-182	F321H	S32109	70	8	1	...	102	...	18Cr-10Ni-Ti	Forgings > 5 in.
SA-182	F321H	S32109	75	8	1	...	102	...	18Cr-10Ni-Ti	Forgings
SA-182	F10	S33100	80	8	2	...	102	...	20Ni-8Cr	Forgings
SA-182	F347	S34700	70	8	1	...	102	...	18Cr-10Ni-Cb	Forgings > 5 in.
SA-182	F347	S34700	75	8	1	...	102	...	18Cr-10Ni-Cb	Forgings
SA-182	F347H	S34709	70	8	1	...	102	...	18Cr-10Ni-Cb	Forgings > 5 in.
SA-182	F347H	S34709	75	8	1	...	102	...	18Cr-10Ni-Cb	Forgings

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding				Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	Group No.	P. No.	S. No.		
SA-182	F348	S34800	70	8	1	...	...	102	...	18Cr-10Ni-Cb	Forgings > 5 in.
SA-182	F348	S34800	75	8	1	...	...	102	...	18Cr-10Ni-Cb	Forgings
SA-182	F348H	S34809	70	8	1	...	...	102	...	18Cr-10Ni-Cb	Forgings > 5 in.
SA-182	F348H	S34809	75	8	1	...	...	102	...	18Cr-10Ni-Cb	Forgings
SA-182	F6b	S41026	110	6	3	...	...	102	...	13Cr-0.5Mo	Forgings
SA-182	F6NM	S41500	115	6	4	...	...	...	...	13Cr-4.5Ni-Mo	Forgings
SA-182	F429	S42900	60	6	2	...	...	...	...	15Cr	Forgings
SA-182	F430	S43000	60	7	2	...	...	...	...	17Cr	Forgings
SA-182	FXM-27Cb	S44627	60	101	1	...	...	...	...	27Cr-1Mo	Forgings
SA-192	...	K01201	47	1	1	...	...	101	...	C-Si	Smls. tube
SA-199	T11	K11597	60	4	1	...	...	102	...	1.25Cr-0.5Mo-Si	Smls. tube
SA-199	T22	K21590	60	5A	1	...	...	102	...	2.25Cr-1Mo	Smls. tube
SA-199	T4	K31509	60	5A	1	...	...	102	...	2.25Cr-0.5Mo-0.75Si	Smls. tube
SA-199	T21	K31545	60	5A	1	...	...	102	...	3Cr-1Mo	Smls. tube
SA-199	T5	K41545	60	5B	1	...	...	102	...	5Cr-0.5Mo	Smls. tube
SA-199	T9	K81590	60	5B	1	...	...	102	...	9Cr-1Mo	Smls. tube
SA-199	T91	...	85	5B	2	...	...	...	...	9Cr-1Mo-V	Smls. tube
SA-202	A	K11742	75	4	1	...	...	102	...	0.5Cr-1.25Mn-Si	Plate
SA-202	B	K12542	85	4	1	...	...	101	...	0.5Cr-1.25Mn-Si	Plate
SA-203	A	K21703	65	9A	1	...	...	102	...	2.5Ni	Plate
SA-203	B	K22103	70	9A	1	...	...	102	...	2.5Ni	Plate
SA-203	D	K31718	65	9B	1	...	...	102	...	3.5Ni	Plate
SA-203	E	K32018	70	9B	1	...	...	102	...	3.5Ni	Plate
SA-203	F	...	75	9B	1	...	...	...	...	3.5Ni	Plate, > 2 in.
SA-203	F	...	80	9B	1	...	...	...	...	3.5Ni	Plate, 2 in. & under
SA-204	A	K11820	65	3	1	...	...	101	...	C-0.5Mo	Plate
SA-204	B	K12020	70	3	2	...	...	101	...	C-0.5Mo	Plate
SA-204	C	K12320	75	3	2	...	...	101	...	C-0.5Mo	Plate
SA-209	T1b	K11422	53	3	1	...	...	101	...	C-0.5Mo	Smls. tube
SA-209	T1	K11522	55	3	1	...	...	101	...	C-0.5Mo	Smls. tube

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding			Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	P. No.	S. No.		
SA-209	T1a	K12023	60	3	1	...	101	...	C-0.5Mo	Smls. tube
SA-210	A-1	K02707	60	1	1	...	101	...	C-Si	Smls. tube
SA-210	C	K03501	70	1	2	...	101	...	C-Mn-Si	Smls. tube
A 211	A570A	...	45	...	...	...	...	101	C	Welded pipe
A 211	A570 Gr30	K02502	49	...	...	...	...	101	C	Welded pipe
A 211	A570B	...	49	...	...	...	...	101	C	Welded pipe
A 211	A570 Gr33	K02502	52	...	...	...	...	101	C	Welded pipe
A 211	A570C	...	52	...	...	...	...	101	C	Welded pipe
A 211	A570D	...	55	...	...	...	...	101	C	Welded pipe
SA-213	T2	K11547	60	3	1	...	101	...	0.5Cr-0.5Mo	Smls. tube
SA-213	T12	K11562	60	4	1	...	102	...	1Cr-0.5Mo	Smls. tube
SA-213	T11	K11597	60	4	1	...	102	...	1.25Cr-0.5Mo-Si	Smls. tube
SA-213	T17	K12047	60	10B	1	...	102	...	1Cr-V	Smls. tube
SA-213	T22	K21590	60	5A	1	...	102	...	2.25Cr-1Mo	Smls. tube
SA-213	T21	K31545	60	5A	1	...	102	...	3Cr-1Mo	Smls. tube
SA-213	T5c	K41245	60	5B	1	...	102	...	5Cr-0.5Mo-Ti	Smls. tube
SA-213	T5	K41545	60	5B	1	...	102	...	5Cr-0.5Mo	Smls. tube
SA-213	T5b	K51545	60	5B	1	...	102	...	5Cr-0.5Mo-Si	Smls. tube
SA-213	T9	K81590	60	5B	1	...	102	...	9Cr-1Mo	Smls. tube
SA-213	T91	...	85	5B	2	...	...	...	9Cr-1Mo-V	Smls. tube
SA-213	TP201	S20100	95	8	3	...	...	...	17Cr-4Ni-6Mn	Smls. tube
SA-213	TP202	S20200	90	8	3	...	...	...	18Cr-5Ni-9Mn	Smls. tube
SA-213	TP304	S30400	75	8	1	...	102	...	18Cr-8Ni	Smls. tube
SA-213	TP304L	S30403	70	8	1	...	102	...	18Cr-8Ni	Smls. tube
SA-213	TP304H	S30409	75	8	1	...	102	...	18Cr-8Ni	Smls. tube
SA-213	TP304N	S30451	80	8	1	...	102	...	18Cr-8Ni-N	Smls. tube
SA-213	TP304LN	S30453	75	8	1	...	...	...	18Cr-8Ni-N	Smls. tube
SA-213	S30600	S30600	78	8	1	...	...	...	18Cr-15Ni-4Si	Smls. tube
SA-213	S30815	S30815	87	8	2	...	...	...	21Cr-11Ni-N	Smls. tube
SA-213	TP309S	S30908	75	8	2	...	...	...	23Cr-12Ni-S	Smls. tube
SA-213	Type 309H	S30909	75	8	2	...	...	...	23Cr-12Ni	Smls. tube

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding				Brazing		Nominal Composition	Product Form
				P- No.	Group No.	S- No.	Group No.	P- No.	S- No.		
SA-213	TP309Cb	S30940	75	8	2	...	...	...	23Cr-12Ni-Cb	Smls. tube
SA-213	Type 309HCb	S30941	75	8	2	...	...	...	23Cr-12Ni-Cb	Smls. tube
SA-213	TP310S	S31008	75	8	2	...	...	...	25Cr-20Ni-S	Smls. tube
SA-213	Type 310H	S31009	75	8	2	...	...	...	25Cr-20Ni	Smls. tube
SA-213	TP310Cb	S31040	75	8	2	...	...	...	25Cr-20Ni-Cb	Smls. tube
SA-213	Type 310HCb	S31041	75	8	2	...	...	...	25Cr-20Ni-Cb	Smls. tube
SA-213	TP316	S31600	75	8	1	...	102	...	16Cr-12Ni-2Mo	Smls. tube	
SA-213	TP316L	S31603	70	8	1	...	102	...	16Cr-12Ni-2Mo	Smls. tube	
SA-213	TP316H	S31609	75	8	1	...	102	...	16Cr-12Ni-2Mo	Smls. tube	
SA-213	TP316N	S31651	80	8	1	...	102	...	16Cr-12Ni-2Mo-N	Smls. tube	
SA-213	TP316LN	S31653	75	8	1	...	...	...	16Cr-12Ni-2Mo-N	Smls. tube
SA-213	S31725	S31725	75	8	4	...	...	...	19Cr-15Ni-4Mo	Smls. tube
SA-213	S31726	S31726	80	8	4	...	...	...	19Cr-15.5Ni-4Mo	Smls. tube
SA-213	TP321	S32100	75	8	1	...	102	...	18Cr-10Ni-Ti	Smls. tube	
SA-213	TP321H	S32109	75	8	1	...	102	...	18Cr-10Ni-Ti	Smls. tube	
SA-213	TP347	S34700	75	8	1	...	102	...	18Cr-10Ni-Cb	Smls. tube	
SA-213	TP347H	S34709	75	8	1	...	102	...	18Cr-10Ni-Cb	Smls. tube	
SA-213	TP348	S34800	75	8	1	...	102	...	18Cr-10Ni-Cb	Smls. tube	
SA-213	TP348H	S34809	75	8	1	...	102	...	18Cr-10Ni-Cb	Smls. tube	
SA-213	XM-15	S38100	75	8	1	...	102	...	18Cr-18Ni-2Si	Smls. tube	
SA-214	...	K01807	...	1	1	...	...	...	C	E.R.W. tube
SA-216	WCA	J02502	60	1	1	...	101	...	C-Si	Castings	
SA-216	WCC	J02503	70	1	2	...	101	...	C-Mn-Si	Castings	
SA-216	WCB	J03002	70	1	2	...	101	...	C-Si	Castings	
SA-217	WC6	J12072	70	4	1	...	101	...	1.25Cr-0.5Mo	Castings	
SA-217	WC4	J12082	70	4	1	...	102	...	1Ni-0.5Cr-0.5Mo	Castings	
SA-217	WC1	J12522	65	3	1	...	101	...	C-0.5Mo	Castings	
SA-217	WC9	J21890	70	5A	1	...	102	...	2.25Cr-1Mo	Castings	
SA-217	WC5	J22000	70	4	1	...	102	...	0.75Ni-1Mo-0.75Cr	Castings	
SA-217	C5	J42025	90	5B	1	...	102	...	5Cr-0.5Mo	Castings	
SA-217	C12	J82090	90	5B	1	...	102	...	9Cr-1Mo	Castings	
SA-217	CA15	J91150	90	6	3	...	...	...	13Cr	Castings

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding			Brazing			Nominal Composition	Product Form
				P. No.	Group No.	S. No.	P. No.	S. No.			
									Group No.		
SA-225	D	...	75	10A	1	...	...	...	Mn-0.5Ni-V	Plate, > 3 in.
SA-225	D	...	80	10A	1	...	...	...	Mn-0.5Ni-V	Plate, 3 in. & under
SA-225	C	K12524	105	10A	1	...	...	...	Mn-0.5Ni-V	Plate
SA-226		K01201	47	1	1	...	...	101	C-Si	E.R.W. tube
SA-234	WPB	K03006	60	1	1	...	...	101	C-Si	Piping fitting
SA-234	WPC	K03501	70	1	2	...	...	101	C-Si	Piping fitting
SA-234	WP11, Cl. 1	...	60	4	1	...	...	102	1.25Cr-0.5Mo-Si	Piping fitting
SA-234	WP12, Cl. 1	K12062	60	4	1	...	...	101	1Cr-0.5Mo	Piping fitting
SA-234	WPI	K12821	55	3	1	...	...	101	C-0.5Mo	Piping fitting
SA-234	WP22, Cl.1	K21590	60	5A	1	...	...	102	2.25Cr-1Mo	Piping fitting
SA-234	WPR	K22035	63	9A	1	...	...	101	2Ni-1Cu	Piping fitting
SA-234	WP5	K41545	60	5B	1	...	...	102	5Cr-0.5Mo	Piping fitting
SA-234	WP9	K90941	60	5B	1	...	...	102	9Cr-1Mo	Piping fitting
SA-234	WP91	...	85	5B	2	...	...	...	9Cr-1Mo-V	Piping fitting
SA-240	Type 201-1	S20100	95	8	3	...	...	...	17Cr-4Ni-6Mn	Plate, Sheet & Strip
SA-240	Type 202	S20200	90	8	3	...	...	...	18Cr-5Ni-9Mn	Plate, Sheet & Strip
SA-240	Type XM-19	S20910	100	8	3	...	...	...	22Cr-13Ni-5Mn	Plate, Sheet & Strip
SA-240	Type XM-19	S20910	105	8	3	...	...	...	22Cr-13Ni-5Mn	Plate, Sheet & Strip
SA-240	Type XM-17	S21600	90	8	3	...	...	...	19Cr-8Mn-6Ni-Mo-N	Plate, Sheet & Strip
SA-240	Type XM-17	S21600	100	8	3	...	...	...	19Cr-8Mn-6Ni-Mo-N	Plate, Sheet & Strip
SA-240	Type XM-18	S21603	90	8	3	...	...	...	19Cr-8Mn-6Ni-Mo-N	Plate, Sheet & Strip
SA-240	Type XM-18	S21603	100	8	3	...	...	...	19Cr-8Mn-6Ni-Mo-N	Plate, Sheet & Strip
SA-240	S21800	S21800	95	8	3	...	...	...	18Cr-8Ni-4Si-N	Plate, Sheet & Strip
SA-240	Type XM-29	S24000	100	8	3	...	...	...	18Cr-3Ni-12Mn	Plate, Sheet & Strip
SA-240	Type 302	S30200	75	8	1	...	...	102	18Cr-8Ni	Plate, Sheet & Strip
SA-240	Type 304	S30400	75	8	1	...	...	102	18Cr-8Ni	Plate, Sheet & Strip
SA-240	Type 304L	S30403	70	8	1	...	...	102	18Cr-8Ni	Plate, Sheet & Strip
SA-240	Type 304H	S30409	75	8	1	...	...	102	18Cr-8Ni	Plate, Sheet & Strip
SA-240	Type 304N	S30451	80	8	1	...	...	102	18Cr-8Ni-N	Plate, Sheet & Strip
SA-240	Type XM-21	S30452	85	8	1	...	...	...	18Cr-8Ni-N	Plate, Sheet & Strip
SA-240	Type XM-21	S30452	90	8	1	...	...	...	18Cr-8Ni-N	Plate, Sheet & Strip

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding			Brazing			Nominal Composition	Product Form
				P. No.	Group No.	S. No.	P. No.	S. No.			
SA-240	Type 304LN	S30453	75	8	1	...	...	...	18Cr-8Ni-N	Plate, Sheet & Strip
SA-240	S30600	S30600	78	8	1	...	...	...	18Cr-15Ni-4Si	Plate, Sheet & Strip
SA-240	S30600	S30600	78	8	1	...	...	...	18Cr-15Ni-4Si	Bar & Shape
SA-240	S30815	S30815	87	8	2	...	...	...	21Cr-11Ni-N	Plate, Sheet & Strip
SA-240	Type 309S	S30908	75	8	2	...	102	...	23Cr-12Ni-S	Plate, Sheet & Strip	
SA-240	Type 309H	S30909	75	8	2	...	...	...	23Cr-12Ni	Plate, Sheet & Strip
SA-240	Type 309Cb	S30940	75	8	2	...	...	...	23Cr-12Ni-Cb	Plate, Sheet & Strip
SA-240	Type 309HCb	S30949	75	8	2	...	...	...	23Cr-12Ni-Cb	Plate, Sheet & Strip
SA-240	Type 310S	S31008	75	8	2	...	102	...	25Cr-20Ni-S	Plate, Sheet & Strip	
SA-240	Type 310Cb	S31040	75	8	2	...	...	...	25Cr-20Ni-Cb	Plate, Sheet & Strip
SA-240	Type 310HCb	S31049	75	8	2	...	...	...	25Cr-20Ni-Cb	Plate, Sheet & Strip
SA-240	S31200	S31200	100	10H	1	...	...	...	25Cr-6Ni-Mo-N	Plate, Sheet & Strip
SA-240	S31254	S31254	94	8	4	...	...	...	20Cr-18Ni-6Mo	Plate, Sheet & Strip
SA-240	Type 316	S31600	75	8	1	...	102	...	16Cr-12Ni-2Mo	Plate, Sheet & Strip	
SA-240	Type 316L	S31603	70	8	1	...	102	...	16Cr-12Ni-2Mo	Plate, Sheet & Strip	
SA-240	Type 316H	S31609	75	8	1	...	102	...	16Cr-12Ni-2Mo	Plate, Sheet & Strip	
SA-240	Type 316Ti	S31635	75	8	1	...	...	...	16Cr-12Ni-2Mo-Ti	Plate, Sheet & Strip
SA-240	Type 316Cb	S31640	75	8	1	...	102	...	16Cr-12Ni-2Mo-Cb	Plate, Sheet & Strip	
SA-240	Type 316N	S31651	80	8	1	...	102	...	16Cr-12Ni-2Mo-N	Plate, Sheet & Strip	
SA-240	Type 316LN	S31653	75	8	1	...	...	...	16Cr-12Ni-2Mo-N	Plate, Sheet & Strip
SA-240	Type 317	S31700	75	8	1	...	102	...	18Cr-13Ni-3Mo	Plate, Sheet & Strip	
SA-240	Type 317L	S31703	75	8	1	...	102	...	18Cr-13Ni-3Mo	Plate, Sheet & Strip	
SA-240	S31725	S31725	75	8	4	...	...	...	19Cr-15Ni-4Mo	Plate, Sheet & Strip
SA-240	S31726	S31726	80	8	4	...	...	...	19Cr-15.5Ni-4Mo	Plate, Sheet & Strip
SA-240	S31753	S31753	80	8	1	...	...	...	18Cr-13Ni-3Mo-N	Plate, Sheet & Strip
SA-240	S31803	S31803	90	10H	1	...	...	...	22Cr-5Ni-3Mo-N	Plate, Sheet & Strip
SA-240	Type 321	S32100	75	8	1	...	102	...	18Cr-10Ni-Ti	Plate, Sheet & Strip	
SA-240	Type 321H	S32109	75	8	1	...	...	...	18Cr-10Ni-Ti	Plate, Sheet & Strip
SA-240	S32550	S32550	110	10H	1	...	...	...	25Cr-5Ni-3Mo-2Cu	Plate, Sheet & Strip
SA-240	Type 329	S32900	90	10H	1	...	...	...	26Cr-4Ni-Mo	Plate, Sheet & Strip
SA-240	S32950	S32950	90	10H	1	...	...	...	26Cr-4Ni-Mo-N	Plate, Sheet & Strip
SA-240	Type 347	S34700	75	8	1	...	102	...	18Cr-10Ni-Cb	Plate, Sheet & Strip	

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
 Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi (Note (1))	Welding		Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	Group No.		
SA-240	Type 347H	S34709	75	8	1	...	...	18Cr-10Ni-Cb	Plate, Sheet & Strip
SA-240	Type 348	S34800	75	8	1	...	102	18Cr-10Ni-Cb	Plate, Sheet & Strip
SA-240	Type 348H	S34809	75	8	1	...	102	18Cr-10Ni-Cb	Plate, Sheet & Strip
SA-240	Type XM-15	S38100	75	8	1	...	102	18Cr-18Ni-2Si	Plate, Sheet & Strip
SA-240	Type 405	S40500	60	7	1	...	102	12Cr-1Al	Plate, Sheet & Strip
SA-240	Type 409	S40900	55	7	1	...	102	11Cr-Ti	Plate, Sheet & Strip
SA-240	Type 410	S41000	65	6	1	...	102	13Cr	Plate, Sheet & Strip
SA-240	Type 410S	S41008	60	7	1	...	102	13Cr	Plate, Sheet & Strip
SA-240	S41500	S41500	115	6	4	...	102	13Cr-4.5Ni-Mo	Plate, Sheet & Strip
SA-240	Type 429	S42900	65	6	2	...	102	15Cr	Plate, Sheet & Strip
SA-240	Type 430	S43000	65	7	2	...	102	17Cr	Plate, Sheet & Strip
SA-240	Type 439	S43035	65	7	2	...	...	17Cr-Ti	Plate, Sheet & Strip
SA-240	S44400	S44400	60	7	2	...	...	18Cr-2Mo	Plate, Sheet & Strip
SA-240	Type XM-33	S44626	68	10I	1	...	...	27Cr-1Mo-Ti	Plate, Sheet & Strip
SA-240	Type XM-27	S44627	65	10I	1	...	...	27Cr-1Mo	Plate, Sheet & Strip
SA-240	S44635	S44635	90	10I	1	...	...	25Cr-4Ni-4Mo-Ti	Plate, Sheet & Strip
SA-240	S44660	S44660	85	10K	1	...	...	26Cr-3Ni-3Mo	Plate, Sheet & Strip
SA-240	S44700	S44700	80	10J	1	...	...	29Cr-4Mo	Plate, Sheet & Strip
SA-240	S44800	S44800	80	10K	1	...	...	29Cr-4Mo-2Ni	Plate, Sheet & Strip
SA-249	TP201	S20100	95	8	3	...	...	17Cr-4Ni-6Mn	Welded tube
SA-249	TP202	S20200	90	8	3	...	...	18Cr-5Ni-9Mn	Welded tube
SA-249	TP XM-19	S20910	100	8	3	...	...	22Cr-13Ni-5Mn	Welded tube
SA-249	TP XM-29	S24000	100	8	3	...	...	18Cr-3Ni-12Mn	Welded tube
SA-249	TP304	S30400	75	8	1	...	...	18Cr-8Ni-N	Welded tube
SA-249	TP304L	S30403	70	8	1	...	102	18Cr-8Ni-N	Welded tube
SA-249	TP304H	S30409	75	8	1	...	...	18Cr-8Ni-N	Welded tube
SA-249	TP304N	S30451	80	8	1	...	...	18Cr-8Ni-N	Welded tube
SA-249	TP304LN	S30453	75	8	1	...	...	18Cr-8Ni-N	Welded tube
SA-249	S30815	S30815	87	8	2	...	...	21Cr-11Ni-N	Welded tube
SA-249	TP309S	S30908	75	8	2	...	102	23Cr-12Ni-S	Welded tube
SA-249	Type 309H	S30909	75	8	2	...	...	23Cr-12Ni	Welded tube
SA-249	TP309Cb	S30940	75	8	2	...	...	23Cr-12Ni-Cb	Welded tube

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
 Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding				Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	Group No.	P. No.	S. No.		
SA-249	TP309Hcb	S30941	75	8	2	...	...	...	23Cr-12Ni-Cb	Welded tube
SA-249	TP310	S31000	75	8	2	...	...	102	25Cr-20Ni	Welded tube
SA-249	TP310S	S31008	75	8	2	...	...	102	25Cr-20Ni-S	Welded tube
SA-249	Type 310H	S31009	75	8	2	...	...	...	25Cr-20Ni	Welded tube
SA-249	TP310Cb	S31040	75	8	2	...	...	...	25Cr-20Ni-Cb	Welded tube
SA-249	S31254	S31254	94	8	4	...	...	...	20Cr-18Ni-6Mo	Welded tube
SA-249	TP316L	S31603	70	8	1	...	...	102	16Cr-12Ni-2Mo	Welded tube
SA-249	TP316H	S31609	75	8	1	...	...	...	16Cr-12Ni-2Mo	Welded tube
SA-249	TP316N	S31651	80	8	1	...	...	102	16Cr-12Ni-2Mo-N	Welded tube
SA-249	TP316LN	S31653	75	8	1	...	...	102	16Cr-12Ni-2Mo-N	Welded tube
SA-249	TP317	S31700	75	8	1	...	...	...	18Cr-13Ni-3Mo	Welded tube
SA-249	S31725	S31725	75	8	4	...	...	...	19Cr-15Ni-4Mo	Welded tube
SA-249	S31726	S31726	80	8	4	...	...	...	19Cr-15.5Ni-4Mo	Welded tube
SA-249	TP321	S32100	75	8	1	...	...	...	18Cr-10Ni-Ti	Welded tube
SA-249	TP321H	S32109	75	8	1	...	...	102	18Cr-10Ni-Ti	Welded tube
SA-249	TP347	S34700	75	8	1	...	...	...	18Cr-10Ni-Cb	Welded tube
SA-249	TP347H	S34709	75	8	1	...	...	...	18Cr-10Ni-Cb	Welded tube
SA-249	TP348	S34800	75	8	1	...	...	...	18Cr-10Ni-Cb	Welded tube
SA-249	TP348H	S34809	75	8	1	...	...	...	18Cr-10Ni-Cb	Welded tube
SA-249	TP XM-15	S38100	75	8	1	...	...	102	18Cr-18Ni-2Si	Welded tube
SA-250	T2	...	60	3	1	...	...	101	0.5Cr-0.5Mo	E.R.W. tube
SA-250	T11	...	60	4	1	...	...	102	1.25Cr-0.5Mo	E.R.W. tube
SA-250	T22	...	60	5A	1	...	...	102	2.25Cr-1Mo	E.R.W. tube
SA-250	T1b	K11422	53	3	1	...	...	101	C-0.5Mo	E.R.W. tube
SA-250	T1	K11522	55	3	1	...	...	101	C-0.5Mo	E.R.W. tube
SA-250	T1a	...	60	3	1	...	...	...	C-0.5Mo	E.R.W. tube
A 254	Cl.1	K01001	42	...	...	...	...	...	C	Cu Brazed tube
A 254	Cl.2	K01001	42	...	...	...	...	...	C	Cu Brazed tube
SA-266	Cl. 4	K03017	70	1	2	...	...	101	C-Mn-Si	Forgings
SA-266	Cl. 1	K03506	60	1	1	...	...	101	C-Si	Forgings
SA-266	Cl. 2	K03506	70	1	2	...	...	101	C-Si	Forgings
SA-266	Cl. 3	K05001	75	1	2	...	...	101	C-Si	Forgings

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding				Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	Group No.	P. No.	S. No.		
SA-268	TP405	S40500	60	7	1	...	...	102	...	12Cr-1Al	Smls. & welded tube
SA-268	S40800	S40800	55	7	1	...	...	...	...	12Cr-Ti	Smls. & welded tube
SA-268	TP409	S40900	55	7	1	...	...	...	...	11Cr-Ti	Smls. & welded tube
SA-268	TP410	S41000	60	6	1	...	...	...	...	13Cr	Smls. & welded tube
SA-268	S41500	S41500	115	6	4	...	...	...	...	13Cr-4.5Ni-Mo	Smls. & welded tube
SA-268	TP429	S42900	60	6	2	...	...	...	...	15Cr	Smls. & welded tube
SA-268	TP430	S43000	60	7	2	...	...	...	...	17Cr	Smls. & welded tube
SA-268	TP439	S43035	60	7	2	...	...	...	...	17Cr-Ti	Smls. & welded tube
SA-268	TP430Ti	S43036	60	7	1	...	...	...	...	18Cr-Ti-Cb	Smls. & welded tube
SA-268	18Cr-2Mo	S44400	60	7	2	...	...	...	...	18Cr-2Mo-Ti	Smls. & welded tube
SA-268	TP446-2	S44600	65	10I	1	...	...	...	...	27Cr	Smls. & welded tube
SA-268	TP446-1	S44600	70	10I	1	...	...	...	...	27Cr	Smls. & welded tube
SA-268	TP XM-33	S44626	68	10I	1	...	...	...	...	27Cr-1Mo-Ti	Smls. & welded tube
SA-268	TP XM-27	S44627	65	10I	1	...	...	...	...	27Cr-1Mo	Smls. & welded tube
SA-268	25-4-4	S44635	90	10I	1	...	...	...	...	25Cr-4Ni-4Mo-Ti	Smls. & welded tube
SA-268	26-3-3	S44660	85	10K	1	...	...	...	...	26Cr-3Ni-3Mo	Smls. & welded tube
SA-268	29-4	S44700	80	10J	1	...	...	...	...	29Cr-4Mo	Smls. & welded tube
SA-268	S44735	S44735	75	10J	1	...	...	...	...	29Cr-4Mo-Ti	Smls. & welded tube
SA-268	29-4-2	S44800	80	10K	1	...	...	...	...	29Cr-4Mo-2Ni	Smls. & welded tube
A 269	TP316L	...	70	...	...	...	...	...	102	16Cr-12Ni-2Mo	Smls. & welded tube
A 269	TP316	...	75	...	...	...	...	...	102	16Cr-12Ni-2Mo	Smls. & welded tube
A 269	TP304	S30400	75	...	...	...	...	...	102	18Cr-8Ni	Smls. & welded tube
A 269	TP304L	S30403	70	...	...	...	...	...	102	18Cr-8Ni	Smls. & welded tube
A 271	TP304	S30400	75	...	...	...	...	...	102	18Cr-8Ni	Smls. tube
A 271	TP304L	S30403	70	...	...	...	...	...	102	18Cr-8Ni	Smls. tube
A 276	TP316L	...	70	...	...	...	...	...	102	16Cr-12Ni-2Mo	Bar
A 276	TP316	...	75	...	...	...	...	...	102	16Cr-12Ni-2Mo	Bar
A 276	TP304	S30400	75	...	...	...	...	...	102	18Cr-8Ni	Bar
A 276	TP304L	S30403	70	...	...	...	...	...	102	18Cr-8Ni	Bar
A 276	TP410	...	65	...	...	...	...	...	...	13Cr	Bar
SA-283	A	...	45	1	1	...	...	101	...	C	Plate

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding				Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	Group No.	P. No.	S. No.		
SA-283	B	...	50	1	1	...	...	101	C	Plate
SA-283	C	...	55	1	1	...	...	101	C	Plate
SA-283	D	...	60	1	1	...	...	101	C	Plate
SA-285	A	K01700	45	1	1	...	...	101	C	Plate
SA-285	B	K02200	50	1	1	...	...	101	C	Plate
SA-285	C	K02801	55	1	1	...	...	101	C	Plate
SA-299	...	K02803	75	1	2	...	...	101	C-Mn-Si	Plate
SA-302	A	K12021	75	3	2	...	...	101	Mn-0.5Mo	Plate
SA-302	B	K12022	80	3	3	...	...	...	Mn-0.5Mo	Plate
SA-302	C	K12039	80	3	3	...	...	101	Mn-0.5Mo-0.5Ni	Plate
SA-302	D	K12054	80	3	3	...	...	101	Mn-0.5Mo-0.75Ni	Plate
SA-312	TP XM-19	S20910	100	8	3	...	...	...	22Cr-13Ni-5Mn	Smls. & welded pipe
SA-312	TP XM-11	S21903	90	8	3	...	...	...	21Cr-6Ni-9Mn	Smls. & welded pipe
SA-312	TP XM-29	S24000	100	8	3	...	...	...	18Cr-3Ni-12Mn	Smls. & welded pipe
SA-312	TP304	S30400	75	8	1	...	...	...	18Cr-8Ni	Smls. & welded pipe
SA-312	TP304L	S30403	75	8	1	...	...	102	18Cr-8Ni	Smls. & welded pipe
SA-312	TP304H	S30409	75	8	1	...	...	...	18Cr-8Ni	Smls. & welded pipe
SA-312	TP304N	S30451	80	8	1	...	...	...	18Cr-8Ni-N	Smls. & welded pipe
SA-312	TP304LN	S30453	75	8	1	...	...	...	18Cr-8Ni-N	Smls. & welded pipe
SA-312	TP304LN	S30453	75	8	1	...	...	...	18Cr-8Ni-N	Smls. & welded pipe
SA-312	S30600	S30600	78	8	1	...	...	...	18Cr-15Ni-4Si	Smls. & welded pipe
SA-312	S30815	S30815	87	8	2	...	...	...	21Cr-11Ni-N	Smls. & welded pipe
SA-312	TP309S	S30908	75	8	2	...	...	102	23Cr-12Ni-S	Smls. & welded pipe
SA-312	TP309H	S30909	75	8	2	...	...	...	23Cr-12Ni	Smls. & welded pipe
SA-312	TP309Cb	S30940	75	8	2	...	...	...	23Cr-12Ni-Cb	Smls. & welded pipe
SA-312	TP309HCb	S30941	75	8	2	...	...	...	23Cr-12Ni-Cb	Smls. & welded pipe
SA-312	TP310S	S31008	75	8	2	...	...	102	25Cr-20Ni-S	Smls. & welded pipe
SA-312	TP310H	S31009	75	8	2	...	...	...	25Cr-20Ni	Smls. & welded pipe
SA-312	TP310Cb	S31040	75	8	2	...	...	...	25Cr-20Ni-Cb	Smls. & welded pipe
SA-312	TP310HCb	S31041	75	8	2	...	...	...	25Cr-20Ni-Cb	Smls. & welded pipe
SA-312	S31254	S31254	94	8	4	...	...	...	20Cr-18Ni-6Mo	Smls. & welded pipe

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi (Note 1)	Welding			Brazing			Nominal Composition	Product Form
				P. No.	Group No.	S. No.	P. No.	S. No.			
SA-312	TP316	S31600	75	8	1	...	...	...	16Cr-12Ni-2Mo	Smls. & welded pipe
SA-312	TP316L	S31603	70	8	1	...	102	...	16Cr-12Ni-2Mo	Smls. & welded pipe	
SA-312	TP316H	S31609	75	8	1	...	...	...	16Cr-12Ni-2Mo	Smls. & welded pipe
SA-312	TP316N	S31651	80	8	1	...	102	...	16Cr-12Ni-2Mo-N	Smls. & welded pipe	
SA-312	TP316LN	S31653	75	8	1	...	...	...	16Cr-12Ni-2Mo-N	Smls. & welded pipe
SA-312	TP317	S31700	75	8	1	...	...	...	18Cr-13Ni-3Mo	Smls. & welded pipe
SA-312	TP317L	S31703	75	8	1	...	...	...	18Cr-13Ni-3Mo	Smls. & welded pipe
SA-312	S31725	S31725	75	8	4	...	...	...	19Cr-15Ni-4Mo	Smls. & welded pipe
SA-312	S31726	S31726	80	8	4	...	...	...	19Cr-15.5Ni-4Mo	Smls. & welded pipe
SA-312	TP321	S32100	70	8	1	...	...	...	18Cr-10Ni-Ti	Smls. & welded pipe
SA-312	TP321	S32100	75	8	1	...	...	...	18Cr-10Ni-Ti	Smls. & welded pipe
SA-312	TP321H	S32109	70	8	1	...	102	...	18Cr-10Ni-Ti	Smls. & welded pipe	
SA-312	TP321H	S32109	75	8	1	...	102	...	18Cr-10Ni-Ti	Smls. & welded pipe	
SA-312	TP347	S34700	75	8	1	...	...	...	18Cr-10Ni-Cb	Smls. & welded pipe
SA-312	TP347H	S34709	75	8	1	...	...	...	18Cr-10Ni-Cb	Smls. & welded pipe
SA-312	TP348	S34800	75	8	1	...	...	...	18Cr-10Ni-Cb	Smls. & welded pipe
SA-312	TP348H	S34809	75	8	1	...	...	...	18Cr-10Ni-Cb	Smls. & welded pipe
SA-312	TP XM-15	S38100	75	8	1	...	102	...	18Cr-18Ni-2Si	Smls. & welded pipe	
A 331	8620 CW	G86200	90	...	...	...	3	...	0.5Ni-0.5Cr-Mo	Bar
SA-333	6	K03006	60	1	1	...	101	...	C-Mn-Si	Smls. & welded pipe	
SA-333	1	K03008	55	1	1	...	101	...	C-Mn	Smls. & welded pipe	
SA-333	4	K11267	60	4	2	...	...	...	0.75Cr-0.75Ni-Cu-Al	Smls. & welded pipe
SA-333	7	K21903	65	9A	1	...	102	...	2.5Ni	Smls. & welded pipe	
SA-333	9	K22035	63	9A	1	...	102	...	2Ni-1Cu	Smls. & welded pipe	
SA-333	3	K31918	65	9B	1	...	102	...	3.5Ni	Smls. & welded pipe	
SA-333	10	...	80	1	3	...	...	...	C-Mn-Si	Smls. & welded pipe
SA-333	8	K81340	100	11A	1	...	102	...	9Ni	Smls. & welded pipe	
SA-334	6	K03006	60	1	1	...	101	...	C-Mn-Si	Welded tube	
SA-334	1	K03008	55	1	1	...	101	...	C-Mn	Welded tube	
SA-334	7	K21903	65	9A	1	...	102	...	2.5Ni	Welded tube	
SA-334	9	K22035	63	9A	1	...	102	...	2Ni-1Cu	Welded tube	
SA-334	3	K31918	65	9B	1	...	102	...	3.5Ni	Welded tube	

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding			Brazing			Nominal Composition	Product Form
				P. No.	Group No.	S. No.	Group No.	P. No.	S. No.		
SA-334	8	K81340	100	11A	1	...	...	102	9Ni	Welded tube
SA-335	P1	K11522	55	3	1	...	...	101	C-0.5Mo	Smls. pipe
SA-335	P2	K11547	55	3	1	...	...	101	0.5Cr-0.5Mo	Smls. pipe
SA-335	P12	K11562	60	4	1	...	...	102	1Cr-0.5Mo	Smls. pipe
SA-335	P15	K11578	60	3	1	...	...	101	1.5Si-0.5Mo	Smls. pipe
SA-335	P11	K11597	60	4	1	...	...	...	1.25Cr-0.5Mo-Si	Smls. pipe
SA-335	P22	K21590	60	5A	1	...	...	102	2.25Cr-1Mo	Smls. pipe
SA-335	P21	K31545	60	5A	1	...	...	...	3Cr-1Mo	Smls. pipe
SA-335	P5c	K41245	60	5B	1	...	...	102	5Cr-0.5Mo-Ti	Smls. pipe
SA-335	P5	K41545	60	5B	1	...	...	102	5Cr-0.5Mo	Smls. pipe
SA-335	P5b	K51545	60	5B	1	...	...	102	5Cr-0.5Mo-Si	Smls. pipe
SA-335	P9	K81590	60	5B	1	...	...	102	9Cr-1Mo	Smls. pipe
SA-335	P91	...	85	5B	2	...	...	...	9Cr-1Mo-V	Smls. pipe
SA-336	F6	...	85	6	3	...	...	...	13Cr	Forgings
SA-336	F12	K11564	70	4	1	...	...	...	1Cr-0.5Mo	Forgings
SA-336	F11B	...	60	4	1	...	...	102	1.25Cr-0.5Mo-Si	Forgings
SA-336	F11	K11572	70	4	1	...	...	...	1.25Cr-0.5Mo-Si	Forgings
SA-336	F11A	K11572	75	4	1	...	...	102	1.25Cr-0.5Mo-Si	Forgings
SA-336	F1	K12520	70	3	2	...	...	...	C-0.5Mo	Forgings
SA-336	F22A	K21590	60	5A	1	...	...	102	2.25Cr-1Mo	Forgings
SA-336	F22	K21590	75	5A	1	...	...	102	2.25Cr-1Mo	Forgings
SA-336	F21A	K31545	60	5A	1	...	...	...	3Cr-1Mo	Forgings
SA-336	F21	K31545	75	5A	1	...	...	102	3Cr-1Mo	Forgings
SA-336	F3V	K31830	85	5C	1	...	...	...	3Cr-1Mo-0.25V	Forgings
SA-336	F5	K41545	60	5B	1	...	...	102	5Cr-0.5Mo	Forgings
SA-336	F5A	K42544	80	5B	1	...	...	102	5Cr-0.5Mo	Forgings
SA-336	F9	K81590	85	5B	1	...	...	102	9Cr-1Mo	Forgings
SA-336	F91	...	85	5B	2	...	...	...	9Cr-1Mo-V	Forgings
SA-336	F46	S30600	78	8	4	...	...	...	17Cr-14Ni-4Si	Forgings
SA-336	FXM-19	S20910	100	8	3	...	...	...	22Cr-13Ni-5Mn	Forgings
SA-336	FXM-11	S21904	90	8	3	...	...	...	21Cr-6Ni-9Mn	Forgings
SA-336	F304	S30400	70	8	1	...	...	...	18Cr-8Ni	Forgings

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
 Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding		Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	Group No.		
SA-336	F304L	S30403	65	8	1	...	...	18Cr-8Ni	Forgings
SA-336	F304H	S30409	70	8	1	...	...	18Cr-8Ni	Forgings
SA-336	F304N	S30451	80	8	1	...	...	18Cr-8Ni-N	Forgings
SA-336	F304LN	S30453	70	8	1	...	...	18Cr-8Ni-N	Forgings
SA-336	F310	S31000	75	8	2	...	...	25Cr-20Ni	Forgings
SA-336	F316	S31600	70	8	1	...	...	16Cr-12Ni-2Mo	Forgings
SA-336	F316L	S31603	65	8	1	...	...	16Cr-12Ni-2Mo	Forgings
SA-336	F316H	S31609	70	8	1	...	...	16Cr-12Ni-2Mo	Forgings
SA-336	F316N	S31651	80	8	1	...	...	16Cr-12Ni-2Mo-N	Forgings
SA-336	F316LN	S31653	70	8	1	...	...	16Cr-12Ni-2Mo-N	Forgings
SA-336	F321	S32100	70	8	1	...	...	18Cr-10Ni-Ti	Forgings
SA-336	F321H	S32109	70	8	1	...	...	18Cr-10Ni-Ti	Forgings
SA-336	F347	S34700	70	8	1	...	...	18Cr-10Ni-Cb	Forgings
SA-336	F347H	S34709	70	8	1	...	...	18Cr-10Ni-Cb	Forgings
SA-336	F348	S34800	70	8	1	...	...	18Cr-10Ni-Cb	Forgings
SA-336	F348H	S34809	70	8	1	...	...	18Cr-10Ni-Cb	Forgings
SA-336	FXM-27Cb	S44627	60	101	1	...	...	27Cr-1Mo	Forgings
SA-350	LF1	K03009	60	1	1	...	...	C-Mn-Si	Forgings
SA-350	LF2	K03011	70	1	2	...	...	C-Mn-Si	Forgings
SA-350	LF5 Cl. 1	K13050	60	9A	1	...	...	1.5Ni	Forgings
SA-350	LF5 Cl. 2	K13050	70	9A	1	...	...	1.5Ni	Forgings
SA-350	LF9	K22036	63	9A	1	...	...	2Ni-1Cu	Forgings
SA-350	LF3	K32025	70	9B	1	...	...	3.5Ni	Forgings
SA-351	CF3	J92500	70	8	1	...	...	18Cr-8Ni	Castings
SA-351	CF3A	J92500	77	8	1	...	...	18Cr-8Ni	Castings
SA-351	CF8A	J92600	77	8	1	...	...	18Cr-8Ni	Castings
SA-351	CF8C	J92710	70	8	1	...	...	18Cr-10Ni-Cb	Castings
SA-351	CF3M	J92800	70	8	1	...	...	16Cr-12Ni-2Mo	Castings
SA-351	CF8M	J92900	70	8	1	...	...	16Cr-12Ni-2Mo	Castings
SA-351	CF10	...	70	8	1	...	...	19Cr-9Ni-0.5Mo	Castings
SA-351	CF10M	...	70	8	1	...	...	19Cr-9Ni-2Mo	Castings
SA-351	CE8MN	J93345	95	10H	1	...	...	24Cr-10Ni-Mo-N	Castings

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding				Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	Group No.	P. No.	S. No.		
SA-351	CD4MCu	J93370	100	10H	1	...	...	...	25Cr-5Ni-3Mo-2Cu	Castings
SA-351	CH8	J93400	65	8	2	...	...	102	25Cr-12Ni	Castings
SA-351	CH20	J93402	70	8	2	...	...	102	25Cr-12Ni	Castings
SA-351	CG6MMN	J93790	85	8	3	...	...	...	22Cr-12Ni-5Mn	Castings
SA-351	CK20	J94202	65	8	2	...	...	102	25Cr-20Ni	Castings
A 351	CA15	...	90	...	...	6	3	...	13Cr	Castings
SA-352	LCA	J02504	60	1	1	...	...	101	C-Si	Castings
SA-352	LCC	J02505	70	1	2	...	...	101	C-Mn-Si	Castings
SA-352	LCB	J03003	65	1	1	...	...	101	C-Si	Castings
SA-352	LC1	J12522	65	3	1	...	...	101	C-0.5Mo	Castings
SA-352	LC2	J22500	70	9A	1	...	...	102	2.5Ni	Castings
SA-352	LC3	J31550	70	9B	1	...	...	102	3.5Ni	Castings
SA-352	LC4	J41500	70	9C	1	...	...	...	4.5Ni	Castings
SA-352	LC2-1	J42215	105	11A	5	...	...	...	3Ni-1.5Cr-0.5Mo	Castings
SA-352	CA6NM	J91540	110	6	4	...	...	...	13Cr-4Ni	Castings
SA-353	...	K81340	100	11A	1	...	...	102	9Ni	Plate
SA-358	XM-19	S22100	100	8	3	...	...	...	22Cr-13Ni-5Mn	Fusion welded pipe
SA-358	XM-29	S28300	100	8	3	...	...	...	18Cr-3Ni-12Mn	Fusion welded pipe
SA-358	304	S30400	75	8	1	...	...	...	18Cr-8Ni	Fusion welded pipe
SA-358	304L	S30403	70	8	1	...	...	...	18Cr-8Ni	Fusion welded pipe
SA-358	304H	S30409	75	8	1	...	...	...	18Cr-8Ni	Fusion welded pipe
SA-358	304N	S30451	80	8	1	...	...	...	18Cr-8Ni-N	Fusion welded pipe
SA-358	304LN	S30453	75	8	1	...	...	...	18Cr-8Ni-N	Fusion welded pipe
SA-358	S30815	S30815	87	8	2	...	...	...	21Cr-11Ni-N	Fusion welded pipe
SA-358	309	S30900	75	8	2	...	...	...	23Cr-12Ni	Fusion welded pipe
SA-358	309S	S30908	75	8	2	...	...	102	23Cr-12Ni-S	Fusion welded pipe
SA-358	309Cb	S30940	75	8	2	...	...	...	23Cr-12Ni-Cb	Fusion welded pipe
SA-358	310	S31000	75	8	2	...	...	...	25Cr-20Ni	Fusion welded pipe
SA-358	310S	S31008	75	8	2	...	...	102	25Cr-20Ni-S	Fusion welded pipe
SA-358	310Cb	S31040	75	8	2	...	...	...	25Cr-20Ni-Cb	Fusion welded pipe
SA-358	S31254	S31254	94	8	4	...	...	...	20Cr-18Ni-6Mo	Fusion welded pipe

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding				Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	Group No.	P. No.	S. No.		
SA-358	316	S31600	75	8	1	...	...	...	16Cr-12Ni-2Mo	Fusion welded pipe
SA-358	316L	S31603	70	8	1	...	...	...	16Cr-12Ni-2Mo	Fusion welded pipe
SA-358	316H	S31609	75	8	1	...	...	...	16Cr-12Ni-2Mo	Fusion welded pipe
SA-358	316N	S31651	80	8	1	...	...	...	16Cr-12Ni-2Mo-N	Fusion welded pipe
SA-358	316LN	S31653	75	8	1	...	...	...	16Cr-12Ni-2Mo-N	Fusion welded pipe
SA-358	S31725	S31725	75	8	4	...	...	...	19Cr-15Ni-4Mo	Fusion welded pipe
SA-358	S31726	S31726	80	8	4	...	...	...	19Cr-15.5Ni-4Mo	Fusion welded pipe
SA-358	321	S32100	75	8	1	...	...	...	18Cr-10Ni-Ti	Fusion welded pipe
SA-358	347	S34700	75	8	1	...	...	...	18Cr-10Ni-Cb	Fusion welded pipe
SA-358	348	S34800	75	8	1	...	...	...	18Cr-10Ni-Cb	Fusion welded pipe
SA-369	FPA	K02501	48	1	1	...	...	101	C-Si	Forged pipe
SA-369	FPB	K03006	60	1	1	...	...	101	C-Mn-Si	Forged pipe
SA-369	FP1	K11522	55	3	1	...	...	101	C-0.5Mo	Forged pipe
SA-369	FP2	K11547	55	3	1	...	...	101	0.5Cr-0.5Mo	Forged pipe
SA-369	FP12	K11562	60	4	1	...	...	...	1Cr-0.5Mo	Forged pipe
SA-369	FP11	K11597	60	4	1	...	...	102	1.25Cr-0.5Mo-Si	Forged pipe
SA-369	FP22	K21590	60	5A	1	...	...	102	2.25Cr-1Mo	Forged pipe
SA-369	FP21	K31545	60	5A	1	...	...	102	3Cr-1Mo	Forged pipe
SA-369	FP5	K41545	60	5B	1	...	...	102	5Cr-0.5Mo	Forged pipe
SA-369	FP9	K90941	60	5B	1	...	...	102	9Cr-1Mo	Forged pipe
SA-369	FP91	...	85	5B	2	...	...	...	9Cr-1Mo-V	Forged pipe
SA-372	Type I	K03002	60	1	1	...	...	101	C-Si	Forgings
SA-372	Type II	K04001	75	1	2	...	...	101	C-Mn-Si	Forgings
SA-376	16-8-2H	S30400	75	8	1	...	...	...	16Cr-8Ni-2Mo	Smls. pipe
SA-376	TP304	S30400	70	8	1	...	...	102	18Cr-8Ni	Smls. pipe
SA-376	TP304H	S30409	75	8	1	...	...	102	18Cr-8Ni	Smls. pipe
SA-376	TP304N	S30451	80	8	1	...	...	102	18Cr-8Ni-N	Smls. pipe
SA-376	TP304LN	S30453	75	8	1	...	...	102	18Cr-8Ni-N	Smls. pipe
SA-376	TP316	S31600	75	8	1	...	...	102	16Cr-12Ni-2Mo	Smls. pipe
SA-376	TP316H	S31609	75	8	1	...	...	102	16Cr-12Ni-2Mo	Smls. pipe
SA-376	TP316N	S31651	80	8	1	...	...	102	18Cr-13Ni-2Mo-N	Smls. pipe

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding			Brazing			Nominal Composition	Product Form
				P. No.	Group No.	S. No.	P. No.	S. No.			
SA-376	TP316LN	S31653	75	8	1	...	...	...	18Cr-13Ni-2Mo-N	Smls. pipe
SA-376	S31725	S31725	75	8	4	...	...	...	19Cr-15Ni-4Mo	Smls. pipe
SA-376	S31726	S31726	80	8	4	...	...	...	19Cr-15.5Ni-4Mo	Smls. pipe
SA-376	TP321	S32100	70	8	1	...	102	...	18Cr-10Ni-Ti	Smls. pipe	
SA-376	TP321	S32100	75	8	1	...	102	...	18Cr-10Ni-Ti	Smls. pipe	
SA-376	TP321H	S32109	70	8	1	...	102	...	18Cr-10Ni-Ti	Smls. pipe	
SA-376	TP321H	S32109	75	8	1	...	102	...	18Cr-10Ni-Ti	Smls. pipe	
SA-376	TP347	S34700	75	8	1	...	102	...	18Cr-10Ni-Cb	Smls. pipe	
SA-376	TP347H	S34709	75	8	1	...	102	...	18Cr-10Ni-Cb	Smls. pipe	
SA-376	TP348	S34800	75	8	1	...	102	...	18Cr-10Ni-Cb	Smls. pipe	
A 381	Y35	K03013	60	...	...	...	...	101	C	Pipe
A 381	Y42	...	60	...	...	...	...	101	C	Pipe
A381	Y48	...	62	...	...	...	...	101	C-.375in.	Pipe
A 381	Y46	...	63	...	...	...	...	101	C	Pipe
A 381	Y50	...	64	...	...	...	...	101	C	Pipe
A 381	Y52b	...	66	...	...	...	...	101	C-.375in.	Pipe
A 381	Y56b	...	71	...	...	...	...	101	C-.375in.	Pipe
A 381	Y52a	...	72	...	...	...	...	101	C to .375in.	Pipe
A 381	Y56a	...	75	...	...	...	...	101	C to .375in.	Pipe
A 381	Y60b	...	75	...	...	...	...	101	C .125in.	Pipe
A 381	Y60a	...	78	...	...	...	...	101	C to .125in.	Pipe
SA-387	12, Cl. 1	K11757	55	4	1	...	102	...	1Cr-0.5Mo	Plate	
SA-387	12, Cl. 2	K11757	65	4	1	...	102	...	1Cr-0.5Mo	Plate	
SA-387	11, Cl. 1	K11789	60	4	1	...	102	...	1.25Cr-0.5Mo-Si	Plate	
SA-387	11, Cl. 2	K11789	75	4	1	...	102	...	1.25Cr-0.5Mo-Si	Plate	
SA-387	Gr. 2, Cl. 1	K12143	55	3	1	...	101	...	0.5Cr-0.5Mo	Plate	
SA-387	Gr. 2, Cl. 2	K12143	70	3	2	...	101	...	0.5Cr-0.5Mo	Plate	
SA-387	22, Cl. 1	K21590	60	5A	1	...	102	...	2.25Cr-1Mo	Plate	
SA-387	22, Cl. 2	K21590	75	5A	1	...	102	...	2.25Cr-1Mo	Plate	
SA-387	21, Cl. 1	K31545	60	5A	1	...	102	...	3Cr-1Mo	Plate	
SA-387	21, Cl. 2	K31545	75	5A	1	...	102	...	3Cr-1Mo	Plate	
SA-387	5, Cl. 1	K41545	60	5B	1	...	...	...	5Cr-0.5Mo	Plate
SA-387	5, Cl. 2	K41545	75	5B	1	...	102	...	5Cr-0.5Mo	Plate	

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding			Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	P. No.	S. No.		
SA-387	Gr. 91, Cl. 2	...	85	5B	2	...	...	9Cr-1Mo-V	Plate
SA-403	WPXM-19	S20910	100	8	3	...	...	22Cr-13Ni-5Mn	Wrought pipe fitting
SA-403	WP304	S30400	75	8	1	...	102	18Cr-8Ni	Wrought pipe fitting	
SA-403	WP304L	S30403	70	8	1	...	102	18Cr-8Ni	Wrought pipe fitting	
SA-403	WP304H	S30409	75	8	1	...	102	18Cr-8Ni-N	Wrought pipe fitting	
SA-403	WP304N	S30451	80	8	1	...	102	18Cr-8Ni-N	Wrought pipe fitting	
SA-403	WP304LN	S30453	75	8	1	...	...	18Cr-8Ni-N	Wrought pipe fitting
SA-403	WP309	S30900	75	8	2	...	102	23Cr-12Ni	Wrought pipe fitting	
SA-403	WP310	S31000	75	8	2	...	102	25Cr-20Ni	Wrought pipe fitting	
SA-403	WP316	S31600	75	8	1	...	102	16Cr-12Ni-2Mo	Wrought pipe fitting	
SA-403	WP316L	S31603	70	8	1	...	102	16Cr-12Ni-2Mo	Wrought pipe fitting	
SA-403	WP316H	S31609	75	8	1	...	102	16Cr-12Ni-2Mo	Wrought pipe fitting	
SA-403	WP316N	S31651	80	8	1	...	102	16Cr-12Ni-2Mo-N	Wrought pipe fitting	
SA-403	WP316LN	S31653	75	8	1	...	102	16Cr-12Ni-2Mo-N	Wrought pipe fitting	
SA-403	WP317	S31700	75	8	1	...	102	18Cr-13Ni-3Mo	Wrought pipe fitting	
SA-403	WP317L	S31703	75	8	1	...	...	18Cr-13Ni-3Mo	Wrought pipe fitting
SA-403	WP321	S32100	75	8	1	...	102	18Cr-10Ni-Ti	Wrought pipe fitting	
SA-403	WP321H	S32109	75	8	1	...	102	18Cr-10Ni-Ti	Wrought pipe fitting	
SA-403	WP347	S34700	75	8	1	...	102	18Cr-10Ni-Cb	Wrought pipe fitting	
SA-403	WP347H	S34709	75	8	1	...	102	18Cr-10Ni-Cb	Wrought pipe fitting	
SA-403	WP348	S34800	75	8	1	...	102	18Cr-10Ni-Cb	Wrought pipe fitting	
SA-403	WP348H	S34809	75	8	1	...	...	18Cr-10Ni-Cb	Wrought pipe fitting
SA-409	TP304	S30400	75	8	1	...	102	18Cr-8Ni	Welded pipe	
SA-409	TP304L	S30403	70	8	1	...	102	18Cr-8Ni	Welded pipe	
SA-409	S30815	S30815	87	8	2	...	...	21Cr-11Ni-N	Welded pipe
SA-409	TP309S	S30908	75	8	2	...	102	23Cr-12Ni-S	Welded pipe	
SA-409	TP309Cb	S30940	75	8	2	...	...	23Cr-12Ni-Cb	Welded pipe
SA-409	TP310S	S31008	75	8	2	...	102	25Cr-20Ni-S	Welded pipe	
SA-409	TP310Cb	S31040	75	8	2	...	...	25Cr-20Ni-Cb	Welded pipe
SA-409	S31254	S31254	94	8	4	...	...	20Cr-18Ni-6Mo	Welded pipe
SA-409	TP316	S31600	75	8	1	...	102	16Cr-12Ni-2Mo	Welded pipe	
SA-409	TP316L	S31603	70	8	1	...	102	16Cr-12Ni-2Mo	Welded pipe	

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding				Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	Group No.	P. No.	S. No.		
SA-409	TP317	S31700	75	8	1	...	...	102	...	18Cr-13Ni-3Mo	Welded pipe
SA-409	S31725	S31725	75	8	4	...	...	...	...	19Cr-15Ni-4Mo	Welded pipe
SA-409	S31726	S31726	80	8	4	...	...	...	...	19Cr-15.5Ni-4Mo	Welded pipe
SA-409	TP321	S32100	75	8	1	...	...	102	...	18Cr-10Ni-Ti	Welded pipe
SA-409	TP347	S34700	75	8	1	...	...	102	...	18Cr-10Ni-Cb	Welded pipe
SA-409	TP348	S34800	75	8	1	...	...	102	...	18Cr-10Ni-Cb	Welded pipe
SA-414	A	K01501	45	1	1	...	...	101	...	C	Sheet
SA-414	B	K02201	50	1	1	...	...	101	...	C	Sheet
SA-414	C	K02503	55	1	1	...	...	101	...	C	Sheet
SA-414	D	K02505	60	1	1	...	...	...	...	C-Mn	Sheet
SA-414	E	K02704	65	1	1	...	...	...	...	C-Mn	Sheet
SA-414	F	K03102	70	1	2	...	...	101	...	C-Mn	Sheet
SA-414	G	K03103	75	1	2	...	...	...	...	C-Mn	Sheet
SA-420	WPL6	...	60	1	1	...	...	101	...	C-Mn-Si	Piping fitting
SA-420	WPL9	K22035	63	9A	1	...	...	102	...	2Ni-1Cu	Piping fitting
SA-420	WPL3	...	65	9B	1	...	...	...	...	3.5Ni	Piping fitting
SA-420	WPL8	K81340	100	11A	1	...	...	...	...	9Ni	Piping fitting
SA-423	1	K11535	60	4	2	...	...	...	...	0.75Cr-0.5Ni-Cu	Smls. & welded tube
SA-423	2	K11540	60	4	2	...	...	...	...	0.75Ni-0.5Cu-Mo	Smls. & welded tube
SA-426	CP15	J11522	60	3	1	...	...	101	...	C-0.5Mo-Si	Centrifugal Cast pipe
SA-426	CP2	J11547	60	3	1	...	...	101	...	0.5Cr-0.5Mo	Centrifugal Cast pipe
SA-426	CP12	J11562	60	4	1	...	...	102	...	1Cr-0.5Mo	Centrifugal Cast pipe
SA-426	CP11	J12072	70	4	1	...	...	102	...	1.25Cr-0.5Mo	Centrifugal Cast pipe
SA-426	CP1	J12521	65	3	1	...	...	101	...	C-0.5Mo	Centrifugal Cast pipe
SA-426	CP22	J21890	70	5A	1	...	...	102	...	2.25Cr-1Mo	Centrifugal Cast pipe
SA-426	CP21	J31545	60	5A	1	...	...	102	...	3Cr-1Mo	Centrifugal Cast pipe
SA-426	CP5	J42045	90	5B	1	...	...	102	...	5Cr-0.5Mo	Centrifugal Cast pipe
SA-426	CP5b	J51545	60	5B	1	...	...	102	...	5Cr-1.5Si-0.5Mo	Centrifugal Cast pipe
SA-426	CP9	J82090	90	5B	1	...	...	102	...	9Cr-1Mo	Centrifugal Cast pipe
SA-426	CPCA15	J91150	90	6	3	...	...	102	...	13Cr	Centrifugal Cast pipe
SA-430	FP16-8-2H	...	70	8	1	...	...	...	...	16Cr-8Ni-2Mo	Forged pipe
SA-430	FP304	S30400	70	8	1	...	...	102	...	18Cr-8Ni	Forged pipe

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
 Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding			Brazing			Nominal Composition	Product Form
				P- No.	Group No.	S- No.	Group No.	P- No.	S- No.		
SA-430	FP304H	S30409	70	8	1	...	...	102	...	18Cr-8Ni	Forged pipe
SA-430	FP304N	S30451	75	8	1	...	...	102	...	18Cr-8Ni-N	Forged pipe
SA-430	FP316	S31600	70	8	1	...	...	102	...	16Cr-12Ni-2Mo	Forged pipe
SA-430	FP316H	S31609	70	8	1	...	...	102	...	16Cr-12Ni-2Mo	Forged pipe
SA-430	FP316N	S31651	75	8	1	...	...	102	...	16Cr-12Ni-2Mo-N	Forged pipe
SA-430	FP321	S32100	70	8	1	...	...	102	...	18Cr-10Ni-Ti	Forged pipe
SA-430	FP321H	S32109	70	8	1	...	...	102	...	18Cr-10Ni-Ti	Forged pipe
SA-430	FP347	S34700	70	8	1	...	...	102	...	18Cr-10Ni-Cb	Forged pipe
SA-430	FP347H	S34709	70	8	1	...	...	102	...	18Cr-10Ni-Cb	Forged pipe
A 441	1	K12211	70	...	...	...	2	...	101	Mn-Cu-V	Shapes
A441	2	K12211	70	...	...	...	2	...	101	Mn-Cu-V	Shapes
A 446	A	...	45	...	...	...	1	...	101	C	Sheet
SA-451	CPF8	J92600	70	8	1	...	...	102	...	18Cr-8Ni	Centrifugal Cast pipe
SA-451	CPF8A	J92600	77	8	1	...	...	102	...	18Cr-8Ni	Centrifugal Cast pipe
SA-451	CPF8C	J92710	70	8	1	...	...	102	...	18Cr-10Ni-Cb	Centrifugal Cast pipe
SA-451	CPF8M	J92900	70	8	1	...	...	102	...	16Cr-12Ni-2Mo	Centrifugal Cast pipe
SA-451	CPF3	...	70	8	1	...	...	102	...	18Cr-8Ni	Centrifugal Cast pipe
SA-451	CPF3M	...	70	8	1	...	...	102	...	16Cr-12Ni-2Mo	Centrifugal Cast pipe
SA-451	CPF3A	...	77	8	1	...	...	...	...	18Cr-8Ni	Centrifugal Cast pipe
SA-451	CPH8	J93400	65	8	2	...	...	102	...	25Cr-12Ni	Centrifugal Cast pipe
SA-451	CPH20	J93402	70	8	2	...	...	102	...	25Cr-12Ni	Centrifugal Cast pipe
SA-451	CPK20	J94202	65	8	2	...	...	102	...	25Cr-20Ni	Centrifugal Cast pipe
SA-452	TP304H	S30409	75	8	1	...	...	102	...	18Cr-8Ni	Centrifugal Cast pipe
SA-452	TP316H	S31609	75	8	1	...	...	102	...	16Cr-12Ni-2Mo	Centrifugal Cast pipe
SA-452	TP347H	S34709	75	8	1	...	...	102	...	18Cr-10Ni-Cb	Centrifugal Cast pipe
SA-455	...	K03300	70	1	2	...	...	101	...	C-Mn-Si	Plate, 0.580-0.750 in.
SA-455	...	K03300	73	1	2	...	...	101	...	C-Mn-Si	Plate, 0.375-0.580 in.
SA-455	...	K03300	75	1	2	...	...	101	...	C-Mn-Si	Plate, > .375 in.
SA-479	XM-19	S20910	100	8	3	...	...	...	...	22Cr-13Ni-5Mn	Bar & Shape
SA-479	XM-17	S21600	90	8	3	...	...	...	...	19Cr-8Mn-6Ni-Mo-N	Bar & Shape

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding				Brazing				Nominal Composition	Product Form
				P. No.	Group No.	S. No.	Group No.	P. No.	S. No.				
SA-479	XM-18	S21603	90	8	3	...	...	...	...	...	19Cr-8Mn-6Ni-Mo-N	Bar & Shape
SA-479	S21800	S21800	95	8	3	...	...	...	...	...	18Cr-8Ni-4Si-N	Bar & Shape
SA-479	XM-11	S21904	90	8	3	...	...	...	...	...	21Cr-6Ni-9Mn	Bar & Shape
SA-479	XM-29	S24000	100	8	3	...	...	...	...	...	18Cr-3Ni-12Mn	Bar & Shape
SA-479	302	S30200	75	8	1	...	...	102	...	...	18Cr-8Ni	Bar & Shape
SA-479	304	S30400	75	8	1	...	...	102	...	...	18Cr-8Ni	Bar & Shape
SA-479	304L	S30403	70	8	1	...	...	102	...	...	18Cr-8Ni	Bar & Shape
SA-479	304H	S30409	75	8	1	...	...	102	...	...	18Cr-8Ni	Bar & Shape
SA-479	304N	S30451	80	8	1	...	...	102	...	...	18Cr-8Ni-N	Bar & Shape
SA-479	304LN	S30453	75	8	1	...	...	102	...	...	18Cr-8Ni-N	Bar & Shape
SA-479	S30815	S30815	87	8	2	...	...	...	...	...	21Cr-11Ni-N	Bar & Shape
SA-479	309S	S30908	75	8	2	...	...	102	...	...	23Cr-12Ni-S	Bar & Shape
SA-479	309Cb	S30940	75	8	2	...	...	...	...	...	23Cr-12Ni-Cb	Bar & Shape
SA-479	310S	S31008	75	8	2	...	...	102	...	...	25Cr-20Ni-S	Bar & Shape
SA-479	310Cb	S31040	75	8	2	...	...	...	...	...	25Cr-20Ni-Cb	Bar & Shape
SA-479	S31254	S31254	94	8	4	...	...	...	...	...	20Cr-18Ni-6Mo	Bar & Shape
SA-479	316	S31600	75	8	1	...	...	102	...	...	16Cr-12Ni-2Mo	Bar & Shape
SA-479	316L	S31603	70	8	1	...	...	102	...	...	16Cr-12Ni-2Mo	Bar & Shape
SA-479	316H	S31609	75	8	1	...	...	102	...	...	16Cr-12Ni-2Mo	Bar & Shape
SA-479	316Ti	S31635	75	8	1	...	...	...	...	...	16Cr-12Ni-2Mo-Ti	Bar & Shape
SA-479	316Cb	S31640	75	8	1	...	...	...	...	...	16Cr-12Ni-2Mo-Cb	Bar & Shape
SA-479	316N	S31651	80	8	1	...	...	102	...	...	16Cr-12Ni-2Mo-N	Bar & Shape
SA-479	316LN	S31653	75	8	1	...	...	...	...	...	16Cr-12Ni-2Mo-N	Bar & Shape
SA-479	S31725	S31725	75	8	4	...	...	...	...	...	19Cr-15Ni-4Mo	Bar & Shape
SA-479	S31726	S31726	80	8	4	...	...	...	...	...	19Cr-15.5Ni-4Mo	Bar & Shape
SA-479	321	S32100	75	8	1	...	...	102	...	...	18Cr-10Ni-Ti	Bar & Shape
SA-479	321H	S32109	75	8	1	...	...	102	...	...	18Cr-10Ni-Ti	Bar & Shape
SA-479	S32550	S32550	110	10H	1	...	...	...	...	...	25Cr-5Ni-3Mo-2Cu	Bar & Shape
SA-479	347	S34700	75	8	1	...	...	102	...	...	18Cr-10Ni-Cb	Bar & Shape
SA-479	347H	S34709	75	8	1	...	...	102	...	...	18Cr-10Ni-Cb	Bar & Shape
SA-479	348	S34800	75	8	1	...	...	102	...	...	18Cr-10Ni-Cb	Bar & Shape
SA-479	348H	S34809	75	8	1	...	...	102	...	...	18Cr-10Ni-Cb	Bar & Shape

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding			Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	P. No.	S. No.		
SA-479	403	S40300	70	6	1	...	102	...	12Cr	Bar & Shape
SA-479	405	S40500	55	7	1	...	102	...	12Cr-1Al	Bar & Shape
SA-479	410	S41000	70	6	1	...	102	...	13Cr	Bar & Shape
SA-479	414	S41400	115	6	4	...	...	...	12.5Cr-2Ni-Si	Bar & Shape
SA-479	S41500	S41500	115	6	4	...	...	...	13Cr-4.5Ni-Mo	Bar & Shape
SA-479	430	S43000	70	7	2	...	102	...	17Cr	Bar & Shape
SA-479	439	S43035	70	7	2	...	...	...	17Cr-Ti	Bar & Shape
SA-479	S44400	S44400	60	7	2	...	...	...	18Cr-2Mo-Ti	Bar & Shape
SA-479	XM-27	S44627	65	10I	1	...	...	...	27Cr-1Mo	Bar & Shape
SA-479	S44700	S44700	70	10J	1	...	...	...	29Cr-4Mo	Bar & Shape
SA-479	S44800	S44800	70	10K	1	...	...	...	29Cr-4Mo-2Ni	Bar & Shape
SA-487	Gr. 16, Cl. A	...	70	1	2	...	101	...	Low C-Mn-Ni	Castings
SA-487	Gr. 1, Cl. A	J03004	85	10A	1	...	...	...	Mn-V	Castings
SA-487	Gr. 1, Cl. B	J03004	90	10A	1	...	...	...	Mn-V	Castings
SA-487	Gr. 2, Cl. A	J13005	85	10F	1	...	...	...	Mn-0.25Mo-V	Castings
SA-487	Gr. 2, Cl. B	J13005	90	10F	1	...	...	...	Mn-0.25Mo-V	Castings
SA-487	Gr. 4, Cl. A	J13047	90	10F	1	...	...	...	0.5Ni-0.5Cr-0.25Mo-V	Castings
SA-487	Gr. 4, Cl. B	J13047	105	11A	3	...	...	...	0.5Ni-0.5Cr-0.25Mo-V	Castings
SA-487	Gr. 4, Cl. E	J13047	115	11A	3	...	...	...	0.5Ni-0.5Cr-0.25Mo-V	Castings
SA-487	Gr. 8, Cl. A	J22091	85	5C	1	...	102	...	2.25Cr-1Mo	Castings
SA-487	Gr. 8, Cl. C	J22091	100	5C	4	...	...	...	2.25Cr-1Mo	Castings
SA-487	Gr. 8, Cl. B	J22091	105	5C	4	...	...	...	2.25Cr-1Mo	Castings
SA-487	CA15M Cl. A	J91151	90	6	3	...	102	...	13Cr	Castings
SA-487	CA15 Cl. C	...	90	6	3	...	...	...	13Cr	Castings
SA-487	CA15 Cl. B	...	90	6	3	...	...	...	13Cr	Castings
SA-487	CA15 Cl. D	...	100	6	3	...	...	...	13Cr	Castings
SA-487	CA6NM Cl. B	J91540	100	6	4	...	102	...	13Cr-4Ni	Castings
SA-487	CA6NM Cl. A	J91540	110	6	4	...	...	...	13Cr-4Ni	Castings
A 500	C	K02705	62	...	...	...	...	101	C	Tube
A 500	B	K03000	58	...	...	...	...	101	C	Tube

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding			Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	P. No.	S. No.		
A 501		K03000	58	...	1	...	101	C	Tube	
SA-508	Cl. 1a	...	70	1	2	...	101	C-Mn-Si	Forgings	
SA-508	Cl. 3	K12042	80	3	3	...	101	0.75Ni-0.5Mo-Cr-V	Forgings	
SA-508	Cl. 3a	K12042	90	3	3	...	102	0.75Ni-0.5Mo-Cr-V	Forgings	
SA-508	Cl. 2	K12766	80	3	3	...	101	0.75Ni-0.5Mo-0.3Cr-V	Forgings	
SA-508	Cl. 2a	K12766	90	3	3	...	101	0.75Ni-0.5Mo-0.3Cr-V	Forgings	
SA-508	Cl. 1	K13502	70	1	2	...	...	C-Si	Forgings
SA-508	Cl. 4b	K22375	90	3	3	...	...	3.5Ni-1.75Cr-0.5Mo-V	Forgings
SA-508	Cl. F3V	...	85	5C	1	...	...	3Cr-1Mo-0.25V	Forgings
SA-508	Cl. 4	K22375	105	11A	5	...	102	3.5Ni-1.75Cr-0.5Mo-V	Forgings	
SA-508	Cl. 4a	K22375	115	11A	5	...	...	3.5Ni-1.75Cr-0.5Mo-V	Forgings
SA-508	Cl. 5	K42365	105	11A	5	...	...	3.5Ni-1.75Cr-0.5Mo-V	Forgings
SA-508	Cl. 5a	K42365	115	11A	5	...	...	3.5Ni-1.75Cr-0.5Mo-V	Forgings
A 513	1015 CW	G10150	65	...	...	...	...	C	Tube
A 513	1020 CW	G10200	70	...	2	...	101	C	Tube	
A 513	1025 CW	G10250	75	...	2	...	101	C	Tube	
A 513	1026 CW	G10260	80	...	3	...	101	C	Tube	
A 514	F	K11576	110	...	3	...	...	0.75Ni-0.5Cr-0.5Mo-V	Plate, < 2 1/2 in.
A 514	J	K11625	110	...	6	...	...	C-0.5Mo	Plate, < 1 1/4 in.
A 514	B	K11630	110	...	4	...	...	0.5Cr-0.2Mo-V	Plate, < 1 1/4 in.
A 514	D	K11662	110	...	5	...	...	1Cr-0.2Mo-Si	Plate, < 1 1/4 in.
A 514	A	K11856	110	...	1	...	...	0.5Cr-0.25Mo-Si	Plate, < 1 1/4 in.
A 514	E	K21604	100	...	2	...	...	1.75Cr-0.5Mo-Cu	Plate, 2 1/2 in.-6 in.
A 514	E	K21604	110	...	2	...	...	1.75Cr-0.5Mo-Cu	Plate, < 2 1/2 in.
A 514	P	K21650	100	...	8	...	...	1.25Ni-1Cr-0.5Mo	Plate, 2 1/2 in.-6 in.
A 514	P	K21650	110	...	8	...	...	1.25Ni-1Cr-0.5Mo	Plate, < 2 1/2 in.
A 514	Q	...	100	...	9	...	...	1.3Ni-1.3Cr-0.5Mo-V	Plate, 2 1/2 in.-6 in.
A 514	Q	...	110	...	9	...	...	1.3Ni-1.3Cr-0.5Mo-V	Plate, < 2 1/2 in.
SA-515	55	K02001	55	1	1	...	101	C-Si	Plate	
SA-515	60	K02401	60	1	1	...	101	C-Si	Plate	
SA-515	65	K02800	65	1	1	...	101	C-Si	Plate	
SA-515	70	K03101	70	1	2	...	101	C-Si	Plate	

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding			Brazing			Nominal Composition	Product Form
				P. No.	Group No.	S. No.	P. No.	S. No.	Group No.		
SA-516	55	K01800	55	1	1	...	101	...	C-Si	Plate	
SA-516	60	K02100	60	1	1	...	101	...	C-Mn-Si	Plate	
SA-516	65	K02403	65	1	1	...	101	...	C-Mn-Si	Plate	
SA-516	70	K02700	70	1	2	...	101	...	C-Mn-Si	Plate	
SA-517	F	K11576	105	11B	3	...	...	...	0.75Ni-0.5Cr-0.5Mo-V	Plate
SA-517	F	K11576	115	11B	3	...	...	...	0.75Ni-0.5Cr-0.5Mo-V	Plate
SA-517	J	K11625	105	11B	6	...	...	...	C-0.5Mo	Plate
SA-517	J	K11625	115	11B	6	...	...	...	C-0.5Mo	Plate
SA-517	B	K11630	105	11B	4	...	...	...	0.5Cr-0.2Mo-V	Plate
SA-517	B	K11630	115	11B	4	...	...	...	0.5Cr-0.2Mo-V	Plate
SA-517	A	K11856	105	11B	1	...	...	...	0.5Cr-0.25Mo-Si	Plate
SA-517	A	K11856	115	11B	1	...	...	...	0.5Cr-0.25Mo-Si	Plate
SA-517	E	K21604	115	11B	2	...	...	...	1.75Cr-0.5Mo-Cu	Plate, < 2 1/2 in.
SA-517	P	K21650	105	11B	8	...	...	...	1.25Ni-1Cr-0.5Mo	Plate
SA-517	P	K21650	115	11B	8	...	...	...	1.25Ni-1Cr-0.5Mo	Plate
A 519	1018 HR	G10180	50	...	...	...	...	101	C	Tube
A 519	1018 CW	G10180	70	...	...	...	...	101	C	Tube
A 519	1020 HR	G10200	50	...	...	...	...	101	C	Tube
A 519	1020 CW	G10200	70	...	...	...	...	101	C	Tube
A 519	1022 HR	G10220	50	...	...	...	...	101	C	Tube
A 519	1022 CW	G10220	70	...	...	...	...	101	C	Tube
A 519	1025 HR	G10250	55	...	...	...	...	101	C	Tube
A 519	1025 CW	G10250	75	...	...	...	...	101	C	Tube
A 519	1026 HR	G10260	55	...	...	...	...	101	C	Tube
A 519	1026 CW	G10260	75	...	...	...	...	101	C	Tube
A 521	Cl. CC	...	60	...	...	...	...	101	C	Forgings
A 521	Cl. CE	...	75	...	...	...	...	101	C	Forgings
SA-522	Type II	K71340	100	11A	1	...	...	...	8Ni	Forgings
SA-522	Type I	K81340	100	11A	1	...	...	...	9Ni	Forgings
SA-524	II	K02104	55	1	1	...	101	...	C-Mn-Si	Smls. pipe	
SA-524	I	K02104	60	1	1	...	101	...	C-Mn-Si	Smls. pipe	

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding			Brazing			Nominal Composition	Product Form
				P. No.	Group No.	S. No.	P. No.	S. No.			
									Group No.		
SA-533	Type A, Cl. 1	K12521	80	3	3	...	101	...	Mn-0.5Mo	Plate	
SA-533	Type A, Cl. 2	K12521	90	3	3	...	101	...	Mn-0.5Mo	Plate	
SA-533	Type A, Cl. 3	K12521	100	11A	4	...	...	...	Mn-0.5Mo	Plate
SA-533	Type D, Cl. 1	K12529	80	3	3	...	101	...	Mn-0.5Mo-0.25Ni	Plate	
SA-533	Type D, Cl. 2	K12529	90	3	3	...	101	...	Mn-0.5Mo-0.25Ni	Plate	
SA-533	Type D, Cl. 3	K12529	100	11A	4	...	...	...	Mn-0.5Mo-0.25Ni	Plate
SA-533	Type B, Cl. 1	K12539	80	3	3	...	101	...	Mn-0.5Mo-0.5Ni	Plate	
SA-533	Type B, Cl. 2	K12539	90	3	3	...	101	...	Mn-0.5Mo-0.5Ni	Plate	
SA-533	Type B, Cl. 3	K12539	100	11A	4	...	...	...	Mn-0.5Mo-0.5Ni	Plate
SA-533	Type C, Cl. 1	K12554	80	3	3	...	101	...	Mn-0.5Mo-0.75Ni	Plate	
SA-533	Type C, Cl. 2	K12554	90	3	3	...	101	...	Mn-0.5Mo-0.75Ni	Plate	
SA-533	Type C, Cl. 3	K12554	100	11A	4	...	...	...	Mn-0.5Mo-0.75Ni	Plate
SA-537	Cl. 1	K02400	65	1	2	...	101	...	C-Mn-Si	Plate, > 2 1/2 in.	
SA-537	Cl. 1	K02400	70	1	2	...	101	...	C-Mn-Si	Plate, 2 1/2 in. & under	
SA-537	Cl. 2	K02400	70	1	3	...	101	...	C-Mn-Si	Plate, 4-6 in.	
SA-537	Cl. 2	K02400	75	1	3	...	...	...	C-Mn-Si	Plate, > 2 1/2-4 in.
SA-537	Cl. 2	K02400	80	1	3	...	101	...	C-Mn-Si	Plate, 2 1/2 in. & under	
SA-541	Cl. 1	K03506	70	1	2	...	101	...	C-Si	Forgings	
SA-541	Cl. 1A	...	70	1	2	...	101	...	C-Mn-Si	Forgings	
SA-541	Cl. 3	K12045	80	3	3	...	101	...	0.5Ni-0.5Mo-V	Forgings	
SA-541	Cl. 3A	K12045	90	3	3	...	101	...	0.5Ni-0.5Mo-V	Forgings	
SA-541	Cl. 2	K12765	80	3	3	...	101	...	0.75Ni-0.5Mo-0.3Cr-V	Forgings	
SA-541	Cl. 2A	K12765	90	3	3	...	101	...	0.75Ni-0.5Mo-0.3Cr-V	Forgings	
SA-541	Cl. 11C	...	80	4	1	...	102	...	1.25Cr-0.5Mo-Si	Forgings	
SA-541	Cl. 3V	K31830	85	5C	1	...	...	...	3Cr-1Mo-0.25V	Forgings
SA-541	Cl. 22C	...	105	5C	4	...	...	...	2.25Cr-1Mo	Forgings
SA-541	Cl. 22D	...	115	5C	5	...	...	...	2.25Cr-1Mo	Forgings
SA-542	Type B, Cl. 4a	K21590	85	5C	1	...	...	...	2.25Cr-1Mo	Plate
SA-542	Type B, Cl. 4	K21590	85	5C	1	...	...	...	2.25Cr-1Mo	Plate
SA-542	Type A, Cl. 4	K21590	85	5C	1	...	...	...	2.25Cr-1Mo	Plate
SA-542	Type A, Cl. 4a	K21590	85	5C	1	2.25Cr-1Mo	Plate	
SA-542	Type A, Cl. 3	K21590	95	5C	3	2.25Cr-1Mo	Plate	

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QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding			Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	P. No.	S. No.		
SA-542	Type B, Cl. 3	K21590	95	5C	3	...	...	...	2.25Cr-1Mo	Plate
SA-542	Type A, Cl. 1	K21590	105	5C	4	...	...	...	2.25Cr-1Mo	Plate
SA-542	Type B, Cl. 1	K21590	105	5C	4	...	102	...	2.25Cr-1Mo	Plate
SA-542	Type B, Cl. 2	K21590	115	5C	5	...	102	...	2.25Cr-1Mo	Plate
SA-542	Type A, Cl. 2	K21590	115	5C	5	...	...	...	2.25Cr-1Mo	Plate
SA-542	Type C, Cl. 4	K31545	85	5C	1	...	...	...	3Cr-1Mo	Plate
SA-542	Type C, Cl. 4a	K31545	85	5C	1	...	...	...	3Cr-1Mo	Plate
SA-542	Type C, Cl. 3	K31545	95	5C	3	...	...	...	3Cr-1Mo	Plate
SA-542	Type C, Cl. 1	K31545	105	5C	4	...	...	...	3Cr-1Mo	Plate
SA-542	Type C, Cl. 2	K31545	115	5C	5	...	...	...	3Cr-1Mo	Plate
SA-543	B Cl. 3	K42338	90	11A	5	...	...	...	3Ni-1.75Cr-0.5Mo	Plate
SA-543	C Cl. 3	K42338	90	11A	5	...	...	...	2.75Ni-1.5Cr-0.5Mo	Plate
SA-543	B Cl. 1	K42338	105	11A	5	...	...	...	3Ni-1.75Cr-0.5Mo	Plate
SA-543	C Cl. 1	K42338	105	11A	5	...	...	...	2.75Ni-1.5Cr-0.5Mo	Plate
SA-543	B Cl. 2	K42338	115	11B	10	...	...	...	3Ni-1.75Cr-0.5Mo	Plate
SA-543	C Cl. 2	K42338	115	11B	10	...	...	...	2.75Ni-1.5Cr-0.5Mo	Plate
A 543	B Cl. 3	K42338	90	...	...	...	...	...	3Ni-1.75Cr-0.5Mo	Plate
A 543	C Cl. 3	K42338	90	...	...	...	...	...	2.75Ni-1.5Cr-0.5Mo	Plate
A 543	B Cl. 1	K42338	105	...	...	...	...	...	3Ni-1.75Cr-0.5Mo	Plate
A 543	C Cl. 1	K42338	105	...	...	...	...	...	2.75Ni-1.5Cr-0.5Mo	Plate
A 543	B Cl. 2	K42338	115	...	...	...	...	...	3Ni-1.75Cr-0.5Mo	Plate
A 543	C Cl. 2	K42338	115	...	...	...	...	...	2.75Ni-1.5Cr-0.5Mo	Plate
SA-553	Type II	K71340	100	11A	1	...	...	...	8Ni	Plate
SA-553	Type I	K81340	100	11A	1	...	102	...	9Ni	Plate
SA-556	A2	K01807	47	1	1	...	101	...	C	Smils. tube
SA-556	B2	K02707	60	1	1	...	101	...	C-Si	Smils. tube
SA-556	C2	K03006	70	1	2	...	101	...	C-Si	Smils. tube
SA-557	A2	K01807	47	1	1	...	101	...	C	E.R.W. tube
SA-557	B2	K03007	60	1	1	...	101	...	C	E.R.W. tube
SA-557	C2	K03505	70	1	2	...	101	...	C-Mn	E.R.W. tube
SA-562	...	K11224	55	1	1	...	101	...	C-Mn-Ti	Plate

(See Notes at end of QW/QB-422.)

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
 Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)]	Welding		Brazing		Nominal Composition	Product Form
				P. No.	Group No.	S. No.	Group No.		
SA-841	...	...	65	10C	1	...	...	C-Mn-Si	Plate, > 2 1/2 in.
SA-841	...	...	70	10C	1	...	...	C-Mn-Si	Plate, 2 1/2 in. & under
API5L	A25, Cl.1	...	45	...	...	...	101	C-Mn	Smls./Welded
API5L	A25, Cl.1	...	45	...	...	...	101	C-Mn	Smls./Welded
API5L	A	...	48	...	...	...	101	C-Mn	Smls./Welded
API5L	B	...	60	...	...	...	101	C-Mn	Smls./Welded
API5L	X42	...	60	...	...	...	101	C-Mn	Smls./Welded
API5L	X46	...	63	...	...	...	101	C-Mn	Smls./Welded
API5L	X52	...	66	...	...	...	101	C-Mn	Smls./Welded
API5L	X56	...	71	...	...	...	101	C-Mn	Smls./Welded
API5L	X60	...	75	...	...	...	101	C-Mn	Smls./Welded
API5L	X65	...	77	...	...	...	101	C-Mn	Smls./Welded
API5L	X70	...	82	...	...	...	101	C-Mn	Smls./Welded
API5L	X80	...	90	...	...	...	101	C-Mn	Smls./Welded
...	...	...	...	5C	2	...	...	...	...

(Spaces in above line intentionally left blank)

(See Notes at end of QW/QB-422.)

QW/QB-422 NONFERROUS P-NUMBERS AND S-NUMBERS
(Grouping of Base Metals for Qualification)

Spec. No.	UNS No.	Type or Grade	Alloy	Minimum Specified Tensile, ksi [Note (1)]	Welding		Brazing		Condition	Size(s), or Thickness, in.	Nominal Composition	Product Form
					P. No.	S. No.	P. No.	S. No.				
B-26	...	55A (43), F	...	17	...	21	...	104	...	...	Al-Si	Castings
B-26	...	5G70A	...	25	...	21	...	104	...	...	Al-Si	Castings
B-26	...	(356), T71	...	30	...	21	...	104	...	...	Al-Si	Castings
B-26	...	(356), T6	...	30	...	21	...	104	...	...	Al-Si	Castings
SB-42	C10200	(7)	061	30	...	31	...	107	...	All	99.95Cu + Ag	Smls. pipe
SB-42	C10200	(7)	H55	36	...	31	...	107	...	2.5-12	99.95Cu + Ag	Smls. pipe
SB-42	C10200	(7)	H80	45	...	31	...	107	...	0.125-2, incl.	99.95Cu + Ag	Smls. pipe
SB-42	C12000	(7)	061	30	...	31	...	107	...	All	99.9Cu + Ag	Smls. pipe
SB-42	C12000	(7)	H55	36	...	31	...	107	...	2.5-12	99.9Cu + Ag	Smls. pipe
SB-42	C12200	(7)	H80	45	...	31	...	107	...	0.125-2, incl.	99.9Cu + Ag	Smls. pipe
SB-43	C23000	...	...	40	...	32	...	107	Annealed	All	15Zn	Smls. pipe
B-68	C10200	102	...	30	...	31	...	107	...	...	99.95Cu + Ag	Tube
B-68	C12000	120	...	30	...	31	...	107	...	...	99.95Cu + Ag	Tube
B-68	C12200	122	...	30	...	31	...	107	...	...	99.95Cu + Ag	Tube
SB-75	C10200	(7)	...	30	...	31	...	107	Annealed	All	99.95Cu + Ag	Smls. tube
SB-75	C10200	(7)	...	36	...	31	...	107	Light Drawn (6)	All	99.95Cu + Ag	Smls. tube
SB-75	C10200	(7)	...	45	...	31	...	107	Hard Drawn	All	99.95Cu + Ag	Smls. tube
SB-75	C12000	(7)	...	30	...	31	...	107	Annealed	All	99.9Cu + Ag	Smls. tube
SB-75	C12000	(7)	...	45	...	31	...	107	Hard Drawn	All	99.9Cu + Ag	Smls. tube
SB-75	C12200	(7)	...	30	...	31	...	107	Annealed	All	99.9Cu + Ag	Smls. tube
SB-75	C12200	(7)	...	36	...	31	...	107	Light Drawn (6)	All	99.9Cu + Ag	Smls. tube
SB-75	C12200	(7)	...	45	...	31	...	107	Hard Drawn	All	99.9Cu + Ag	Smls. tube
B-85	...	...	...	...	...	31	...	...	...	...	...	Die Castings
B-88	C10200	102	...	30	...	31	...	107	...	...	Ann, 99.95Cu + Ag	Tube
B-88	C10200	102	...	36	...	31	...	107	...	...	Drawn, 99.95Cu + Ag	Tube
B-88	C12000	120	...	30	...	31	...	107	...	...	Ann, 99.9Cu + Ag	Tube
B-88	C12000	120	...	36	...	31	...	107	...	...	Drawn, 99.9Cu + Ag	Tube
B-88	C12200	122	...	30	...	31	...	107	...	...	Ann, 99.9Cu + Ag	Tube
B-88	C12200	122	...	36	...	31	...	107	...	...	Drawn, 99.9Cu + Ag	Tube
SB-96	C65500	...	...	50	...	33	...	107	Annealed	...	3.3Si	Plt, sht, strip, & bar
SB-98	C65100	...	...	40	...	33	...	107	Soft	...	1.6Si	Rod, bar, & shapes
SB-98	C65100	...	...	55	...	33	...	...	Half Hard (6)	To 2 diam.	1.6Si	Rod, bar, & shapes
SB-98	C65100	...	...	75	...	33	...	...	Boil Temper (6)	over 1-1.5	1.6Si	Rod, bar, & shapes

(See Notes at end of QW/QB-422.)

QW/QB-422 (CONT'D)

NOTES:

- (1) See QW-153.1(a), (b), and (d).
- (2) Tensile value is expected minimum.
- (3) Some of the indicated product forms are not normally produced in all the sizes indicated; for more specific coverage, see applicable tables of Section II, Part B.
- (4) Specified minimum tensile strength is for full-thickness specimens that include cladding.
- (5) Specified minimum tensile strength is for specimens taken from the core.
- (6) For copper and copper-base alloys, the acceptance value for the tensile test of the welding procedure qualification shall be that given for the base metal in the annealed condition.
- (7) C10200 — oxygen free; C10400, C10500, C10700 — oxygen free, silver bearing; C12000 — deoxidized, low phosphorus; C12200 — deoxidized, high phosphorus; C12300 — deoxidized, phosphorized, silver bearing; C14200 — deoxidized, phosphorized, arsenical.
- (8) Values in parentheses are not designated in the respective SB documents and are the acceptance values for qualification using T4 or T6 temper base metal and tested in the as-welded condition.

(See Notes at end of QW/QB-422.)

QW-423 Alternate Base Materials for Welder Qualification

QW-423.1 Base material used for welder qualification may be substituted for the P-Number material specified in the WPS in accordance with the following.

Base Metal(s) for Welder Qualification	Qualified Production Base Metal(s)
P-No. 1 through P-No. 11 or P-No. 4X	P-No. 1 through P-No. 11, P-No. 4X and unassigned metals of similar chemical composition to these metals
P-No. 21 through P-No. 25	P-No. 21 through P-No. 25
P-No. 34 or P-No. 42	P-No. 34 and P-No. 42
P-No. 5x or P-No. 6x	P-No. 5x and P-No. 6x

QW-424 Base Metals Used for Procedure Qualification

QW-424.1 Base metals are assigned P-Numbers in QW-422; metals which do not appear in QW-422 are considered to be unassigned metals except as otherwise defined in QW-420.1 for base metals having the same UNS numbers. Unassigned metals shall be identified in the WPS and on the PQR by specification, type and grade, or by chemical analysis and mechanical

properties. The minimum tensile strength shall be defined by the organization which specified the unassigned metal if the tensile strength of that metal is not defined by the material specification.

Base Metal(s) Used for Procedure Qualification Coupon	Base Metals Qualified
One metal from a P-Number to any metal from the same P-Number	Any metals assigned that P-Number
One metal from a P-Number to any metal from any other P-Number	Any metal assigned the first P-Number to any metal assigned the second P-Number
One metal from P-No. 3 to any metal from P-No. 3	Any P-No.3 metal to any metal from P-No. 3 or P-No. 1
One metal from P-No. 4 to any metal from P-No. 4	Any P-No. 4 metal to any metal from P-Nos. 4, 3, or 1
One metal from P-No. 5A to any metal from P-No. 5A	Any P-No. 5A metal to any metal from P-Nos. 5A, 4, 3, or 1 metals
One metal from P-No. 5A, P-No. 4, or P-No. 3 to a metal from a lower P-No.	Any P-No. 5A, P-No. 4, or P-No.3 metal to any metal assigned to any lower P-No.
Any unassigned metal to the same unassigned metal	The unassigned metal to itself
Any unassigned metal to any P-Number metal	The unassigned metal to any metal assigned to the same P-Number as the qualified metal
Any unassigned metal to any other unassigned metal	The first unassigned metal to the second unassigned metal

QW-430 F-NUMBERS

QW-431 General

The following F-Number grouping of electrodes and welding rods in QW-432 is based essentially on their usability characteristics, which fundamentally determine the ability of welders to make satisfactory welds with a given filler metal. This grouping is made to reduce the number of welding procedure and performance qualifications, where this can logically be done. The grouping does not imply that base metals or filler metals within a group may be indiscriminately substituted for

a metal which was used in the qualification test without consideration of the compatibility of the base and filler metals from the standpoint of metallurgical properties, postweld heat treatment design and service requirements, and mechanical properties.

- QW-432.1 Steel and Steel Alloys
- QW-432.2 Aluminum and Aluminum-Base Alloys
- QW-432.3 Copper and Copper-Base Alloys
- QW-432.4 Nickel and Nickel-Base Alloys
- QW-432.5 Titanium and Titanium Alloys
- QW-432.6 Zirconium and Zirconium Alloys
- QW-432.7 Hard-Facing Weld Metal Overlay

QW-432 F-NUMBERS

Grouping of Electrodes and Welding Rods for Qualification

QW	F-No.	ASME Specification No.	AWS Classification No.
Steel and Steel Alloys			
432.1	1	SFA-5.1 & 5.5	EXX 20, EXX 22, EXX 24, EXX 27, EXX 28
	1	SFA-5.4	EXX 25, EXX 26
	2	SFA-5.1 & 5.5	EXX 12, EXX 13, EXX 14, EXX 19
	3	SFA-5.1 & 5.5	EXX 10, EXX 11
	4	SFA-5.1 & 5.5	EXX 15, EXX 16, EXX 18, EXX 48
	4	SFA-5.4 other than austenitic and duplex	EXX 15, EXX 16, EXX 17
	5	SFA-5.4 (austenitic and duplex)	EXX 15, EXX 16, EXX 17
	6	SFA-5.2	RX
	6	SFA-5.17	FXX-EXX
	6	SFA-5.9	ERXX
	6	SFA-5.18	ERXXS-X, EXXC-X, EXXC-XX
	6	SFA-5.20	EXXT-X
	6	SFA-5.22	EXXT-X
	6	SFA-5.23	FXX-EXXX-X, FXX-ECXXX-X, and FXX-EXXX-XN, FXX-ECXXX-XN
	6	SFA-5.25	FESXX-EXXXX-EW
	6	SFA-5.26	EGXXS-X and EGXXT-X
	6	SFA-5.28	ERXXS-X and EXXC-X
	6	SFA-5.29	EXXTX-X
6	SFA-5.30	IN XXXX	
Aluminum and Aluminum-Base Alloys			
432.2	21	SFA-5.10	ER 1100
	22	SFA-5.10	ER 5554, ER 5356, ER 5556, ER 5183, ER 5654
	23	SFA-5.10	ER 4009, ER 4010, ER 4043, ER 4047 ER 4145, R 4009, R 4010, R4011
	24	SFA-5.10	R-A356.0
Copper and Copper-Base Alloys			
432.3	31	SFA-5.6	ECu
	31	SFA-5.7	ER Cu
	31	SFA-5.27	ER Cu

QW-432
F-NUMBERS (CONT'D)
Grouping of Electrodes and Welding Rods for Qualification

QW	F-No.	ASME Specification No.	AWS Classification No.	
Copper and Copper-Base Alloys (Cont'd)				
432.3	32	SFA-5.6	ECuSi	
	32	SFA-5.7	ER CuSi-A	
	32	SFA-5.27	ER CuSi-A	
	33	SFA-5.6	ECuSn-A, ECuSn-C	
	33	SFA-5.7	ER CuSn-A	
	34	SFA-5.6	ECuNi	
	34	SFA-5.7	ER CuNi	
	34	SFA-5.30	IN 67	
	35	SFA-5.27	RB CuZn-A	
	35		RB CuZn-B	
	35		RB CuZn-C	
	35		RB CuZn-D	
	36	SFA-5.6	ECuAl-A2	
	36		ECuAl-B	
	36	SFA-5.7	ER CuAl-A1	
	36		ER CuAl-A2	
	36		ER CuAl-A3	
	37	SFA-5.6	ECuNiAl	
	37		ECuMnNiAl	
	37	SFA-5.7	ER CuNiAl	
	37		ER CuMnNiAl	
	Nickel and Nickel-Base Alloys			
	432.4	41	SFA-5.11	E Ni-1
41		SFA-5.14	ER Ni-1	
41		SFA-5.30	IN 61	
42		SFA-5.11	E NiCu-7	
42		SFA-5.14	ER NiCu-7	
42		SFA-5.30	IN 60	
43		SFA-5.11	E NiCrFe-1	
43		SFA-5.11	E NiCrFe-2	
43		SFA-5.11	E NiCrFe-3	
43		SFA-5.11	E NiCrFe-4	
43		SFA-5.11	E NiCrCoMo-1	
43		SFA-5.11	E NiCrMo-2	
43		SFA-5.11	E NiCrMo-3	
43		SFA-5.11	E NiCrMo-6	
43		SFA-5.14	ER NiCr-3	

QW-432
F-NUMBERS (CONT'D)
Grouping of Electrodes and Welding Rods for Qualification

QW	F-No.	ASME Specification No.	AWS Classification No.
Nickel and Nickel-Base Alloys (Cont'd)			
432.4	43	SFA-5.14	ER NiCrFe-5
	43	SFA-5.14	ER NiCrFe-6
	43	SFA-5.14	ER NiCrCoMo-1
	43	SFA-5.14	ER NiCrMo-2
	43	SFA-5.14	ER NiCrMo-3
	43	SFA-5.30	IN 82
	43	SFA-5.30	IN 62
	43	SFA-5.30	IN 6A
	44	SFA-5.11	E NiMo-1
	44	SFA-5.11	E NiMo-3
	44	SFA-5.11	E NiMo-7
	44	SFA-5.11	E NiCrMo-4
	44	SFA-5.11	E NiCrMo-5
	44	SFA-5.11	E NiCrMo-7
	44	SFA-5.11	E NiCrMo-10
	44	SFA-5.14	ER NiMo-1
	44	SFA-5.14	ER NiMo-2
	44	SFA-5.14	ER NiMo-7 (Alloy B-2)
	44	SFA-5.14	ER NiCrMo-4
	44	SFA-5.14	ER NiCrMo-5
	44	SFA-5.14	ER NiCrMo-7 (Alloy C-4)
	44	SFA-5.14	ER NiCrMo-10
	45	SFA-5.11	E NiCrMo-1
	45	SFA-5.11	E NiCrMo-9
	45	SFA-5.11	E NiCrMo-11
	45	SFA-5.14	ER NiCrMo-1
	45	SFA-5.14	ER NiFeCr-1
	45	SFA-5.14	ER NiCrMo-8
45	SFA-5.14	ER NiCrMo-9	
45	SFA-5.14	ER NiCrMo-11	
Titanium and Titanium Alloys			
432.5	51	SFA-5.16	ERTi-1, ERTi-2, ERTi-3, ERTi-4
	52	SFA-5.16	ERTi-7
	53	SFA-5.16	ERTi-9, ERTi-9ELI
	54	SFA-5.16	ERTi-12
Zirconium and Zirconium Alloys			
432.6	61	SFA-5.24	ER Zr2 ER Zr3 ER Zr4
Hard-Facing Weld Metal Overlay			
432.7	71	SFA-5.13	RXXX-X, EXXX-X
	72	SFA-5.21	RXXX-X

QW-433 Alternate F-Numbers for Welder Performance Qualification

The following tables identify the filler metal or electrode that the welder used during qualification testing as "Qualified With," and the electrodes or filler metals that the welder is qualified to use in production welding as "Qualified For." See QW-432 for the F-Number assignments.

Qualified With → Qualified For ↓	F-No. 1 With Backing	F-No. 1 Without Backing	F-No. 2 With Backing	F-No. 2 Without Backing	F-No. 3 With Backing	F-No. 3 Without Backing	F-No. 4 With Backing	F-No. 4 Without Backing
F-No. 1 With Backing	X	X	X	X	X	X	X	X
F-No. 1 Without Backing		X						
F-No. 2 With Backing			X	X	X	X	X	X
F-No. 2 Without Backing				X				
F-No. 3 With Backing					X	X	X	X
F-No. 3 Without Backing						X		
F-No. 4 With Backing							X	X
F-No. 4 Without Backing								X

Qualified With	Qualified For
Any F-No. 5	All F-No. 5
Any F-No. 6	All F-No. 6 [Note (1)]
Any F-No. 21 through F-No. 24	All F-No. 21 through F-No. 24
Any F-No. 31 through F-No. 37	Only the same F-Number as was used during the qualification test
Any F-No. 41 through F-No. 45	All F-No. 41 through F-No. 45
Any F-No. 51 through F-No. 54	All F-No. 51 through F-No. 54
Any F-No. 61	All F-No. 61
Any F-No. 71 through F-72	Only the same F-Number as was used during the qualification test

Note (1): Deposited weld metal made using a bare rod not covered by an SFA Specification but which conforms to an analysis listed in QW-442 shall be considered to be classified as F-No. 6.

**QW-440 WELD METAL CHEMICAL
COMPOSITION**

QW-441 General

Identification of weld metal chemical composition designated on the PQR and WPS shall be as given in QW-404.5.

**QW-442
A-NUMBERS
Classification of Ferrous Weld Metal Analysis for Procedure Qualification**

A-No.	Types of Weld Deposit	Analysis, % [Note (1)]					
		C	Cr	Mo	Ni	Mn	Si
1	Mild Steel	0.15	...	...	...	1.60	1.00
2	Carbon-Molybdenum	0.15	0.50	0.40-0.65	...	1.60	1.00
3	Chrome (0.4% to 2%)-Molybdenum	0.15	0.40-2.00	0.40-0.65	...	1.60	1.00
4	Chrome (2% to 6%)-Molybdenum	0.15	2.00-6.00	0.40-1.50	...	1.60	2.00
5	Chrome (6% to 10.5%)-Molybdenum	0.15	6.00-10.50	0.40-1.50	...	1.20	2.00
6	Chrome-Martensitic	0.15	11.00-15.00	0.70	...	2.00	1.00
7	Chrome-Ferritic	0.15	11.00-30.00	1.00	...	1.00	3.00
8	Chromium-Nickel	0.15	14.50-30.00	4.00	7.50-15.00	2.50	1.00
9	Chromium-Nickel	0.30	25.00-30.00	4.00	15.00-37.00	2.50	1.00
10	Nickel to 4%	0.15	...	0.55	0.80-4.00	1.70	1.00
11	Manganese-Molybdenum	0.17	...	0.25-0.75	0.85	1.25-2.25	1.00
12	Nickel-Chrome-Molybdenum	0.15	1.50	0.25-0.80	1.25-2.80	0.75-2.25	1.00

NOTE:

(1) Single values shown above are maximum.

QW-450 SPECIMENS
QW-451 Procedure Qualification Thickness Limits and Test Specimens
QW-451.1
GROOVE-WELD TENSION TESTS AND TRANSVERSE-BEND TESTS

Thickness <i>T</i> of Test Coupon Welded, in.	Range of Thickness <i>T</i> of Base Metal Qualified, in. [Note (1)]		Thickness <i>t</i> of Deposited Weld Metal Qualified, in. [Note (1)]		Type and Number of Tests Required (Tension and Guided-Bend Tests) [Note (4)]			
	Min.	Max.	Min.	Max.	Tension QW-150	Side Bend QW-160	Face Bend QW-160	Root Bend QW-160
Less than 1/16	<i>T</i>	2 <i>T</i>		2 <i>t</i>	2	...	2	2
1/16 to 3/16, incl.	1/16	2 <i>T</i>		2 <i>t</i>	2	Note (3)	2	2
Over 3/16, but less than 3/4	3/16	2 <i>T</i>		2 <i>t</i>	2	Note (3)	2	2
3/4 to less than 1 1/2	3/16	2 <i>T</i>		2 <i>t</i> when <i>t</i> < 3/4	2 (5)	4	...	...
	3/16	2 <i>T</i>		2 <i>T</i> when <i>t</i> ≥ 3/4	2 (5)	4	...	...
1 1/2 and over	3/16	8 (2)		2 <i>t</i> when <i>t</i> < 3/4	2 (5)	4	...	...
	3/16	8 (2)		8 (2) when <i>t</i> ≥ 3/4	2 (5)	4	...	...

- NOTES:**
(1) See QW-403 (.2, .3, .6, .9, .10), QW-404.32, and QW-407.4 for further limits on range of thickness qualified. Also see QW-202 (.2, .3, .4) for allowable exceptions.
(2) For the welding processes of QW-403.7 only; otherwise per Note (1) or 2*T*, or 2*t*, whichever is applicable.
(3) Four side-bend tests may be substituted for the required face- and root-bend tests, when thickness *T* is 3/8 in. and over.
(4) For combination of welding procedures, see QW-200.4.
(5) See QW-151 (.1, .2, .3) for details on multiple specimens when coupon thicknesses are over 1 in.

QW-451 Procedure Qualification Thickness Limits and Test Specimens (Cont'd)

QW-451.2 GROOVE-WELD TENSION TESTS AND LONGITUDINAL-BEND TESTS

Thickness <i>T</i> of Test Coupon Welded, in.	Range of Thickness <i>T</i> of Base Metal Qualified, in. [Note (1)]		Thickness <i>t</i> of Deposited Weld Metal Qualified, in. [Note (1)]		Type and Number of Tests Required Tension and Guided-Bend Tests) [Note (2)]		
	Min.	Max.	Min.	Max.	Tension QW-150	Face Bend QW-160	Root Bend QW-160
Less than 1/16	<i>T</i>	2 <i>T</i>		Max.	2	2	2
1/16 to 3/16, incl.	1/16	2 <i>T</i>		2 <i>t</i>	2	2	2
Over 3/16	3/16	2 <i>T</i>		2 <i>t</i>	2	2	2

NOTES:

(1) See QW-403 (.2, .3, .6, .7, .9, .10), QW-404.32, and QW-407.4 for further limits on range of thicknesses qualified. These are also applicable to deposited weld metal thicknesses. Also see QW-202 (.2, .3, .4) for allowable exceptions.

(2) For combination of welding procedures, see QW-200.4.

QW-451 Procedure Qualification Thickness Limits and Test Specimens (Cont'd)

**QW-451.3
FILLET-WELD TESTS¹**

Type of Joint	Thickness of Test Coupons as Welded, in.	Range Qualified	Type and Number of Tests Required [QW-462.4(a) or QW-462.4(d)] Macro
Fillet	Per QW-462.4(a)	All fillet sizes on all base metal thicknesses and all diameters	5
Fillet	Per QW-462.4(d)		4

NOTE:

(1) Production assembly mockups may be substituted in accordance with QW-181.1.1. When production assembly mockups are used, range qualified shall be limited to the fillet sizes, base metal thicknesses, and configuration of the mockup.

**QW-451.4
FILLET WELDS QUALIFIED BY GROOVE-WELD TESTS**

Thickness <i>T</i> of Test Coupon (Plate or Pipe) as Welded	Range Qualified	Type and Number of Tests Required
All groove tests	All fillet sizes on all base metal thicknesses and all diameters	Fillet welds are qualified when the groove weld is qualified in accordance with either QW-451.1 or QW-451.2 (see QW-202.2)

QW-452 Performance Qualification Thickness Limits and Test Specimens

QW-452.1
TRANSVERSE-BEND TESTS

Type of Joint	Thickness of Test Coupon Welded, in. (Note (1))	Thickness <i>t</i> of Deposited Weld Metal Qualified, in. (Note (2)) (See QW-310.1)	Type and Number of Tests Required (Guided-Bend Tests) (Notes (3), (4), (8))		
			Side Bend QW-462.2	Face Bend QW-462.3(a)	Root Bend (Note (5)) QW-462.3(a)
Groove	Up to 3/8 in.	2 <i>t</i>	Note (6)	1	1
Groove	Over 3/8 but less than 3/4	2 <i>t</i>	Note (7)	1	1
Groove	3/4 and over	Max. to be welded	2	...	...

NOTES:

- (1) When using one, two, or more welders, the thickness *t* of the deposited weld metal for each welder with each process shall be determined and used individually in the Thickness column.
- (2) Two or more pipe test coupons of different thicknesses may be used to determine the deposited weld metal thickness qualified and that thickness may be applied to production welds to the smallest diameter for which the welder is qualified in accordance with QW-452.3.
- (3) Thickness of test coupon of 3/4 in. or over shall be used for qualifying a combination of three or more welders each of which may use the same or a different welding process.
- (4) To qualify for positions 5G and 6G, as prescribed in QW-302.3, two root and two face-bend specimens or four side bend specimens, as applicable to the test coupon thickness, are required.
- (5) Face- and root-bend tests may be used to qualify a combination test of:
 - (a) one welder using two welding processes; or
 - (b) two welders using the same or a different welding process.
- (6) For a 3/8 in. thick coupon, a side-bend test may be substituted for each of the required face- and root-bend tests.
- (7) A side-bend test may be substituted for each of the required face- and root-bend tests.
- (8) Test coupons shall be visually examined per QW-302.4.

QW-452 Performance Qualification Thickness Limits and Test Specimens (Cont'd)

**QW-452.2
LONGITUDINAL-BEND TESTS**

Type of Joint	Thickness Test Coupon Welded, in. [Note (1)]	Thickness <i>t</i> of Deposited Weld Metal Qualified, in. Max.	Type and Number of Tests Required (Guided-Bend Tests) [Note (2)]	
			Face Bend [Note (3)] QW-462.3(b)	Root Bend [Note (3)] QW-462.3(b)
Groove	Up to $\frac{3}{8}$, incl.	2 <i>t</i>	1	1
Groove	Over $\frac{3}{8}$	2 <i>t</i>	1	1

NOTES:

- (1) When using one, two, or more welders, the thickness *t* of the deposited weld metal for each welder with each process shall be determined and used individually in the Thickness column.
- (2) Thickness of test coupon of $\frac{3}{8}$ in. or over shall be used for qualifying a combination of three or more welders, each of which may use the same or a different welding process.
- (3) Face- and root-bend tests may be used to qualify a combination test of:
 - (a) one welder using two welding processes; or
 - (b) two welders using the same or a different welding process.

**QW-452.3
GROOVE-WELD DIAMETER LIMITS^{1,2}**

Outside Diameter of Test Coupon, in.	Outside Diameter Qualified, in.	
	Min.	Max.
Less than 1	Size welded	Unlimited
1 to less than $2\frac{7}{8}$	1	Unlimited
$2\frac{7}{8}$ and over	$2\frac{7}{8}$	Unlimited

NOTES:

- (1) Type and number of tests required shall be in accordance with QW-452.1.
- (2) $2\frac{7}{8}$ in. O.D. is the equivalent of NPS $2\frac{1}{2}$.

QW-452 Performance Qualification Thickness Limits and Test Specimens (Cont'd)

QW-452.4
SMALL DIAMETER FILLET-WELD TEST^{1,2}

Outside Diameter of Test Coupon, in.	Minimum Outside Diameter Qualified, in.	Thickness Qualified
Less than 1	Size welded	All
1 to less than 2 $\frac{7}{8}$	1	All
2 $\frac{7}{8}$ and over	2 $\frac{7}{8}$	All

NOTES:

- (1) Type and number of tests required shall be in accordance with QW-452.5.
 (2) 2 $\frac{7}{8}$ in. O.D. is considered the equivalent of NPS 2 $\frac{1}{2}$.

QW-452.5
FILLET-WELD TEST²

Type of Joint	Thickness of Test Coupon as Welded, in.	Range Qualified	Type and Number of Tests Required [QW-462.4(b) or QW-462.4(c)]	
			Macro	Fracture
Tee fillet	$\frac{3}{16}$ - $\frac{3}{8}$	All base material thicknesses, fillet sizes, and diameters 2 $\frac{7}{8}$ O.D. and over (1)	1	1
	Less than $\frac{3}{16}$	T to 2T base material thickness, 7 maximum fillet size, and all diameters 2 $\frac{7}{8}$ O.D. and over (1)	1	1

NOTE:

- (1) 2 $\frac{7}{8}$ in. O.D. is considered the equivalent of NPS 2 $\frac{1}{2}$. For smaller diameter qualifications, refer to QW-452.4 or QW-452.6.
 (2) Production assembly mockups may be substituted in accordance with QW-181.2.1. When production assembly mockups are used, range qualified shall be limited to the fillet sizes, base metal thicknesses, and configuration of the mockup.

QW-452.6
FILLET QUALIFICATION BY GROOVE-WELD TESTS

Type of Joint	Thickness of Test Coupon as Welded, in.	Range Qualified	Type and Number of Tests Required
Any groove	All thicknesses	All base material thicknesses, fillet sizes, and diameters	Fillet welds are qualified when a welder/welding operator qualifies on a groove weld test

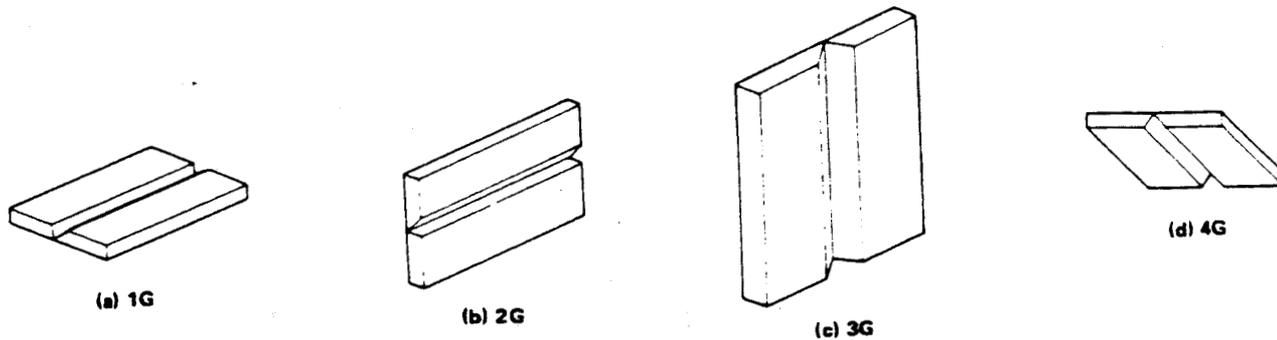
**QW-453
PROCEDURE/PERFORMANCE QUALIFICATION THICKNESS LIMITS AND TEST
SPECIMENS FOR HARD-FACING (WEAR RESISTANT) AND CORROSION
RESISTANT OVERLAYS**

Thickness of Test coupon (T)	Corrosion Resistant [Note (1)] Overlay		Hardfacing Overlay (Wear Resistant) [Note (2)]	
	Nominal Base Metal Thickness Qualified (T)	Type & Number of Tests required	Nominal Base Metal Thickness Qualified (T)	Type & Number of Tests Required
Procedure Qualification Testing				
Less than 1 inch T	T qualified to unlimited 1 inch to unlimited	Notes: (4), (5), and (9)	T qualified up to 1 inch 1 inch to unlimited	Notes: (3), (7), (8), and (9)
1 inch and over T				
Performance Qualification Testing				
Less than 1 inch T	T qualified to unlimited 1 inch to unlimited	Note (6)	T qualified to unlimited 1 inch to unlimited	Notes (8) and (10)
1 inch and over T				

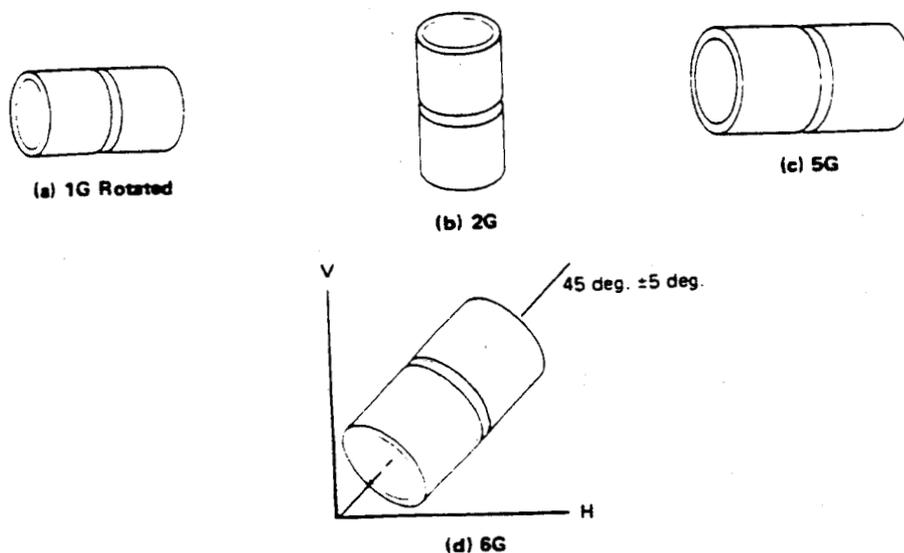
NOTES:

- (1) The qualification test coupon shall consist of base metal not less than 6 in. x 6 in. The weld overlay cladding shall be a minimum of 1½ in. wide by approximately 6 in. long. For qualification on pipe, the pipe length shall be a minimum of 6 in., and a minimum diameter to allow the required number of test specimens. The weld overlay shall be continuous around the circumference of the test coupon. For processes (performance qualification only) depositing a weld bead width greater than ½ in. wide, the weld overlay shall consist of a minimum of three weld beads in the first layer.
- (2) The test base metal coupon shall have minimum dimensions of 6 in. wide x approximately 6 in. long with a hard-faced layer a minimum of 1½ in. wide x 6 in. long. The minimum hard-faced thickness shall be as specified in the Welding Procedure Specification. Alternatively, the qualification may be performed on a test base metal coupon which represents the size of the production part. For qualification on pipe, the pipe length shall be 6 in. minimum, and of a minimum diameter to allow the required number of test specimens. The weld overlay shall be continuous around the circumference of the test coupon.
- (3) The hard-facing surface shall be examined by the liquid penetrant method and shall meet the acceptance standards as specified in the WPS. Surface conditioning prior to liquid penetrant examination is permitted.
- (4) The corrosion resistant surface shall be examined by the liquid penetrant method and shall meet the acceptance standards as specified in QW-195.
- (5) Following the liquid penetrant examination, four guided side-bend tests shall be made from the test coupon in accordance with QW-161. The test specimens shall be cut so that there are either two specimens parallel and two specimens perpendicular to the direction of the welding, or four specimens perpendicular to the direction of the welding. For coupons which are less than ½ in. thick, the width of the side-bend specimens may be reduced to the thickness of the test coupon. The side-bend specimens shall be removed from locations specified in QW-462.5(c) or QW-462.5(d).
- (6) The test coupon shall be sectioned to make side-bend test specimens perpendicular to the direction of the welding in accordance with QW-161. Test specimens shall be removed at locations specified in QW-462.5(c) or QW-462.5(d).
- (7) After surface conditioning to the minimum thickness specified in the WPS, a minimum of three hardness readings shall be made on each of the specimens from the locations shown in QW-462.5(c) or QW-462.5(e).
- (8) The base metal shall be sectioned transversely to the direction of the hard-facing overlay. The two faces of the hard-facing exposed by sectioning shall be polished and etched with a suitable etchant and shall be visually examined with x5 magnification for cracks in the base metal or the heat affected zone, lack of fusion, or other linear defects. The overlay and the base metal shall meet the requirements specified in the WPS. All exposed faces shall be examined.
- (9) Chemical analysis specimens shall be removed at locations specified in QW-462.5(b) or QW-462.5(e). The chemical analysis shall be performed in accordance with QW-462.5(a).
- (10) At a thickness greater than or equal to the minimum thickness specified in the WPS, the weld surface shall be examined by the liquid penetrant method and shall meet the acceptance standards as specified in the WPS. Surface conditioning prior to liquid penetrant examination is permitted.

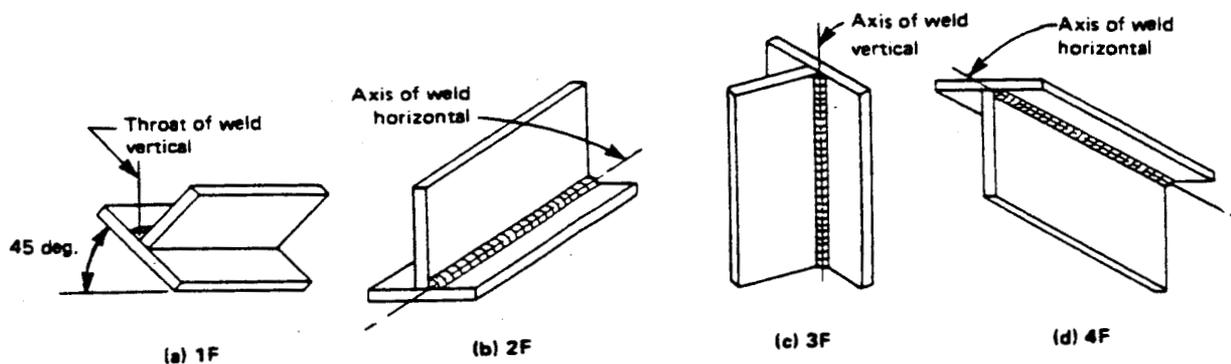
QW-461 Positions (Cont'd)



QW-461.3 GROOVE WELDS IN PLATE — TEST POSITIONS

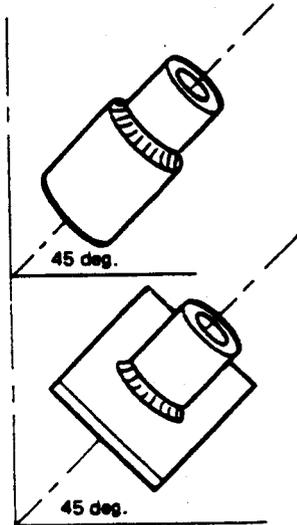


QW-461.4 GROOVE WELDS IN PIPE — TEST POSITIONS

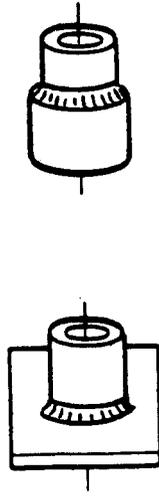


QW-461.5 FILLET WELDS IN PLATE — TEST POSITIONS

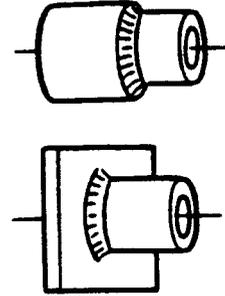
QW-461 Positions (Cont'd)



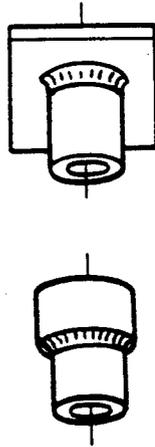
(a) 1F (Rotated)



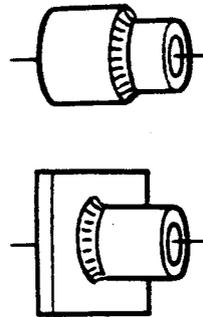
(b) 2F



(c) 2FR (Rotated)



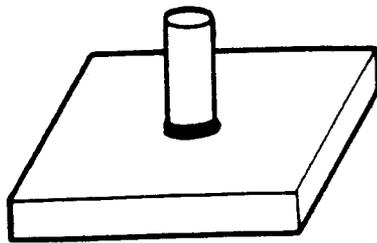
(d) 4F



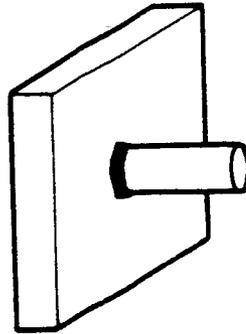
(e) 5F

QW-461.6 FILLET WELDS IN PIPE — TEST POSITIONS

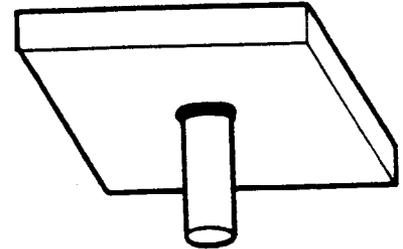
QW-461 Positions (Cont'd)



(a) 1S

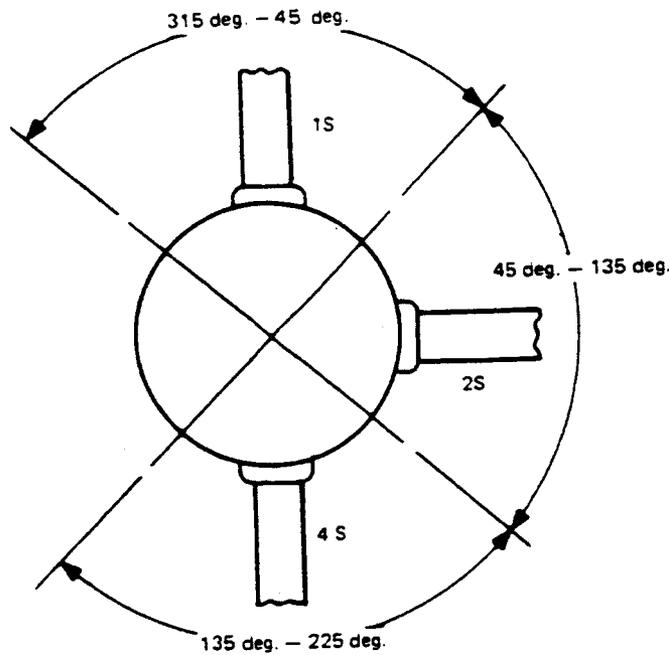


(2) 2S



(c) 4S

QW-461.7 STUD WELDS — TEST POSITIONS



QW-461.8 STUD WELDS — WELDING POSITIONS

QW-461 Positions (Cont'd)

QW-461.9
 PERFORMANCE QUALIFICATION — POSITION AND DIAMETER LIMITATIONS
 (Within the Other Limitations of QW-303)

Qualification Test		Position and Type Weld Qualified [Note (1)]		
		Groove		Fillet
Weld	Position	Plate and Pipe Over 24 in. O.D.	Pipe ≤ 24 in. O.D.	Plate and Pipe
Plate — Groove	1G	F	F [Note (2)]	F
	2G	F,H	F,H [Note (2)]	F,H
	3G	F,V	F [Note (2)]	F,H,V
	4G	F,O	F [Note (2)]	F,H,O
	3G and 4G	F,V,O	F [Note (2)]	All
	2G, 3G, and 4G Special Positions (SP)	All SP,F	F,H [Note (2)] SP,F	All SP,F
Plate — Fillet	1F	...	...	F [Note (2)]
	2F	...	...	F,H [Note (2)]
	3F	...	...	F,H,V [Note (2)]
	4F	...	...	F,H,O [Note (2)]
	3F and 4F	...	...	All [Note (2)]
	Special Positions (SP)	...	...	SP,F [Note (2)]
Pipe — Groove [Note (3)]	1G	F	F	F
	2G	F,H	F,H	F,H
	5G	F,V,O	F,V,O	All
	6G	All	All	All
	2G and 5G	All	All	All
	Special Positions (SP)	SP,F	SP,F	SP,F
Pipe — Fillet [Note (3)]	1F	...	...	F
	2F	...	...	F,H
	2FR	...	...	F,H
	4F	...	...	F,H,O
	5F	...	...	All
	Special Positions (SP)	...	...	SP,F

NOTES:

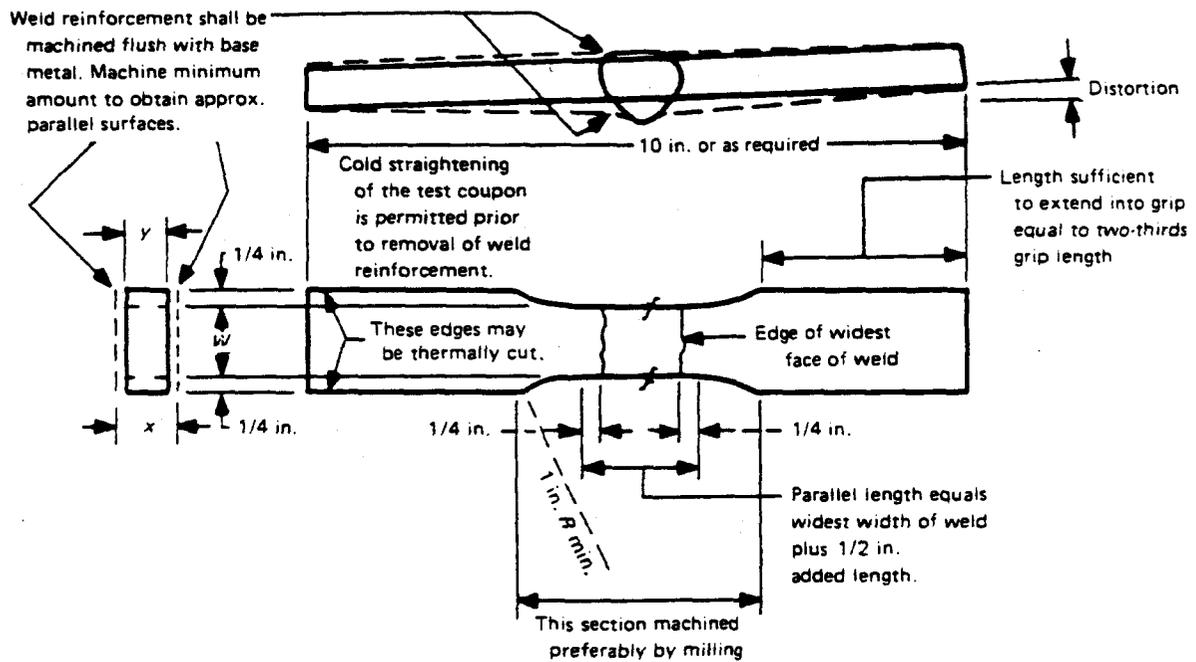
- (1) Positions of welding as shown in QW-461.1 and QW-461.2.
 F = Flat
 H = Horizontal
 V = Vertical
 O = Overhead
- (2) Pipe 2 7/8 in. O.D. and over.
- (3) See diameter restrictions in QW-452.3, QW-452.4, and QW-452.6.

QW-462 Test Specimens

The purpose of the QW-462 figures is to give the manufacturer or contractor guidance in dimensioning test specimens for tests required for procedure and performance qualifications. Unless a minimum, maximum, or tolerance is given in the figures (or as QW-150, QW-160, or QW-180 requires), the dimensions

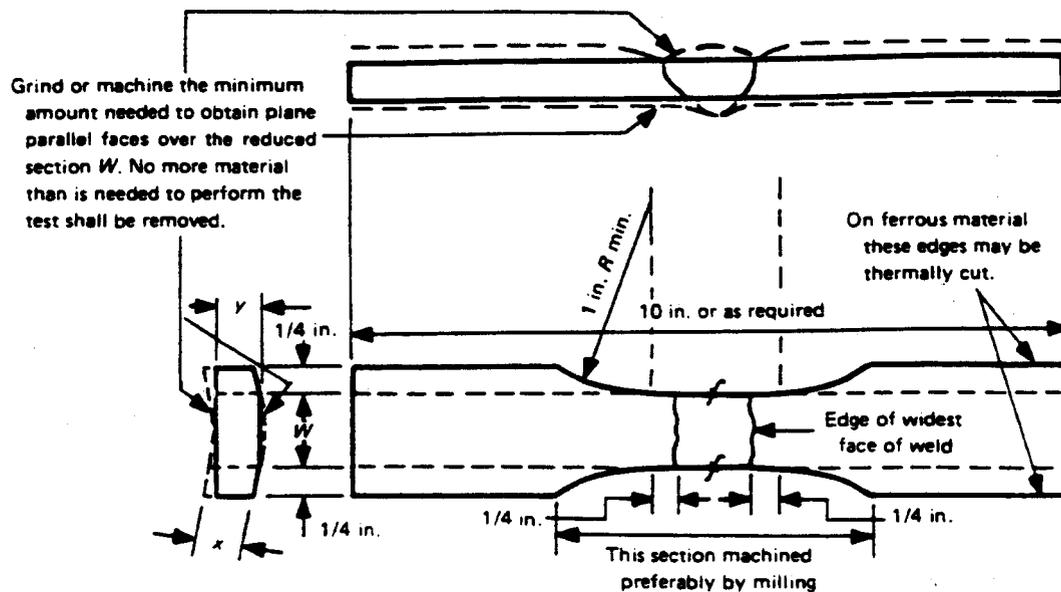
are to be considered approximate. All welding processes and filler material to be qualified must be included in the test specimen.

- x = coupon thickness including reinforcement
- y = specimen thickness
- T = coupon thickness excluding reinforcement
- W = specimen width, $\frac{3}{4}$ in.

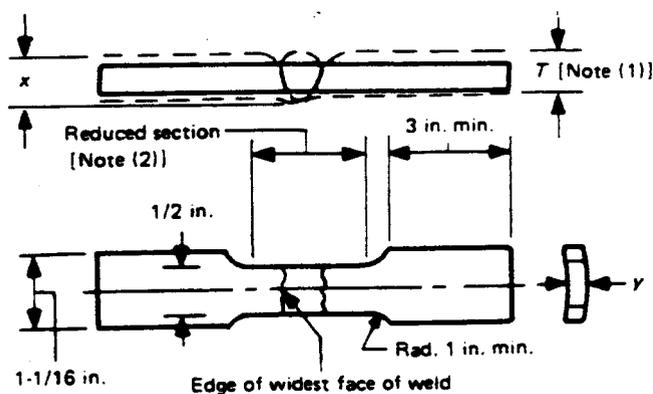


QW-462.1(a) TENSION — REDUCED SECTION — PLATE

QW-462 Test Specimens (Cont'd)



QW-462.1(b) TENSION — REDUCED SECTION — PIPE

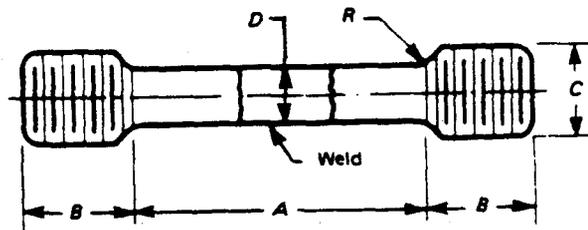


NOTES:

- (1) The weld reinforcement shall be ground or machined so that the weld thickness does not exceed the base metal thickness T . Machine minimum amount to obtain approximately parallel surfaces.
- (2) The reduced section shall not be less than the width of the weld plus $2y$.

QW-462.1(c) TENSION — REDUCED SECTION ALTERNATE FOR PIPE

QW-462 Test Specimens (Cont'd)



	Standard Dimensions, in.			
	(a) 0.505 Specimen	(b) 0.353 Specimen	(c) 0.252 Specimen	(d) 0.188 specimen
A — Length of reduced section	[Note (1)]	[Note (1)]	[Note (1)]	[Note (1)]
D — Diameter	0.500 ± 0.010	0.350 ± 0.007	0.250 ± 0.005	0.188 ± 0.003
R — Radius of fillet	3/8, min.	1/4, min.	3/16, min.	1/8, min.
B — Length of end section	1-3/8, approx.	1-1/8, approx.	7/8, approx.	1/2, approx.
C — Diameter of end section	3/4	1/2	3/8	1/4

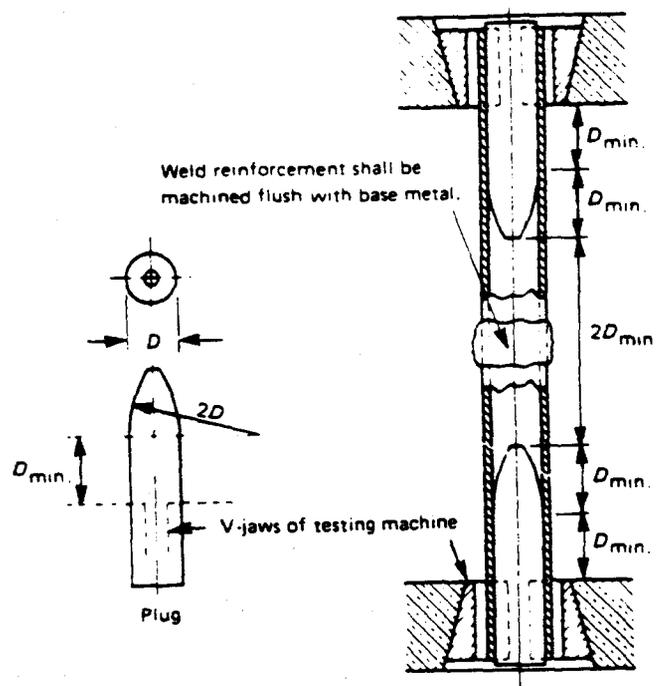
GENERAL NOTES:

- (a) Use maximum diameter specimen (a), (b), (c), or (d) that can be cut from the section.
- (b) Weld should be in center of reduced section.
- (c) Where only a single coupon is required the center of the specimen should be midway between the surfaces.
- (d) The ends may be of any shape to fit the holders of the testing machine in such a way that the load is applied axially.

NOTE:

- (1) Reduced section A should not be less than width of weld plus $2D$.

QW-462.1(d) TENSION — REDUCED SECTION — TURNED SPECIMENS



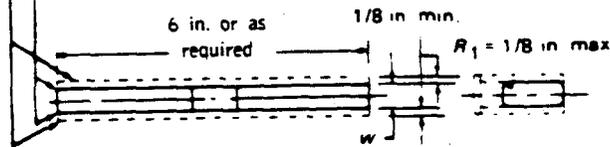
QW-462.1(e) TENSION — FULL SECTION — SMALL DIAMETER PIPE

QW-462 Test Specimens (Cont'd)

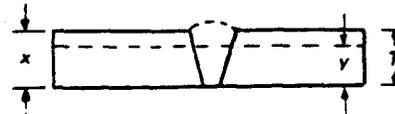
(1a) For procedure qualification of materials other than P-No. 1 in QW-422, if the surfaces of the side bend test specimens are gas cut, removal by machining or grinding of not less than 1/8 in. from the surface shall be required.

(1b) Such removal is not required for P-No. 1 materials, but any resulting roughness shall be dressed by machining or grinding.

(2) For performance qualification of all materials in QW-422, if the surfaces of side bend tests are gas cut, any resulting roughness shall be dressed by machining or grinding.



T, in.	y, in.	w (in.)	
		P-No. 23, F-No. 23, or P-No. 35	All other metals
3/8 to 1-1/2, incl.	T	1/8	3/8
> 1-1/2	[Note (1)]	1/8	3/8



GENERAL NOTE:

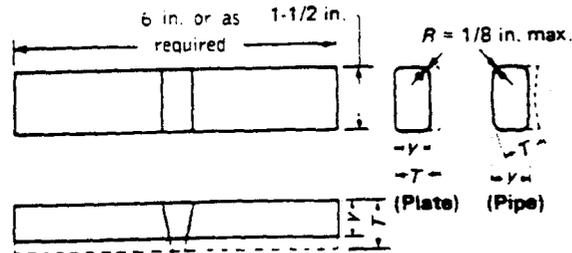
Weld reinforcement and backing strip or backing ring, if any, may be removed flush with the surface of the specimen. Thermal cutting, machining, or grinding may be employed. Cold straightening is permitted prior to removal of the reinforcement.

NOTE:

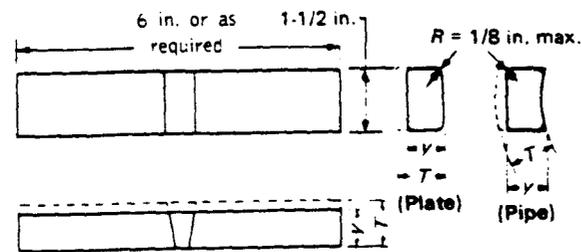
- (1) When specimen thickness *T* exceeds 1-1/2 in., use one of the following.
 - (a) Cut specimen into multiple test specimens *y* of approximately equal dimensions (3/4 in. to 1-1/2 in.).
 y = tested specimen thickness when multiple specimens are taken from one coupon
 - (b) The specimen may be bent at full width. See requirements on jig width in QW-466.1.

QW-462.2 SIDE BEND

QW-462 Test Specimens (Cont'd)



Face-bend specimen — Plate and Pipe



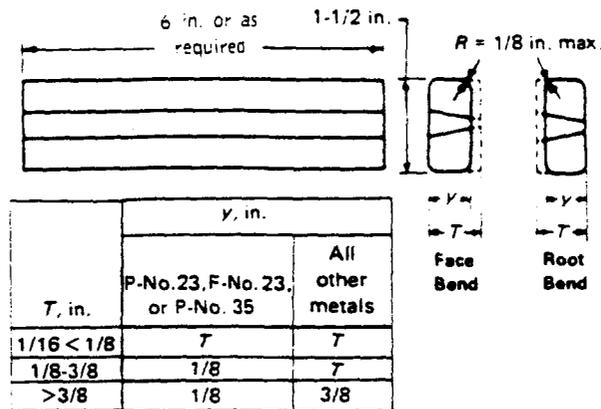
Root-bend specimens — Plate and pipe

T, in.	y, in.	
	P-No. 23, F-No. 23, or P-No. 35	All other metals
1/16 < 1/8	T	T
1/8-3/8	1/8	T
>3/8	1/8	3/8

NOTES:

- (1) Weld reinforcement and backing strip or backing ring, if any, shall be removed flush with the surface of the specimen. If a recessed ring is used, this surface of the specimen may be machined to a depth not exceeding the depth of the recess to remove the ring, except that in such cases the thickness of the finished specimen shall be that specified above. Do not flame-cut nonferrous material.
- (2) If the pipe being tested is 4 in. nominal diameter or less, the width of the bend specimen may be 3/4 in. for pipe diameters 2 in. to and including 4 in. The bend specimen width may be 3/8 in. for pipe diameters less than 2 in. down to and including 3/8 in. and as an alternative, if the pipe being tested is equal to or less than 1 in. nominal pipe size (1.315 in. O. D.), the width of the bend specimens may be that obtained by cutting the pipe into quarter sections, less an allowance for saw cuts or machine cutting. These specimens cut into quarter sections are not required to have one surface machined flat as shown in QW-462.3(a). Bend specimens taken from tubing of comparable sizes may be handled in a similar manner.

QW-462.3(a) FACE AND ROOT BENDS — TRANSVERSE^{1,2}



T, in.	y, in.	
	P-No. 23, F-No. 23, or P-No. 35	All other metals
1/16 < 1/8	T	T
1/8-3/8	1/8	T
>3/8	1/8	3/8

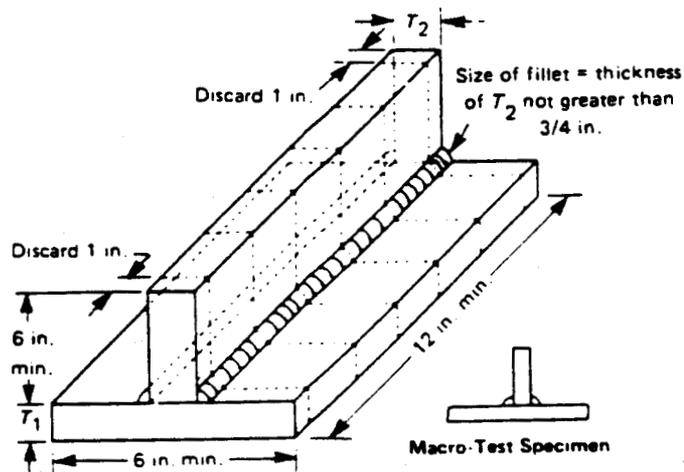
NOTE:

- (1) Weld reinforcements and backing strip or backing ring, if any, shall be removed essentially flush with the undisturbed surface of the base material. If a recessed strip is used, this surface of the specimen may be machined to a depth not exceeding the depth of the recess to remove the strip, except that in such cases the thickness of the finished specimen shall be that specified above.

QW-462.3(b) FACE AND ROOT BENDS — LONGITUDINAL¹

QW-462 Test Specimens (Cont'd)

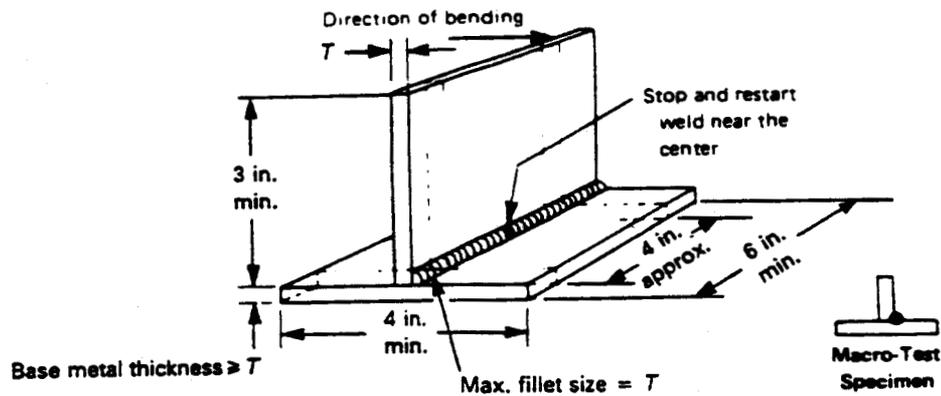
T_1	T_2
$\frac{1}{8}$ in. and less	T_1
Over $\frac{1}{8}$ in.	Equal to or less than T_1 but not less than $\frac{1}{8}$ in.



GENERAL NOTE:

Macro test - The fillet shall show fusion at the root of the weld but not necessarily beyond the root. The weld metal and heat affected zone shall be free of cracks.

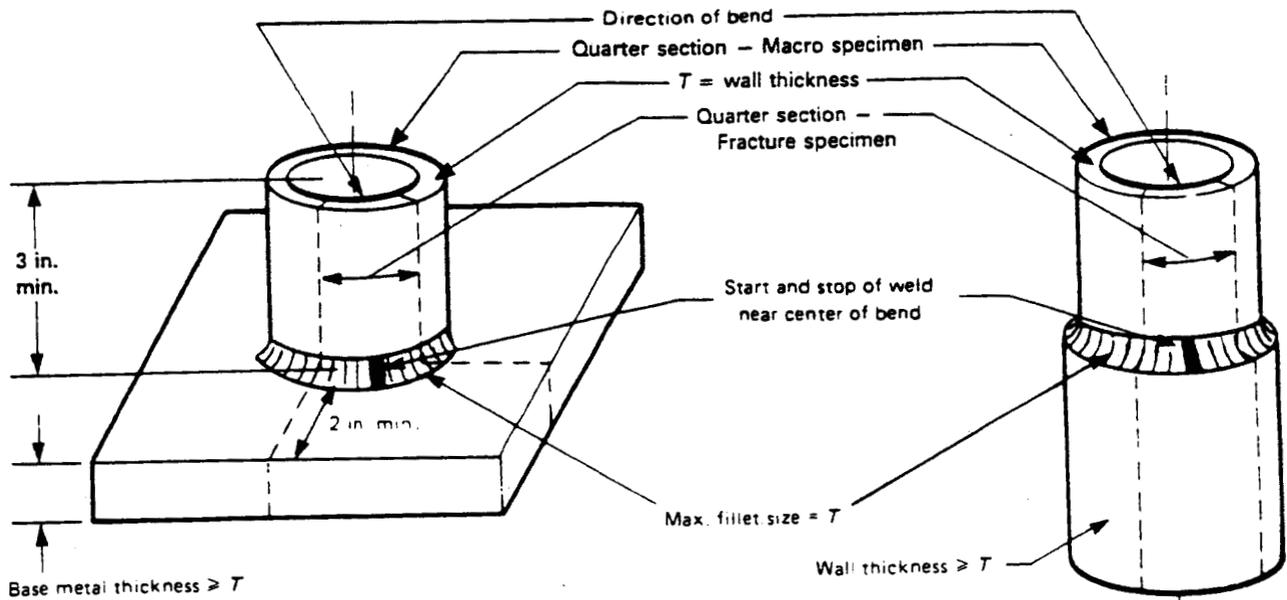
QW-462.4(a) FILLET WELDS — PROCEDURE



GENERAL NOTE: Refer to QW-452.5 for T thickness/qualification ranges.

QW-462.4(b) FILLET WELDS — PERFORMANCE

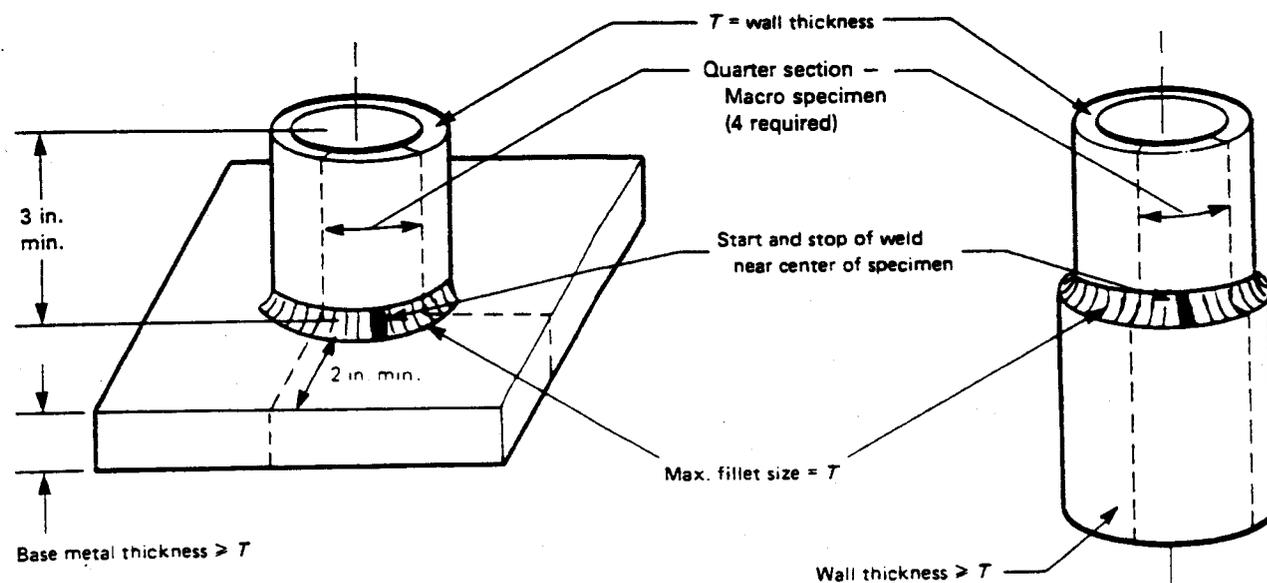
QW-462 Test Specimens (Cont'd)



GENERAL NOTE: Either pipe-to-plate or pipe-to-pipe may be used as shown.

QW-462.4(c) FILLET WELDS IN PIPE — PERFORMANCE

QW-462 Test Specimens (Cont'd)



GENERAL NOTES:

- (1) Either pipe-to-plate or pipe-to-pipe may be used as shown.
- (2) Macro test:
 - (a) The fillet shall show fusion at the root of the weld but not necessarily beyond the root.
 - (b) The weld metal and the heat affected zone shall be free of cracks.

QW-462.4(d) FILLET WELDS IN PIPE — PROCEDURE

QW-463 Order of Removal

Discard		this piece
Reduced section		tensile specimen
Root bend		specimen
Face bend		specimen
Root bend		specimen
Face bend		specimen
Reduced section		tensile specimen
Discard		this piece

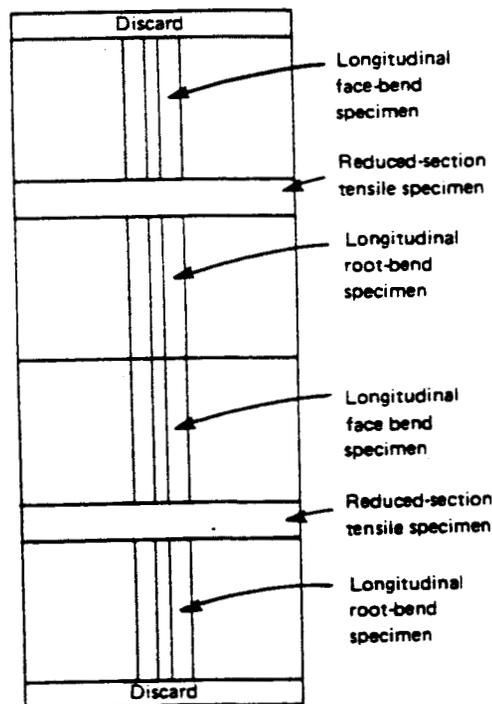
Discard		this piece
Side bend		specimen
Reduced section		tensile specimen
Side bend		specimen
Side bend		specimen
Reduced section		tensile specimen
Side bend		specimen
Discard		this piece



QW-463.1(a) PLATES — LESS THAN 3/4 IN. THICKNESS PROCEDURE QUALIFICATION

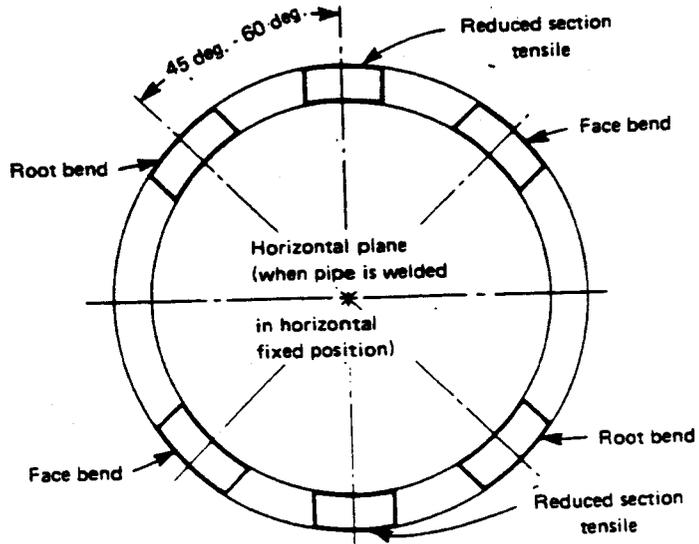


QW-463.1(b) PLATES — 3/4 IN. AND OVER THICKNESS AND ALTERNATE FROM 3/8 IN. BUT LESS THAN 3/4 IN. THICKNESS PROCEDURE QUALIFICATION

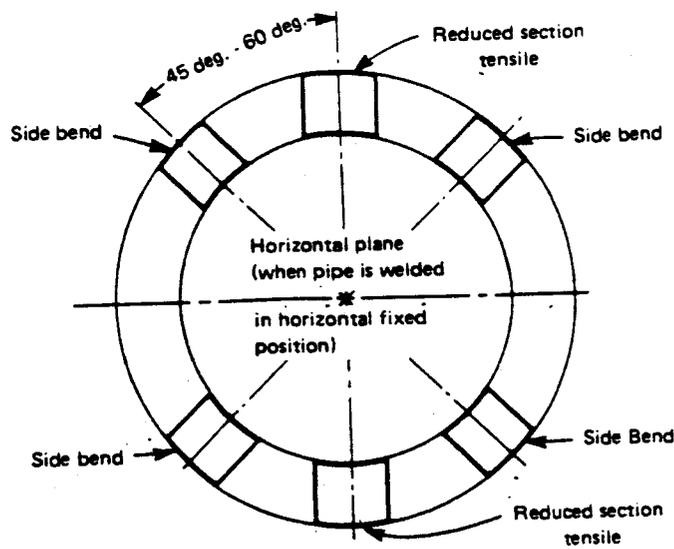


QW-463.1(c) PLATES — LONGITUDINAL PROCEDURE QUALIFICATION

QW-463 Order of Removal (Cont'd)

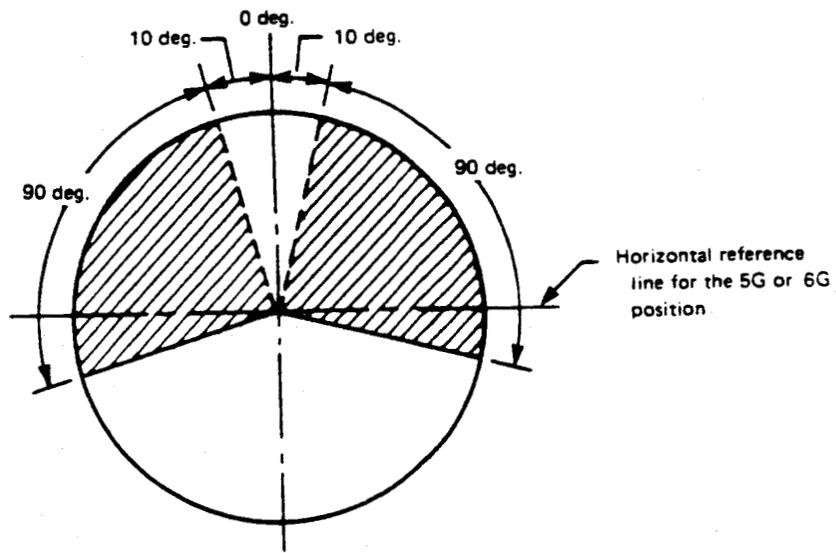


QW-463.1(d) PROCEDURE QUALIFICATION



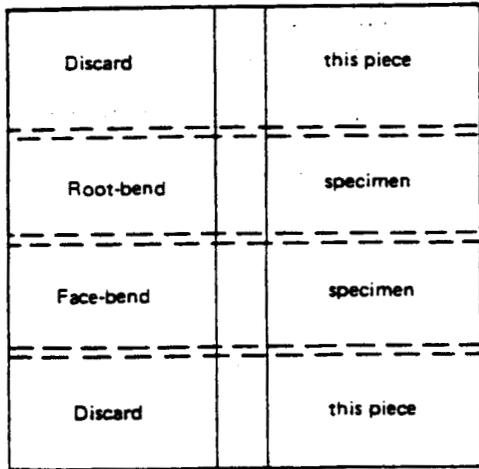
QW-463.1(e) PROCEDURE QUALIFICATION

QW-463 Order of Removal (Cont'd)

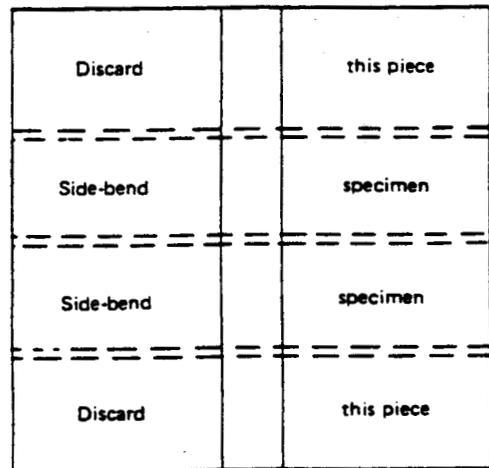


QW-463.1(f) NOTCH-TOUGHNESS TEST SPECIMEN LOCATION

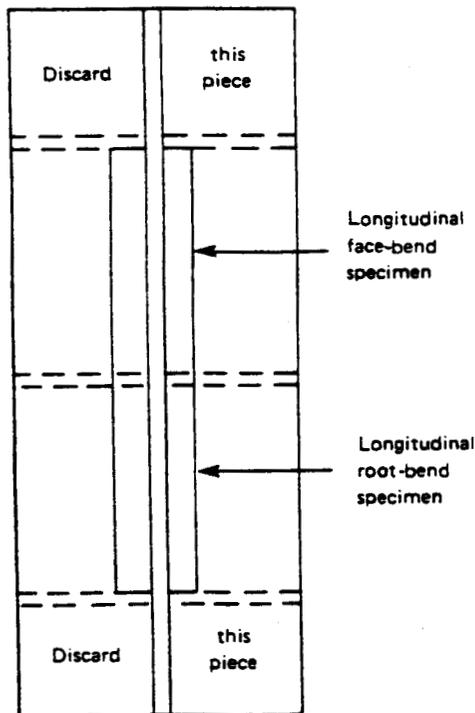
QW-463 Order of Removal (Cont'd)



QW-463.2(a) PLATES — LESS THAN 3/4 IN. THICKNESS PERFORMANCE QUALIFICATION

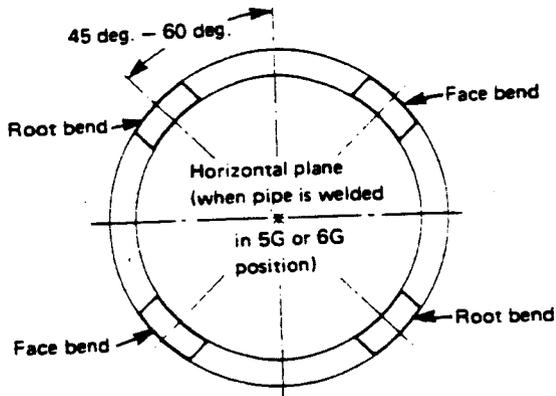


QW-463.2(b) PLATES — 3/4 IN. AND OVER THICKNESS AND ALTERNATE FROM 3/8 IN. BUT LESS THAN 3/4 IN. THICKNESS PERFORMANCE QUALIFICATION

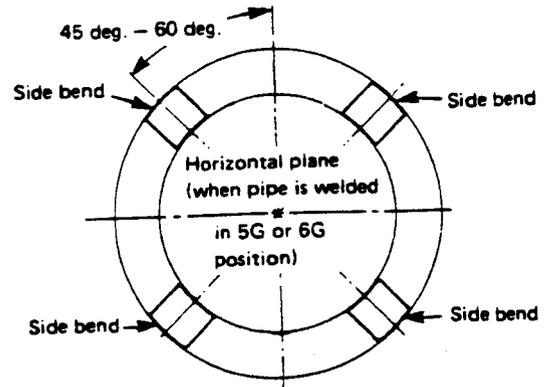


QW-463.2(c) PLATES — LONGITUDINAL PERFORMANCE QUALIFICATION

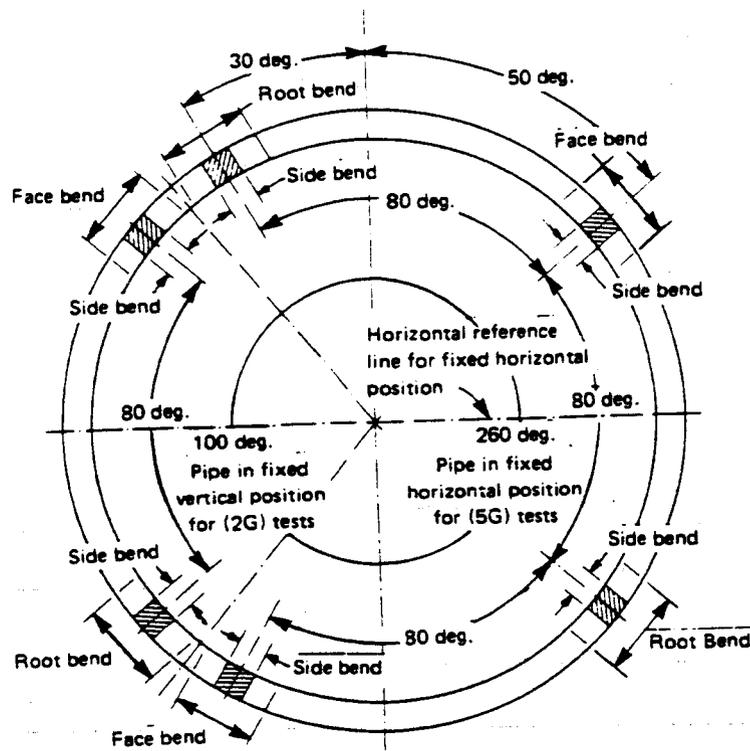
QW-463 Order of Removal (Cont'd)



QW-463.2(d) PERFORMANCE QUALIFICATION

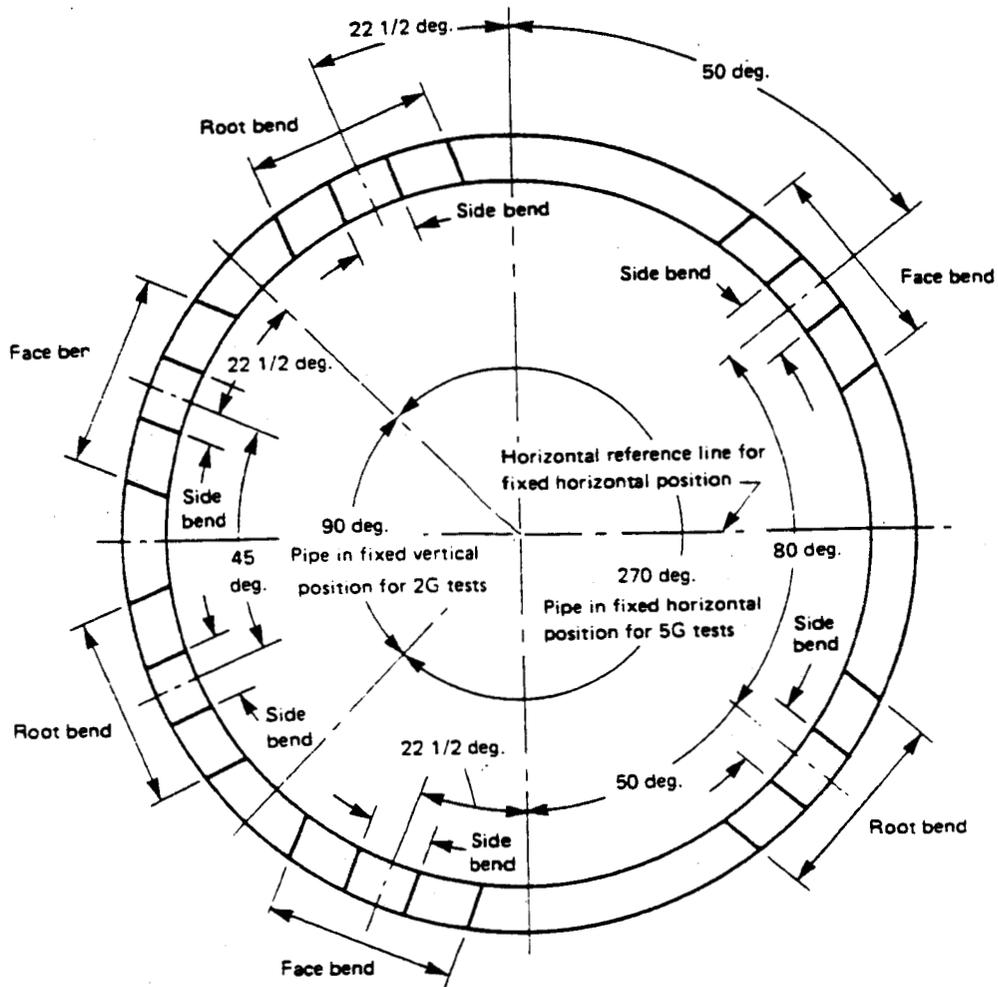


QW-463.2(e) PERFORMANCE QUALIFICATION



QW-463.2(f) PIPE — 10 IN. ASSEMBLY PERFORMANCE QUALIFICATION

QW-463 Order of Removal (Cont'd)

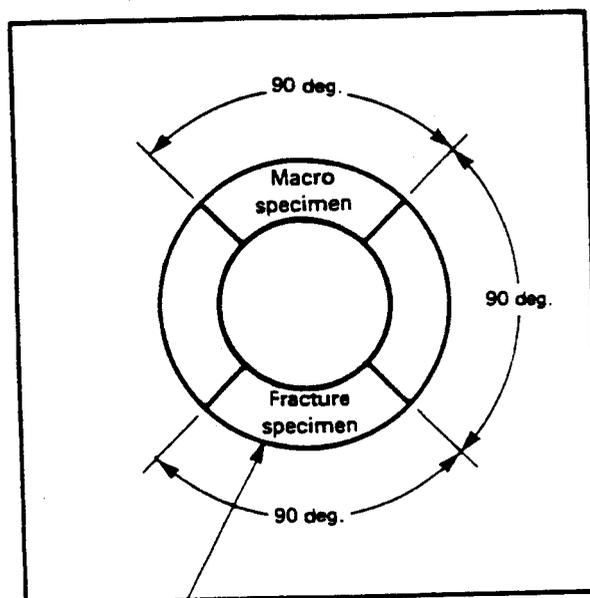


GENERAL NOTE:

When side bend tests are made in accordance with QW-452.1 and QW-452.3, they shall be removed as shown in QW-463.2(g) in place of the face and root bends

QW-463.2(g) 6 IN. OR 8 IN. ASSEMBLY PERFORMANCE QUALIFICATION

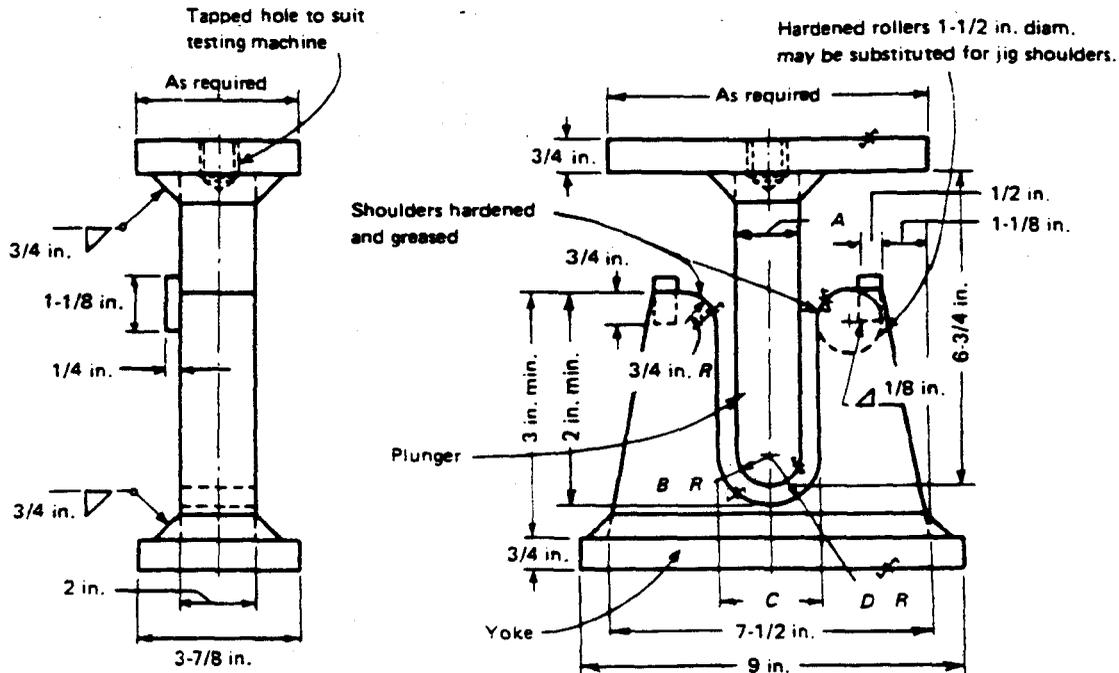
QW-463 Order of Removal (Cont'd)



Fracture specimen to be removed from lower 90 deg. section in position 5 f

QW-463.2(h) PERFORMANCE QUALIFICATION

QW-466 Test Jigs



Material	Thickness of Specimen, in.	A, in.	B, in.	C, in.	D, in.
P-No. 23 to P-No. 2X; P-No. 2X with F-No. 23; P-No. 35; P-No. XX with F-No. 36	1/8 $t = 1/8$ or less	2-1/16 16-1/2t	1-1/32 8-1/4t	2-3/8 18-1/2t + 1/16	1-3/16 9-1/4t + 1/32
P-No. 11, P-No. 25 to P-No. 21 or P-No. 22 or P-No. 25	3/8 $t = 3/8$ or less	2-1/2 6-2/3t	1-1/4 3-1/3t	3-3/8 8-2/3t + 1/8	1-11/16 4-1/3t + 1/16
P-No. 51	3/8 $t = 3/8$ or less	3 8t	1-1/2 4t	3-7/8 10t + 1/8	1-15/16 5t + 1/16
P-No. 52, P-No. 53, P-No. 61, P-No. 62	3/8 $t = 3/8$ or less	3-3/4 10t	1-7/8 5t	4-5/8 12t + 1/8	2-5/16 6t + 1/16
All others with greater than or equal to 20% elongation	3/8 $t = 3/8$ or less	1-1/2 4t	3/4 2t	2-3/8 6t + 1/8	1-3/16 3t + 1/16
All others with less than 20% elongation	$t =$ (see Note b)	32-7/8t, max.	16-7/16t, max.	34-7/8t + 1/16, max.	17-7/16t + 1/32, max.

GENERAL NOTES:

(a) For P-Numbers, see QW-422; for F-Numbers, see QW-432.

(b) The dimensions of the test jig shall be such as to give the bend test specimen a calculated percent outer fiber elongation equal to at least that of the base material with the lower minimum elongation as specified in the base material specification.

$$\text{percent outer fiber elongation} = \frac{100t}{A + t}$$

The following formula is provided for convenience in calculating the bend specimen thickness:

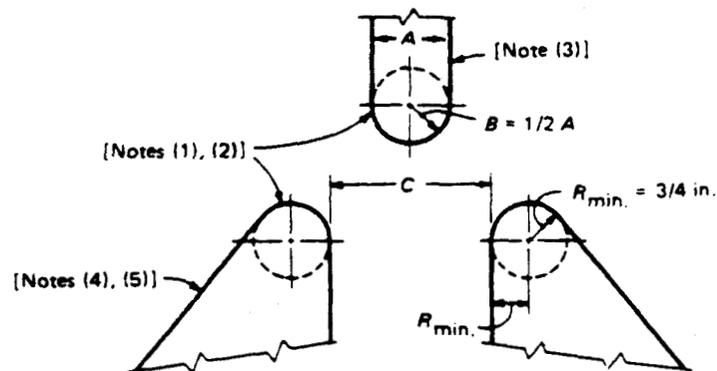
$$\text{thickness of specimen } (t) = \frac{A \times \text{percent elongation}}{[100 - (\text{percent elongation})]}$$

(c) For guided-bend jig configuration, see QW-466.2, QW-466.3, and QW-466.4.

(d) The weld and heat affected zone, in the case of a transverse weld bend specimen, shall be completely within the bend portion of the specimen after testing.

QW-466.1 TEST JIG DIMENSIONS

QW-466 Test Jigs (Cont'd)



GENERAL NOTE:

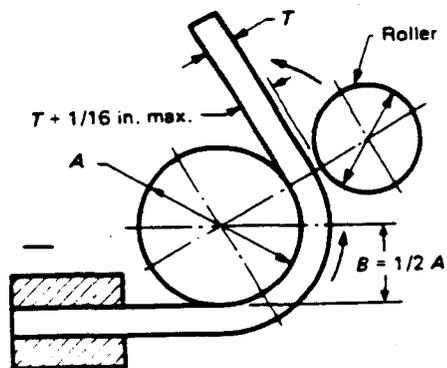
See Table QW-466.1 for jig dimensions and general notes.

NOTES:

- (1) Either hardened and greased shoulders or hardened rollers free to rotate shall be used.
- (2) The shoulders or rollers shall have a minimum bearing surface of 2 in. for placement of the specimen. The rollers shall be high enough above the bottom of the jig so that the specimens will clear the rollers when the ram is in the low position.
- (3) The ram shall be fitted with an appropriate base and provision made for attachment to the testing machine, and shall be of a sufficiently rigid design to prevent deflection and misalignment while making the bend test. The body of the ram may be less than the dimensions shown in column A.
- (4) If desired, either the rollers or the roller supports may be made adjustable in the horizontal direction so that specimens of t thickness may be tested on the same jig.
- (5) The roller supports shall be fitted with an appropriate base designed to safeguard against deflection or misalignment and equipped with means for maintaining the rollers centered midpoint and aligned with respect to the ram.

QW-466.2 GUIDED-BEND ROLLER JIG

QW-466 Test Jigs (Cont'd)

**GENERAL NOTES:**

- (a) See Table QW-466.1 for jig dimensions and other general notes.
- (b) Dimensions not shown are the option of the designer. The essential consideration is to have adequate rigidity so that the jig parts will not spring.
- (c) The specimen shall be firmly clamped on one end so that there is no sliding of the specimen during the bending operation.
- (d) Test specimens shall be removed from the jig when the outer roll has been removed 180 deg. from the starting point.

QW-466.3 GUIDED-BEND WRAP AROUND JIG

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ASME Boiler and Pressure Vessel Code
SECTION IX

INTERPRETATIONS
Volume 44

The Interpretations to the Code will be issued twice a year (July and December) up to the publication of the 2001 Edition of the Code. The Interpretations for each individual Section are published separately and are part of the update service to that Section; Interpretations of Section III, Divisions 1 and 2, are part of the update service to Section III, Subsection NCA.

Interpretations Volumes 36 through 41 were included with the update service to the 1995 Edition of the Code; Volume 42 is the first Interpretations volume to be included with the update service to the 1998 Edition.

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INTERPRETATIONS

NO. 44 — SECTION IX

Replies to Technical Inquiries
July 1, 1998 through December 31, 1998

FOREWORD

General Information

This publication includes all written interpretations issued between the indicated dates by the ASME Staff on behalf of the ASME Boiler and Pressure Vessel Committee in response to inquiries concerning interpretations of the ASME Boiler and Pressure Vessel Code. A contents is also included which lists subjects specific to the interpretations covered in the individual volume.

These interpretations are taken verbatim from the original letters, except for a few typographical and editorial corrections made for the purpose of improved clarity. In some instances, a review of the interpretation revealed a need for corrections of a technical nature. In these cases, a revised interpretation is presented bearing the original Interpretation Number with the suffix R and the original file number with an asterisk. Following these revised interpretations, new interpretations and revisions to them issued during the indicated dates are assigned Interpretation Numbers in chronological order. Interpretations applying to more than one Code Section appear with the interpretations for each affected Section.

ASME procedures provide for reconsideration of these interpretations when or if additional information is available which the inquirer believes might affect the interpretation. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME committee or subcommittee. As stated in the Statement of Policy in the Code documents, ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

An interpretation applies either to the Edition and Addenda in effect on the date of issuance of the interpretation or the Edition and Addenda stated in the interpretation. Subsequent revisions to the Code may supersede the interpretation.

For detailed instructions on preparation of technical inquiries to the ASME Boiler and Pressure Vessel Committee, refer to Appendix A.

Subject and Numerical Indexes

Subject and numerical indexes have been prepared to assist the user in locating interpretations by subject matter or by location in the Code. They cover interpretations issued from Volume 12 up to and including the present volume, and will be updated with each volume.

SECTION IX

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QW-200.1, Welding Procedure Qualifications	IX-98-13	BC98-239
QW-300, Welding Performance Qualifications	IX-98-11	BC98-133
QW-361.2, Machine Welding Variables for Welding Operators; and QW-381, Corrosion-Resistant Weld Metal Overlay	IX-98-14	BC98-447
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QW-407.1, Post Weld Heat Treatment	IX-98-10	BC97-306
		BC97-308
QW-451, Procedure Qualification Thickness Limits and Test Specimens	IX-98-12	BC98-237
		BC98-238
QW-462.5(a), Chemical Analysis and Hardness Specimen Corrosion-Resistant and Hardfacing Weld Metal Overlay	IX-98-16	BC98-453

Interpretation: IX-98-09

Subject: Section IX, QW-150 and QW-462.1, Tension Test Specimens for Pipe and Plate

Date Issued: October 9, 1998

File: BC97-302

Question: Would tensile tests performed in accordance with SA-370 be acceptable for meeting ASME Section IX, QW-462.1(a) and (b)?

Reply: No.

Interpretation: IX-98-10

Subject: Section IX, QW-407.1, Post Weld Heat Treatment

Date Issued: October 9, 1998

File: BC97-306/BC97-308

Question: Is it the intent of Section IX in QW-407.1 to permit reporting the results of more than one PWHT condition on a single report, with a single PQR number, provided all other applicable essential and supplementary essential variables are identical and all required tests are conducted and reported for both conditions?

Reply: Yes.

Interpretation: IX-98-11

Subject: Section IX, QW-300, Welding Performance Qualifications

Date Issued: October 9, 1998

File: BC98-133

Question: May Company A retain the Company B employee responsible for welder performance qualification to review the welder qualification documents of both companies and qualify the welders of Company B to the welding program of Company A without further testing of the welders?

Reply: No.

Interpretation: IX-98-14

Subject: Section IX, QW-361.2, Machine Welding Variables for Welding Operators; and QW-381, Corrosion-Resistant Weld Metal Overlay

Date Issued: December 22, 1998

File: BC98-447

Background: A multiple layer corrosion-resistant weld metal overlay performance qualification (machine welding) is made with the first layer under Direct Visual control and the second layer Remote Visual control.

Question (1): Is the welding operator qualified for both Direct and Remote Visual control techniques applied either in single or multiple layers?

Reply (1): Yes.

Question (2): For the qualification described in the background, may two welding operators qualify on one coupon, provided the requirements of QW-453 and QW-361.2 (which delineate the welding operators "limits of qualification" as per QW-306) are addressed?

Reply (2): Yes.

Interpretation: IX-98-15

Subject: Section IX, QW-405.3, Positions

Date Issued: December 22, 1998

File: BC98-448

Question: May a single-pass "seal weld" as defined in QW-492, used to seal boiler tubes to a boiler tube sheet, be considered a "cover pass" or a "wash pass" for purposes of exemption from QW-405.3?

Reply: No.

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ASME BOILER AND PRESSURE VESSEL CODE
AN INTERNATIONAL CODE

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

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
NEW YORK, NEW YORK



Q090W9

IX

1999 Addenda
July 1, 1999

ASME BOILER AND
PRESSURE VESSEL
COMMITTEE
SUBCOMMITTEE ON
WELDING

SUMMARY OF CHANGES

Addenda to the 1998 Edition of the Code are issued in the form of replacement pages. Revisions, additions, or deletions are incorporated directly into the affected pages. It is advisable, however, that all replaced pages be retained for reference.

Replace or insert the pages listed. Changes given below are identified on the pages by a margin note, **A99**, placed next to the affected area. Revisions to the 1998 Edition are indicated by **98**. For the listing below, the *Page* references the affected area. A margin note, **A99**, placed next to the heading indicates *Location*. Revisions are listed under *Change*.

<i>Page</i>	<i>Location</i>	<i>Change</i>
iii	Listing of Sections	Title to Section III, Division 3 revised
v, vii	Contents	Updated to reflect A99
xv, xvi	Guideline	Deleted by errata
xvii-xxvi	Roster	Updated to reflect A99
2	QW-102	Revised
	QW-103.2	Last line corrected by errata
5	QW-153.1	First sentence revised
	QW-153.1.1	Subparagraph (b) revised
15	QW-201	Second paragraph revised
16	QW-202.4	Last paragraph revised
21	QW-253	Under Nonessential, last entry added by errata
27	QW-255	Under Brief of Variables, last entry corrected by errata
45	QW-284	Revised
49	QW-304	First paragraph revised
50	QW-305	First paragraph revised
55	QW-384	Revised
63	QW-407.1	First sentence revised
	QW-407.2	First sentence revised
	QW-407.4	Revised
	QW-407.5	First sentence revised
64	QW-408.2	First sentence revised
	QW-408.8	Revised
	QW-408.9	Revised
	QW-408.10	Revised
66	QW-410.11	Revised
69	QW-420.1	Paragraph below in-text table revised
	QW-420.2	First and second paragraphs revised
70-124	QW/QB-422	Revised
125	QW-423.1	In-text table revised
126-128	QW-432	Revised
133	QW-451.3	Note revised
159	QW-462.10	Main column head revised
160	QW-462.11	Main column head revised

1998 ASME BOILER AND PRESSURE VESSEL CODE

A99

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- I Rules for Construction of Power Boilers
- II Materials
 - Part A — Ferrous Material Specifications
 - Part B — Nonferrous Material Specifications
 - Part C — Specifications for Welding Rods, Electrodes, and Filler Metals
 - Part D — Properties
- III Subsection NCA — General Requirements for Division 1 and Division 2
- III Division 1
 - Subsection NB — Class 1 Components
 - Subsection NC — Class 2 Components
 - Subsection ND — Class 3 Components
 - Subsection NE — Class MC Components
 - Subsection NF — Supports
 - Subsection NG — Core Support Structures
 - Subsection NH — Class 1 Components in Elevated Temperature Service
 - Appendices
- III Division 2 — Code for Concrete Reactor Vessels and Containments
- III Division 3 — Containment Systems for Storage and Transport Packagings of Spent Nuclear Fuel and High Level Radioactive Material and Waste
- IV Rules for Construction of Heating Boilers
- V Nondestructive Examination
- VI Recommended Rules for the Care and Operation of Heating Boilers
- VII Recommended Guidelines for the Care of Power Boilers
- VIII Rules for Construction of Pressure Vessels
 - Division 1
 - Division 2 — Alternative Rules
 - Division 3 — Alternative Rules for Construction of High Pressure Vessels
- IX Welding and Brazing Qualifications
- X Fiber-Reinforced Plastic Pressure Vessels
- XI Rules for Inservice Inspection of Nuclear Power Plant Components

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 2001 Code. The 1998 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 2001 Code. Interpretations of Section III, Divisions 1 and 2, will be included with the update service to Subsection NCA.

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 1998 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 2001 Code.

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**GUIDELINE ON THE APPROVAL OF NEW WELDING
AND BRAZING MATERIAL CLASSIFICATIONS
UNDER THE ASME BOILER AND
PRESSURE VESSEL CODE**

98
A99

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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.

QW-100.1 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 providing 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. That is, the welding procedure qualification test establishes the properties of the weldment, not the skill of the welder or welding operator. In addition to this general requirement, special considerations for notch toughness are required by other Sections of the Code. Briefly, a WPS lists the variables, both essential and nonessential, and the acceptable ranges of these variables when using the WPS. The WPS is intended to provide direction for the welder/welding operator. The PQR lists what was used in qualifying the WPS and the test results.

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-153 Acceptance Criteria — Tension Tests

A99

QW-153.1 Tensile Strength. Except for P-No. 21 through P-No. 25 and P-No. 35 materials, minimum values are provided under the column heading "Minimum Specified Tensile, ksi" of 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 fusion line, 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.

A99

QW-153.1.1 Additional Requirements for Specific Base Metals

(a) For Aluminum Alclad materials 0.499 in. and less, the specified minimum tensile strength is for full thickness specimens that include cladding. For Aluminum Alclad materials 0.5 in. and greater, the specified minimum tensile strength is for both full thickness specimens that include cladding and specimens taken from the core.

(b) For copper and copper-based alloys, the minimum specified tensile value provided by QW/QB-422 is that given for the base metal in the annealed condition and is the acceptance value for qualification.

(c) All P-No. 23 minimum specified tensile values, provided by QW/QB-422, are not designated in the respective SB documents and are the acceptance values for qualifications using T4 or T6 temper base metal and tested in the as-welded condition.

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 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 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 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 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 QW-462.3(a).

QW-161.5 Longitudinal-Bend Tests. Longitudinal-bend tests may be used in lieu of the transverse side-, face-, 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 QW-462.3(b).

production joint. Each procedure may include one or a combination of processes, filler metals, or other variables.

Where two or more procedures involving different processes or other essential variables are used in one joint, QW-451 shall be used to determine the range of base metal thickness qualified and the maximum thickness of deposited weld metal qualified for each process or procedure. Alternatively, qualification for root deposits only may be made in accordance with QW-200.4(b). The deposited weld metal of each process or procedure shall be included in the tension and bend specimens, and in the notch-toughness specimen (when required). One or more processes or procedures may be deleted from a qualified combination procedure. Each such process or procedure may be used separately provided:

(1) the remaining essential, nonessential, and supplementary essential variables are applied;

(2) the base metal and deposited weld metal thickness limits of QW-451 are applied.

(b) For GTAW, SMAW, GMAW, PAW, and SAW, or combinations of these processes, a PQR for a process recording a test coupon that was at least 1/2 in. (13 mm) thick may be combined with one or more other PQRs recording another welding process and any greater base metal thickness. In this case, the process recorded on the first PQR may be used to deposit the root layers using the process(es) recorded on that PQR up to 2t (for short-circuiting type of GMAW, see QW-404.32) in thickness on base metal of the maximum thickness qualified by the other PQR(s) used to support the WPS. The requirements of Note (1) of QW-451.1 and QW-451.2 shall apply.

A99 QW-201 Manufacturer's or Contractor's Responsibility

Each manufacturer or contractor shall list the parameters applicable to welding that he performs in construction of weldments built in accordance with this Code. These parameters shall be listed in a document known as a Welding Procedure Specification (WPS).

Each manufacturer or contractor shall qualify the WPS by the welding of test coupons and the testing of specimens (as required in this Code), and the recording of the welding data and test results in a document known as a Procedure Qualification Record (PQR). The welders or welding operators used to produce weldments to be tested for qualification of procedures shall be under the full supervision and control of the manufacturer or contractor during the production of these test weldments. The weldments to be tested for qualification of procedures shall be welded either

by direct employees or by individuals engaged by contract for their services as welders or welding operators under the full supervision and control of the manufacturer or contractor. It is not permissible for the manufacturer or contractor to have the supervision and control of welding of the test weldments performed by another organization. It is permissible, however, to subcontract any or all of the work of preparation of test metal for welding and subsequent work on preparation of test specimens from the completed weldment, performance of nondestructive examination, and mechanical tests, provided the manufacturer or contractor accepts the responsibility for any such work.

The Code recognizes a manufacturer or contractor as the organization which has responsible operational control of the production of the weldments to be made in accordance with this Code. If in an organization effective operational control of welding procedure qualification for two or more companies of different names exists, the companies involved shall describe in their Quality Control system/Quality Assurance Program, the operational control of procedure qualifications. In this case separate welding procedure qualifications are not required, provided all other requirements of Section IX are met.

A WPS may require the support of more than one PQR, while alternatively, one PQR may support a number of WPSs.

The manufacturer or contractor shall certify that he has qualified each Welding Procedure Specification, performed the procedure qualification test, and documented it with the necessary Procedure Qualification Record (PQR).

QW-201.1 The Code recognizes that manufacturers or contractors may maintain effective operational control of PQRs and WPSs under different ownership than existed during the original procedure qualification. When a manufacturer or contractor or part of a manufacturer or contractor is acquired by a new owner(s), the PQRs and WPSs may be used by the new owner(s) without requalification, provided all of the following are met:

(a) the new owner(s) takes responsibility for the WPSs and PQRs;

(b) the WPSs reflect the name of the new owner(s);

(c) the Quality Control System/Quality Assurance Program reflects the source of the PQRs as being from the former manufacturer or contractor.

QW-202 Type of Tests Required

QW-202.1 Mechanical Tests. The type and number of test specimens which shall be tested to qualify a groove weld procedure are given in QW-451, and shall

QW-253
WELDING VARIABLES PROCEDURE SPECIFICATIONS (WPS)
Shielded Metal-Arc (SMAW)

Paragraph	Brief of Variables	Essential	Supplementary Essential	Nonessential
QW-402 Joints	.1 ϕ Groove design			X
	.4 - Backing			X
	.10 ϕ Root spacing			X
	.11 \pm Retainers			X
QW-403 Base Metals	.5 ϕ Group Number		X	
	.6 T Limits impact		X	
	.7 T/t Limits > 8 in.	X		
	.8 ϕ T Qualified	X		
	.9 t Pass > 1/2 in.	X		
	.11 ϕ P-No. qualified	X		
	.13 ϕ P-No. 5/9/10	X		
QW-404 Filler Metals	.4 ϕ F-Number	X		
	.5 ϕ A-Number	X		
	.6 ϕ Diameter			X
	.7 ϕ Diam. > 1/4 in.		X	
	.12 ϕ AWS class.		X	
	.30 ϕ t	X		
	.33 ϕ AWS class.			X
QW-405 Positions	.1 + Position			X
	.2 ϕ Position		X	
	.3 ϕ \updownarrow Vertical welding			X
QW-406 Preheat	.1 Decrease > 100°F	X		
	.2 ϕ Preheat maint.			X
	.3 Increase > 100°F (IP)		X	
QW-407 PWHT	.1 ϕ PWHT	X		
	.2 ϕ PWHT (T & T range)		X	
	.4 T Limits	X		
QW-409 Electrical Characteristics	.1 > Heat input		X	
	.4 ϕ Current or polarity		X	X
	.8 ϕ I & E range			X
QW-410 Technique	.1 ϕ String/weave			X
	.5 ϕ Method cleaning			X
	.6 ϕ Method back gouge			X
	.25 ϕ Manual or automatic			X
	.26 \pm Peening			X

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PROCEDURE QUALIFICATIONS

QW-255

QW-255 (CONT'D)
 WELDING VARIABLES PROCEDURE SPECIFICATIONS (WPS)
 Gas Metal-Arc Welding (GMAW and FCAW)

Paragraph	Brief of Variables	Essential	Supplementary Essential	Nonessential
QW-408 Gas	.1 ± Trail or ϕ comp.			X
	.2 ϕ Single, mixture, or %	X		
	.3 ϕ Flow rate			X
	.5 ± or ϕ Backing flow			X
	.9 - Backing or ϕ comp.	X		
	.10 ϕ Shielding or trailing	X		
QW-409 Electrical Characteristics	.1 > Heat input		X	
	.2 ϕ Transfer mode	X		
	.4 ϕ Current or polarity		X	X
	.8 ϕ I & E range			X
QW-410 Technique	.1 ϕ String/weave			X
	.3 ϕ Orifice, cup, or nozzle size			X
	.5 ϕ Method cleaning			X
	.6 ϕ Method back gouge			X
	.7 ϕ Oscillation			X
	.8 ϕ Tube-work distance			X
	.9 ϕ Multi to single pass/side		X	X
	.10 ϕ Single to multi electrodes		X	X
	.15 ϕ Electrode spacing			X
	.25 ϕ Manual or automatic			X
.26 ± Peening			X	

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QW-283 Welds With Buttering

QW-283.1 Scope. This paragraph only applies when the essential variables for the buttering process are different than the essential variables for the process used for subsequent completion of the joint. Common examples are:

- (1) the buttered member is heat treated and the completed weld is not heat treated after welding; and
- (2) the filler metal used for buttering has a different F-number from that used for the subsequent completion of the weld.

QW-283.2 Tests Required. The procedure shall be qualified by buttering the test coupon (including heat treating of the buttered member when this will be done in production welding) and then making the subsequent weld joining the members. The variables for the buttering and for the subsequent weld shall be in accordance with QW-250, except that QW-409.1 shall be an essential variable for the welding process(es) used to complete the weld when the minimum buttering thickness is less than $\frac{3}{16}$ in. (4.8 mm). Mechanical testing of the completed weldment shall be in accordance with QW-202.2(a).

If the buttering is done with filler metal of the same composition as the filler metal used to complete the weld, one weld test coupon may be used to qualify the dissimilar metal joint by welding the first member directly to the second member in accordance with Section IX.

QW-283.3 Buttering Thickness. The thickness of buttering which shall remain on the production buttered member after all machining and grinding is completed and before subsequent completion of the joint shall be required by the WPS. When this thickness is less than $\frac{3}{16}$ in. (4.8 mm), the thickness of buttering on the test coupon shall be measured before the buttered member is welded to the second member. This thickness shall become the minimum qualified thickness of buttering.

QW-283.4 Multiple Organizations. When one organization butters a member and a second organization completes the weld, the second organization shall also qualify the procedure in accordance with QW-283. The buttering thickness shall not be greater, nor the heat input higher than that which was qualified by the first organization. The second organization may substitute any base metal which has an assigned P-Number and a chemical analysis nominally matching the chemical analysis of the buttering weld metal for the buttered base metal of the procedure qualification test coupon.

QW-284 Resistance Welding Machine Qualification98
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Each resistance welding machine shall be tested to determine its ability to make welds consistently and reproducibly. A machine shall be requalified whenever it is rebuilt, moved to a new location requiring a change in power supply, when the power supply is changed, or any other significant change is made to the equipment. Spot and projection welding machine qualification testing shall consist of making a set of 100 consecutive welds. Every fifth of these welds shall be subjected to mechanical shear tests. Five welds, which shall include one of the first five and one of the last five of the set shall be metallographically examined. Seam welding machine qualification testing shall be the same as procedure qualification testing required per QW-286. Maintenance or adjustment of the welding machine shall not be permitted during welding of a set of test welds. Qualification testing on any P-No. 21 through P-No. 25 aluminum alloy shall qualify the machine for all materials. Qualification on P-No. 1 through P-No. 11 iron-base alloys and any P-No. 41 through P-No. 47 nickel-base alloys shall qualify the machine for all P-No. 1 through P-No. 11 and P-No. 41 through P-No. 47 metals. Testing and acceptance criteria shall be in accordance with QW-196.

QW-285 Resistance Spot and Projection Weld Procedure Qualification

Procedure qualification testing for spot or projection welds shall be done following a Welding Procedure Specification, and it shall consist of making a set of 10 consecutive welds. Five of these welds shall be subjected to mechanical shear tests and five to metallographic examination. Examination, testing, and acceptance criteria shall be in accordance with QW-196.

QW-286 Resistance Seam Weld Procedure Qualification

Plates shall be prepared by welding or brazing a pipe nipple to one of the plates at a hole in one of the plates, and then the plates shall be welded around the edges, sealing the space between the plates as shown in QW-462.7. The space between the plates shall be pressurized until failure occurs. The procedure qualification is acceptable if failure occurs in the base metal. An additional seam weld at least 6 in. (152 mm) long shall be made between plates of the same thickness

QW-302.2 Radiographic Examination. When the welder or welding operator is qualified by radiographic examination, as permitted in QW-304 for welders and QW-305 for welding operators, the minimum length of coupon(s) to be examined shall be 6 in. (152 mm) and shall include the entire weld circumference for pipe(s), except that for small diameter pipe, multiple coupons may be required, but the number need not exceed four consecutively made test coupons. The radiographic technique and acceptance criteria shall be in accordance with QW-191.

QW-302.3 Test Coupons in Pipe. For test coupons made on pipe in position 1G or 2G of QW-461.4, two specimens shall be removed as shown for bend specimens in QW-463.2(d) or QW-463.2(e), omitting the specimens in the upper-right and lower-left quadrants, and replacing the root-bend specimen in the upper-left quadrant of QW-463.2(d) with a face-bend specimen. For test coupons made on pipe in position 5G or 6G of QW-461.4, specimens shall be removed in accordance with QW-463.2(d) or QW-463.2(e) and all four specimens shall pass the test. For test coupons made in both positions 2G and 5G on a single pipe test coupon, specimens shall be removed in accordance with QW-463.2(f) or QW-463.2(g).

QW-302.4 Visual Examination. For plate coupons all surfaces (except areas designated "discard") shall be examined visually per QW-194 before cutting of bend specimens. Pipe coupons shall be visually examined per QW-194 over the entire circumference, inside and outside.

QW-303 Limits of Qualified Positions and Diameters
(See QW-461)

QW-303.1 Groove Welds — General. Welders and welding operators who pass the required tests for groove welds in the test positions of QW-461.9 shall be qualified for the positions of groove welds and fillet welds shown in QW-461.9. In addition, welders and welding operators who pass the required tests for groove welds shall also be qualified to make fillet welds in all thicknesses and pipe diameters of any size within the limits of the welding variables of QW-350 or QW-360, as applicable.

QW-303.2 Fillet Welds — General. Welders and welding operators who pass the required tests for fillet welds in the test positions of QW-461.9 shall be qualified for the positions of fillet welds shown in QW-461.9. Welders and welding operators who pass the tests for fillet welds shall be qualified to make fillet

welds only in the thicknesses of material, sizes of fillet welds, and diameters of pipe and tube $2\frac{7}{8}$ in. (73 mm) O.D. and over, as shown in QW-452.5, within the applicable essential variables. Welders and welding operators who make fillet welds on pipe or tube less than $2\frac{7}{8}$ in. (73 mm) O.D. must pass the pipe fillet weld test per QW-452.4 or the required mechanical tests in QW-304 and QW-305 as applicable.

QW-303.3 Special Positions. A fabricator who does production welding in a special orientation may make the tests for performance qualification in this specific orientation. Such qualifications are valid only for the flat position and for the special positions actually tested, except that an angular deviation of ± 15 deg. is permitted in the inclination of the weld axis and the rotation of the weld face, as defined in QW-461.1 and QW-461.2.

QW-303.4 Stud-Weld Positions. Qualification in the 4S position also qualifies for the 1S position. Qualification in the 4S and 2S positions qualifies for all positions.

QW-304 Welders

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Except for the special requirements of QW-380, each welder who welds under the rules of the Code shall have passed the mechanical and visual examinations prescribed in QW-302.1 and QW-302.4 respectively. Alternatively, welders making a groove weld using SMAW, SAW, GTAW, PAW, and GMAW (except short-circuiting mode) or a combination of these processes, may be qualified by radiographic examination, except for P-No. 21 through P-No. 25, P-No. 51 through P-No. 53, and P-No. 61 through P-No. 62 metals. Welders making groove welds in P-No. 21 through P-No. 25 and P-No. 51 through P-No. 53 metals with the GTAW process may also be qualified by radiographic examination. The radiographic examination shall be in accordance with QW-302.2.

A welder qualified to weld in accordance with one qualified WPS is also qualified to weld in accordance with other qualified WPSs, using the same welding process, within the limits of the essential variables of QW-350.

QW-304.1 Examination. Welds made in test coupons for performance qualification may be examined by visual and mechanical examinations (QW-302.1, QW-302.4) or by radiography (QW-302.2) for the process(es) and mode of arc transfer specified in QW-304. Alternatively, a 6 in. (152 mm) length of the first production weld made by a welder using the process(es) and/or mode of arc transfer specified in QW-304 may be qualified by radiography.

weld. Four side bend test specimens shall be removed from the completed test coupon and tested. The groove weld portion and the corrosion-resistant weld metal overlay portion of the test coupon shall be evaluated using the respective criteria in QW-163. Welders and welding operators qualified using composite test coupons are qualified to join base materials as provided by QW-301, and they are qualified to apply corrosion-resistant weld metal overlay as provided by QW-381.

QW-383.2 Applied Linings

(a) Welders and welding operators shall be qualified following the rules for making groove or fillet welds in accordance with QW-301. Plug welds for attaching applied linings shall be considered equivalent to fillet welds for the purpose of performance qualification.

(b) An alternate test coupon shall consist of the geometry to be welded, except the base material need not exceed 1 in. (25 mm) in thickness. The welded

test coupon shall be sectioned and etched to reveal the weld and heat-affected zone. The weld shall show penetration into the base metal.

QW-384 Resistance Welding Operator Qualification

A99

Each welding operator shall be tested on each machine type which he will use. Qualification testing on any P-No. 21 through P-No. 25 metal shall qualify the operator for all materials. Qualification on any P-No. 1 through P-No. 11 or any P-No. 41 through P-No. 47 metals shall qualify the operator for all P-No. 1 through P-No. 11 or P-No. 41 through P-No. 47 metals. Qualification testing shall consist of making a set of 10 consecutive welds, five of which shall be subjected to mechanical shear tests or peel tests, and five to metallographic examination. Examination, testing, and acceptance criteria shall be in accordance with QW-196.

in the inclined fixed position, 6G, shall qualify for all positions.

(b) A fabricator who does production welding in a particular orientation may make the tests for procedure qualification in this particular orientation. Such qualifications are valid only for the positions actually tested, except that an angular deviation of ± 15 deg. is permitted in the inclination of the weld axis and the rotation of the weld face as defined in QW-461.1. A test specimen shall be taken from the test coupon in each special orientation.

(c) For hardfacing weld metal overlay, qualification in the 3G, 5G, or 6G positions, where 5G or 6G pipe coupons include at least one vertical segment completed utilizing the up-hill progression or a 3G plate coupon is completed utilizing the up-hill progression, shall qualify for all positions. Chemical analysis, hardness, and macro-etch tests required in QW-453 may be limited to a single, vertical up-hill overlaid segment as shown in QW-462.5(b).

(d) For hardfacing weld metal overlay, a change from vertical down to vertical up-hill progression shall require requalification.

QW-406 Preheat

QW-406.1 A decrease of more than 100°F (56°C) in the preheat temperature qualified. The minimum temperature for welding shall be specified in the WPS.

QW-406.2 A change in the maintenance or reduction of preheat upon completion of welding prior to any required postweld heat treatment.

QW-406.3 An increase of more than 100°F (56°C) in the maximum interpass temperature recorded on the PQR. This limitation does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.

QW-406.4 A decrease of more than 100°F (56°C) in the preheat temperature qualified or an increase in the maximum interpass temperature recorded on the PQR. The minimum temperature for welding shall be specified in the WPS.

QW-406.5 A change in the maintenance or reduction of preheat upon completion of spraying and prior to fusing.

QW-406.6 A change of more than 10% in the amplitude or number of preheating cycles from that qualified.

QW-407 Postweld Heat Treatment

QW-407.1 A separate procedure qualification is required for each of the following conditions. **A9.**

(a) For P-No. 1, P-No. 3, P-No. 4, P-No. 5, P-No. 6, P-No. 9, P-No. 10, and P-No. 11 materials, the following postweld heat treatment conditions apply:

- (1) No PWHT;
- (2) PWHT below the lower transformation temperature;
- (3) PWHT above the upper transformation temperature (e.g., normalizing);
- (4) PWHT above the upper transformation temperature followed by heat treatment below the lower transformation temperature (e.g., normalizing or quenching followed by tempering);
- (5) PWHT between the upper and lower transformation temperatures.

(b) For all other materials, the following postweld heat treatment conditions apply:

- (1) No PWHT;
- (2) PWHT within a specified temperature range.

QW-407.2 A change in the postweld heat treatment (see QW-407.1) temperature and time range. **A99**

The procedure qualification test shall be subjected to PWHT essentially equivalent to that encountered in the fabrication of production welds, including at least 80% of the aggregate times at temperature(s). The PWHT total time(s) at temperature(s) may be applied in one heating cycle.

QW-407.4 For a procedure qualification test coupon receiving a postweld heat treatment in which the upper transformation temperature is exceeded, the maximum qualified thickness for production welds is 1.1 times the thickness of the test coupon. **A99**

QW-407.5 A separate procedure qualification is required for each of the following conditions: **A99**

- (a) No PWHT;
- (b) A change of more than 10% in the number of post heating cycles following the welding interval;
- (c) PWHT within a specified temperature and time range if heat treatment is performed separately from the welding operation.

QW-407.6 A change in postweld heat treatment condition in QW-407.1 or an increase of 25% or more in total time at postweld heat treating temperature.

QW-407.7 A change in the heat treatment temperature range qualified if heat treatment is applied after fusing.

QW-409.3 The addition or deletion of pulsing current to dc power source.

QW-409.4 A change from ac to dc, or vice versa; and in dc welding, a change from electrode negative (straight polarity) to electrode positive (reverse polarity), or vice versa.

QW-409.5 A change of $\pm 15\%$ from the amperage or voltage ranges in the qualified WPS.

QW-409.6 A change in the beam current of more than $\pm 5\%$, voltage of more than $\pm 2\%$, welding speed of more than $\pm 2\%$, beam focus current of more than $\pm 5\%$, gun-to-work distance of more than $\pm 5\%$, or a change in oscillation length or width of more than $\pm 20\%$ from those previously qualified.

QW-409.7 Any change in the beam pulsing frequency duration from that qualified.

QW-409.8 A change in the range of amperage, or except for SMAW and GTAW welding, a change in the range of voltage. A change in the range of electrode wire feed speed may be used as an alternative to amperage.

QW-409.9 A change in the arc timing of more than $\pm \frac{1}{10}$ sec.

QW-409.10 A change in amperage of more than $\pm 10\%$.

QW-409.11 A change in the power source from one model to another.

QW-409.12 A change in type or size of tungsten electrode.

QW-409.13 A change in the shape or dimensions of the welding electrode; a change from one RWMA (Resistance Welding Manufacturer's Association) class electrode material to another.

QW-409.14 Addition or deletion of upslope or downslope current control, or a change of more than 10% in the slope current time or amplitude.

QW-409.15 A change of more than 5% in the electrode pressure, the welding current, or the welding time cycle from that qualified, except that requalification is not required if there is a change of not more than 10% in either the electrode pressure or the welding current or the welding time cycle, provided the remaining two variables remain at the values qualified. A change from ac to dc or vice versa. The addition or deletion of pulsing current to a dc power source. When using pulsing dc current, a change of more than

5% in the pulse amplitude, width, or number of pulses per cycle from that qualified.

QW-409.16 A change from synchronous to asynchronous timing.

QW-409.17 A change in the power supply primary voltage or frequency, or in the transformer turns ratio, tap setting, choke position, secondary open circuit voltage or phase control setting.

QW-409.18 A change in the procedure or frequency of tip cleaning.

QW-409.19 Any change in the beam pulsing frequency and pulse duration from that qualified.

QW-409.20 Any change in the following variables: mode of operation (from pulsed to continuous and vice versa), energy distribution across the beam (i.e., multimode or gaussian).

QW-409.21 Any change in the following variables: a change of more than 5% in the power delivered to the work surface as measured by calorimeter or other equivalent methods; a change of more than 2% in the travel speed; a change of more than 2% of the ratio of the beam diameter to focal length; a change of more than 2% of the lens to work distance.

QW-409.22 An increase of more than 10% in the amperage used in application for the first layer.

QW-409.23 A change of more than 10% in the ranges of amperage or voltage qualified.

QW-409.24 A change of more than 10% in the filler wire wattage recorded on the PQR. Wattage is a function of current voltage, and stickout dimension.

QW-409.25 A change of more than 10% in the plasma-arc current or voltage recorded on the PQR.

QW-409.26 For the first layer only, an increase in heat input of more than 10% or an increase in volume of weld metal deposited per unit length of weld of more than 10% over that qualified. The increase may be measured by either of the following:

(a) Heat input (J/in.)

$$= \frac{\text{Voltage} \times \text{Amperage} \times 60}{\text{Travel Speed (in./min)}}$$

(b) Volume of Weld Metal = an increase in bead size or a decrease in length of weld bead per unit length of electrode.

QW-420 Material Groupings

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QW-420.1 P-Numbers. To reduce the number of welding and brazing procedure qualifications required, base metals have been assigned P-Numbers, and for ferrous base metals which have specified impact test requirements, Group Numbers within P-Numbers. These assignments are based essentially on comparable base metal characteristics, such as composition, weldability, brazeability, and mechanical properties, where this can logically be done. These assignments do not imply that base metals may be indiscriminately substituted for a base metal which was used in the qualification test without consideration of compatibility from the standpoint of metallurgical properties, postweld heat treatment, design, mechanical properties, and service requirements. Where notch toughness is a consideration, it is presupposed that the base metals meet the specific requirements.

Base Metal	Welding	Brazing
Steel and steel alloys	P-No. 1 through P-No. 11 incl. P-No. 5A, 5B, and 5C	P-No. 101 through P-No. 103
Aluminum and aluminum-base alloys	P-No. 21 through P-No. 25	P-No. 104 and P-No. 105
Copper and copper-base alloys	P-No. 31 through P-No. 35	P-No. 107 and P-No. 108
Nickel and nickel-base alloys	P-No. 41 through P-No. 47	P-No. 110 through P-No. 112
Titanium and titanium-base alloys	P-No. 51 through P-No. 53	P-No. 115
Zirconium and zirconium-base alloys	P-No. 61 through P-No. 62	P-No. 117

When a base metal with a UNS number designation is assigned a P-Number or P-Number plus Group Number, then a base metal listed in a different ASME material specification with the same UNS number shall be considered that P-Number or P-Number plus Group Number. For example, SB-163, UNS N08800 is P-Number 45; therefore, all ASME specifications listing a base metal with the UNS N08800 designation shall be considered P-Number 45 (i.e., SB-407, SB-408, SB-514, etc.) whether or not these specifications are listed in QW/QB-422. Since a minimum tensile value is required for procedure qualification, only base metals listed in QW/QB-422 may be used for test coupons as defined in QW-424.

In those instances where materials in the 1971 Edition of this Section have been given different P-Numbers or assigned to Subgroups within a P-Number in the 1974 Edition of this Section, those procedure and

performance qualifications will continue to be valid based on the new P-Number designation.

In the column heading "Minimum Specified Tensile, ksi" of QW/QB-422, the values given are those of the base metal specification, except as otherwise identified in QW-153 or QB-153. These are also the acceptance values for the room temperature tensile tests of the welding or brazing procedure qualification, except as otherwise allowed in QW-153 or QB-153.

QW-420.2 S-Numbers (Non-Mandatory). S-Numbers are a listing of materials which are acceptable for use by the ASME B31 Code for Pressure Piping, or by selected Boiler and Pressure Vessel Code Cases, but which are not included within ASME Boiler and Pressure Code Material Specifications (Section II). These materials are grouped in S-Number or S-Number plus Group Number groupings similar to the P-Number groupings. There is no mandatory requirement that S-Numbers be used.

Brazing or Welding Procedure Qualification with a base metal in one P-Number (or P-Number plus Group Number) or one S-Number (or S-Number plus Group Number), qualifies for all other base metals in the same S-Number grouping. Also, qualification with a base metal in one S-Number, or S-Number plus Group Number, qualifies for all other base metals in the same S-Number grouping. Qualifications for S-Number materials do not qualify corresponding P-Number materials. Base metals not assigned an S-Number or a P-Number shall require individual procedure qualification.

Material produced under an ASTM specification shall be considered to have the same S-Number or S-Number plus Group Number as that of the P-Number or P-Number plus Group Number assigned to the same grade or type material in the corresponding ASME specification (i.e., SA-240 Type 304 is assigned P-Number 8, Group Number 1; therefore, A 240 Type 304 is considered S-Number 8, Group Number 1). Additionally, when a base metal with a UNS number designation is assigned an S-Number or S-Number plus Group Number, then a base metal listed in a different material specification with the same UNS number shall be considered that S-Number or S-Number plus Group Number. Since a minimum tensile value is required for procedure qualification, only base metals listed in QW/QB-422 may be used for test coupons.

For Performance Qualification of brazers, welders, brazing operators, and welding operators, the requirements for P-Numbers of base metals shall also be applied to the same S-Numbers of base metals. Qualification with P-Numbers in accordance with QB-310.3 and QW-403.18 qualifies for corresponding S-Numbers and vice versa.

A99

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding			Brazing		Nominal Composition	Product Form	
				P- No.	Group No.	S- No.	Group No.	P- No.			S- No.
A 167	Type 304L	S30403	70	...	...	8	1	...	102	18Cr-8Ni	Plate, sheet, & strip
A 167	Type 301	S30100	75	...	...	8	1	...	102	17Cr-7Ni	Plate, sheet, & strip
A 167	Type 305	S30500	70	...	...	8	1	...	102	18Cr-11Ni	Plate, sheet, & strip
A 167	Type 308	S30800	75	...	...	8	2	...	102	20Cr-10Ni	Plate, sheet, & strip
A 167	Type 309	S30900	75	...	...	8	2	...	102	23Cr-12Ni	Plate, sheet, & strip
A 167	Type 309S	S30908	75	...	...	8	2	...	102	23Cr-12Ni	Plate, sheet, & strip
A 167	Type 310	S31000	75	...	...	8	2	...	102	25Cr-20Ni	Plate, sheet, & strip
A 167	Type 310S	S31008	75	...	...	8	2	...	102	25Cr-20Ni	Plate, sheet, & strip
A 167	Type 316L	S31603	70	...	...	8	1	...	102	16Cr-12Ni-2Mo	Plate, sheet, & strip
A 167	Type 317	S31700	75	...	...	8	1	...	102	18Cr-13Ni-3Mo	Plate, sheet, & strip
A 167	Type 317L	S31703	75	...	...	8	1	...	102	18Cr-13Ni-3Mo	Plate, sheet, & strip
A 167	Type 321	S32100	75	...	...	8	1	...	102	18Cr-10Ni-Ti	Plate, sheet, & strip
A 167	Type 347	S34700	75	...	...	8	1	...	102	18Cr-10Ni-Cb	Plate, sheet, & strip
A 167	Type 348	S34800	75	...	...	8	1	...	102	18Cr-10Ni-Cb	Plate, sheet, & strip
SA-178	A	K01200	47	1	1	...	...	101	...	C	E.R.W. tube
SA-178	C	K03503	60	1	1	...	...	101	...	C	E.R.W. tube
SA-178	D	...	70	1	2	...	...	101	...	C-Mn-Si	E.R.W. tube
SA-179	...	K01200	47	1	1	...	...	101	...	C	Smls. tube
SA-181	Cl. 60	K03502	60	1	1	...	...	101	...	C-Si	Pipe flange & fittings
SA-181	Cl. 70	K03502	70	1	2	...	...	101	...	C-Si	Pipe flange & fittings
SA-182	F12, Cl. 1	K11562	60	4	1	...	...	102	...	1Cr-0.5Mo	Forgings
SA-182	F12, Cl. 2	K11564	70	4	1	...	...	102	...	1Cr-0.5Mo	Forgings
SA-182	F11, Cl. 2	K11572	70	4	1	...	...	102	...	1.25Cr-0.5Mo-Si	Forgings
SA-182	F11, Cl. 3	K11572	75	4	1	...	...	102	...	1.25Cr-0.5Mo-Si	Forgings
SA-182	F11, Cl. 1	K11597	60	4	1	...	...	102	...	1.25Cr-0.5Mo-Si	Forgings
SA-182	F2	K12122	70	3	2	...	...	101	...	0.5Cr-0.5Mo	Forgings
SA-182	F1	K12822	70	3	2	...	...	101	...	C-0.5Mo	Forgings
SA-182	F22, Cl. 1	K21590	60	5A	1	...	...	102	...	2.25Cr-1Mo	Forgings
SA-182	F22, Cl. 3	K21590	75	5A	1	...	...	102	...	2.25Cr-1Mo	Forgings
SA-182	FR	K22035	63	9A	1	101	...	2Ni-1Cu	Forgings
SA-182	F21	K31545	75	5A	1	102	...	3Cr-1Mo	Forgings

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Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding			Brazing		Nominal Composition	Product Form
				P- No.	Group No.	S- No.	Group No.	P- No.		
SA-182	F317	S31700	75	8	1	...	...	102	...	18Cr-13Ni-3Mo Forgings
SA-182	F317L	S31703	65	8	1	...	...	102	...	18Cr-13Ni-3Mo Forgings > 5 in.
SA-182	F317L	S31703	70	8	1	...	...	102	...	18Cr-13Ni-3Mo Forgings
SA-182	F51	S31803	90	10H	1	...	...	102	...	22Cr-5Ni-3Mo-N Forgings
SA-182	F321	S32100	70	8	1	...	...	102	...	18Cr-10Ni-Ti Forgings > 5 in.
SA-182	F321	S32100	75	8	1	...	...	102	...	18Cr-10Ni-Ti Forgings
SA-182	F321H	S32109	70	8	1	...	...	102	...	18Cr-10Ni-Ti Forgings > 5 in.
SA-182	F321H	S32109	75	8	1	...	...	102	...	18Cr-10Ni-Ti Forgings
SA-182	F55	S32760	109	...	...	10H	1	...	102	25Cr-8Ni-3Mo-W- Cu-N Forgings
SA-182	F10	S33100	80	8	2	...	...	102	...	20Ni-8Cr Forgings
SA-182	F347	S34700	70	8	1	...	...	102	...	18Cr-10Ni-Cb Forgings > 5 in.
SA-182	F347	S34700	75	8	1	...	...	102	...	18Cr-10Ni-Cb Forgings
SA-182	F347H	S34709	70	8	1	...	...	102	...	18Cr-10Ni-Cb Forgings > 5 in.
SA-182	F347H	S34709	75	8	1	...	...	102	...	18Cr-10Ni-Cb Forgings
SA-182	F348	S34800	70	8	1	...	...	102	...	18Cr-10Ni-Cb Forgings > 5 in.
SA-182	F348	S34800	75	8	1	...	...	102	...	18Cr-10Ni-Cb Forgings
SA-182	F348H	S34809	70	8	1	...	...	102	...	18Cr-10Ni-Cb Forgings > 5 in.
SA-182	F348H	S34809	75	8	1	...	...	102	...	18Cr-10Ni-Cb Forgings
SA-182	F6b	S41026	110	6	3	...	...	102	...	13Cr-0.5Mo Forgings
SA-182	F6NM	S41500	115	6	4	...	...	102	...	13Cr-4.5Ni-Mo Forgings
SA-182	F429	S42900	60	6	2	...	...	102	...	15Cr Forgings
SA-182	F430	S43000	60	7	2	...	...	102	...	17Cr Forgings
SA-182	FXM-27Cb	S44627	60	10I	1	...	...	102	...	27Cr-1Mo Forgings
A 182	F6a, Cl. 3	S41000	110	...	...	6	3	...	102	13Cr Forgings
A 182	F6a, Cl. 4	S41000	130	...	...	6	3	...	102	13Cr-5Mo Forgings
SA-192	...	K01201	47	1	1	...	...	101	...	C-Si Smis. tube
SA-199	T11	K11597	60	4	1	...	...	102	...	1.25Cr-0.5Mo-Si Smis. tube
SA-199	T22	K21590	60	5A	1	...	...	102	...	2.25Cr-1Mo Smis. tube
SA-199	T4	K31509	60	5A	1	...	...	102	...	2.25Cr-0.5Mo-0.75Si Smis. tube
SA-199	T21	K31545	60	5A	1	...	...	102	...	3Cr-1Mo Smis. tube
SA-199	T5	K41545	60	5B	1	102	...	5Cr-0.5Mo Smis. tube
SA-199	T9	K81590	60	5B	1	102	...	9Cr-1Mo Smis. tube

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Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding				Brazing		Nominal Composition	Product Form
				P- No.	Group No.	S- No.	Group No.	P- No.	S- No.		
SA-213	T9	K81590	60	5B	1	...	...	102	...	9Cr-1Mo	Smls. tube
SA-213	T91	...	85	5B	2	...	...	102	...	9Cr-1Mo-V	Smls. tube
SA-213	TP201	S20100	95	8	3	...	...	102	...	17Cr-4Ni-6Mn	Smls. tube
SA-213	TP202	S20200	90	8	3	...	...	102	...	18Cr-5Ni-9Mn	Smls. tube
SA-213	XM-19	S20910	100	8	3	...	...	102	...	22Cr-13Ni-5Mn	Smls. tube
SA-213	TP304	S30400	75	8	1	...	...	102	...	18Cr-8Ni	Smls. tube
SA-213	TP304L	S30403	70	8	1	...	...	102	...	18Cr-8Ni	Smls. tube
SA-213	TP304H	S30409	75	8	1	...	...	102	...	18Cr-8Ni	Smls. tube
SA-213	TP304N	S30451	80	8	1	...	...	102	...	18Cr-8Ni-N	Smls. tube
SA-213	TP304LN	S30453	75	8	1	...	...	102	...	18Cr-8Ni-N	Smls. tube
SA-213	S30815	S30815	87	8	2	...	...	102	...	21Cr-11Ni-N	Smls. tube
SA-213	TP309S	S30908	75	8	2	...	...	102	...	23Cr-12Ni	Smls. tube
SA-213	TP309H	S30909	75	8	2	...	...	102	...	23Cr-12Ni	Smls. tube
SA-213	TP309Cb	S30940	75	8	2	...	...	102	...	23Cr-12Ni-Cb	Smls. tube
SA-213	TP309HCb	S30941	75	8	2	...	...	102	...	23Cr-12Ni-Cb	Smls. tube
SA-213	TP310S	S31008	75	8	2	...	...	102	...	25Cr-20Ni	Smls. tube
SA-213	TP310H	S31009	75	8	2	...	...	102	...	25Cr-20Ni	Smls. tube
SA-213	TP310Cb	S31040	75	8	2	...	...	102	...	25Cr-20Ni-Cb	Smls. tube
SA-213	TP310HCb	S31041	75	8	2	...	...	102	...	25Cr-20Ni-Cb	Smls. tube
SA-213	TP310MoLN	S31050	78	8	2	...	...	102	...	25Cr-22Ni-2Mo-N	Smls. tube, $t > 1/4$ in.
SA-213	TP310MoLN	S31050	84	8	2	...	...	102	...	25Cr-22Ni-2Mo-N	Smls. tube, $t \leq 1/4$ in.
SA-213	TP316	S31600	75	8	1	...	...	102	...	16Cr-12Ni-2Mo	Smls. tube
SA-213	TP316L	S31603	70	8	1	...	...	102	...	16Cr-12Ni-2Mo	Smls. tube
SA-213	TP316H	S31609	75	8	1	...	...	102	...	16Cr-12Ni-2Mo	Smls. tube
SA-213	TP316N	S31651	80	8	1	...	...	102	...	16Cr-12Ni-2Mo-N	Smls. tube
SA-213	TP316LN	S31653	75	8	1	...	...	102	...	16Cr-12Ni-2Mo-N	Smls. tube
SA-213	S31725	S31725	75	8	4	...	...	102	...	19Cr-15Ni-4Mo	Smls. tube
SA-213	S31726	S31726	80	8	4	...	...	102	...	19Cr-15.5Ni-4Mo	Smls. tube
SA-213	TP321	S32100	75	8	1	...	...	102	...	18Cr-10Ni-Ti	Smls. tube
SA-213	TP321H	S32109	75	8	1	...	...	102	...	18Cr-10Ni-Ti	Smls. tube
SA-213	TP347	S34700	75	8	1	...	...	102	...	18Cr-10Ni-Cb	Smls. tube
SA-213	TP347H	S34709	75	8	1	...	...	102	...	18Cr-10Ni-Cb	Smls. tube
SA-213	TP348	S34800	75	8	1	102	...	18Cr-10Ni-Cb	Smls. tube
SA-213	TP348H	S34809	75	8	1	102	...	18Cr-10Ni-Cb	Smls. tube

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Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding			Brazing			Nominal Composition	Product Form
				P- No.	Group No.	S- No.	P- No.	S- No.			
SA-240	Type XM-17	S21600	100	8	3	...	102	...	19Cr-8Mn-6Ni-Mo-N	Sheet & strip	
SA-240	Type XM-18	S21603	90	8	3	...	102	...	19Cr-8Mn-6Ni-Mo-N	Plate	
SA-240	Type XM-18	S21603	100	8	3	...	102	...	19Cr-8Mn-6Ni-Mo-N	Sheet & strip	
SA-240	S21800	S21800	95	8	3	...	102	...	18Cr-8Ni-4Si-N	Plate, sheet, & strip	
SA-240	Type XM-29	S24000	100	8	3	...	102	...	18Cr-3Ni-12Mn	Plate, sheet, & strip	
SA-240	Type 302	S30200	75	8	1	...	102	...	18Cr-8Ni	Plate, sheet, & strip	
SA-240	Type 304	S30400	75	8	1	...	102	...	18Cr-8Ni	Plate, sheet, & strip	
SA-240	Type 304L	S30403	70	8	1	...	102	...	18Cr-8Ni	Plate, sheet, & strip	
SA-240	Type 304H	S30409	75	8	1	...	102	...	18Cr-8Ni	Plate, sheet, & strip	
SA-240	Type 304N	S30451	80	8	1	...	102	...	18Cr-8Ni-N	Plate, sheet, & strip	
SA-240	Type XM-21	S30452	85	8	1	...	102	...	18Cr-8Ni-N	Plate	
SA-240	Type XM-21	S30452	90	8	1	...	102	...	18Cr-8Ni-N	Sheet & strip	
SA-240	Type 304LN	S30453	75	8	1	...	102	...	18Cr-8Ni-N	Plate, sheet, & strip	
SA-240	Type 305	S30500	70	8	1	...	102	...	18Cr-11Ni	Plate, sheet, & strip	
SA-240	S30600	S30600	78	8	1	...	102	...	17Cr-14Ni-4Si	Plate, sheet, & strip	
SA-240	S30815	S30815	87	8	2	...	102	...	21Cr-11Ni-N	Plate, sheet, & strip	
SA-240	Type 309S	S30908	75	8	2	...	102	...	23Cr-12Ni	Plate, sheet, & strip	
SA-240	Type 309H	S30909	75	8	2	...	102	...	23Cr-12Ni	Plate, sheet, & strip	
SA-240	Type 309Cb	S30940	75	8	2	...	102	...	23Cr-12Ni-Cb	Plate, sheet, & strip	
SA-240	Type 309HCb	S30941	75	8	2	...	102	...	23Cr-12Ni-Cb	Plate, sheet, & strip	
SA-240	Type 310S	S31008	75	8	2	...	102	...	25Cr-20Ni	Plate, sheet, & strip	
SA-240	Type 310Cb	S31040	75	8	2	...	102	...	25Cr-20Ni-Cb	Plate, sheet, & strip	
SA-240	Type 310HCb	S31041	75	8	2	...	102	...	25Cr-20Ni-Cb	Plate, sheet, & strip	
SA-240	Type 310MoLN	S31050	80	8	2	...	102	...	25Cr-22Ni-2Mo-N	Plate, sheet, & strip	
SA-240	S31200	S31200	100	10H	1	...	102	...	25Cr-6Ni-Mo-N	Plate, sheet, & strip	
SA-240	S31254	S31254	94	8	4	...	102	...	20Cr-18Ni-6Mo	Plate, sheet, & strip	
SA-240	S31260	S31260	100	10H	1	...	102	...	25Cr-6.5Ni-3Mo-N	Plate, sheet, & strip	
SA-240	Type 316	S31600	75	8	1	...	102	...	16Cr-12Ni-2Mo	Plate, sheet, & strip	
SA-240	Type 316L	S31603	70	8	1	...	102	...	16Cr-12Ni-2Mo	Plate, sheet, & strip	
SA-240	Type 316H	S31609	75	8	1	...	102	...	16Cr-12Ni-2Mo	Plate, sheet, & strip	
SA-240	Type 316Ti	S31635	75	8	1	...	102	...	16Cr-12Ni-2Mo-Ti	Plate, sheet, & strip	
SA-240	Type 316Cb	S31640	75	8	1	...	102	...	16Cr-12Ni-2Mo-Cb	Plate, sheet, & strip	
SA-240	Type 316N	S31651	80	8	1	...	102	...	16Cr-12Ni-2Mo-N	Plate, sheet, & strip	
SA-240	Type 316LN	S31653	75	8	1	...	102	...	16Cr-12Ni-2Mo-N	Plate, sheet, & strip	
SA-240	Type 317	S31700	75	8	1	...	102	...	18Cr-13Ni-3Mo	Plate, sheet, & strip	

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Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding			Brazing			Nominal Composition	Product Form
				P- No.	Group No.	S- No.	P- No.	S- No.			
SA-249	TPXM-19	S20910	100	8	3	...	102	...	22Cr-13Ni-5Mn	Welded tube	
SA-249	TPXM-29	S24000	100	8	3	...	102	...	18Cr-3Ni-12Mn	Welded tube	
SA-249	TP304	S30400	75	8	1	...	102	...	18Cr-8Ni	Welded tube	
SA-249	TP304L	S30403	70	8	1	...	102	...	18Cr-8Ni	Welded tube	
SA-249	TP304H	S30409	75	8	1	...	102	...	18Cr-8Ni	Welded tube	
SA-249	TP304N	S30451	80	8	1	...	102	...	18Cr-8Ni-N	Welded tube	
SA-249	TP304LN	S30453	75	8	1	...	102	...	18Cr-8Ni-N	Welded tube	
SA-249	S30815	S30815	87	8	2	...	102	...	21Cr-11Ni-N	Welded tube	
SA-249	TP309S	S30908	75	8	2	...	102	...	23Cr-12Ni	Welded tube	
SA-249	TP309H	S30909	75	8	2	...	102	...	23Cr-12Ni	Welded tube	
SA-249	TP309Cb	S30940	75	8	2	...	102	...	23Cr-12Ni-Cb	Welded tube	
SA-249	TP309HCb	S30941	75	8	2	...	102	...	23Cr-12Ni-Cb	Welded tube	
SA-249	TP310S	S31008	75	8	2	...	102	...	25Cr-20Ni	Welded tube	
SA-249	TP310H	S31009	75	8	2	...	102	...	25Cr-20Ni	Welded tube	
SA-249	TP310Cb	S31040	75	8	2	...	102	...	25Cr-20Ni-Cb	Welded tube	
SA-249	TP310MoLN	S31050	78	8	2	...	102	...	25Cr-22Ni-2Mo-N	Welded tube, $t > 1/4$ in.	
SA-249	TP310MoLN	S31050	84	8	2	...	102	...	25Cr-22Ni-2Mo-N	Welded tube, $t \leq 1/4$ in.	
SA-249	S31254	S31254	94	8	4	...	102	...	20Cr-18Ni-6Mo	Welded tube	
SA-249	TP316	S31600	75	8	1	...	102	...	16Cr-12Ni-2Mo	Welded tube	
SA-249	TP316L	S31603	70	8	1	...	102	...	16Cr-12Ni-2Mo	Welded tube	
SA-249	TP316H	S31609	75	8	1	...	102	...	16Cr-12Ni-2Mo	Welded tube	
SA-249	TP316N	S31651	80	8	1	...	102	...	16Cr-12Ni-2Mo-N	Welded tube	
SA-249	TP316LN	S31653	75	8	1	...	102	...	16Cr-12Ni-2Mo-N	Welded tube	
SA-249	TP317	S31700	75	8	1	...	102	...	18Cr-13Ni-3Mo	Welded tube	
SA-249	TP317L	S31703	75	8	1	...	102	...	18Cr-13Ni-3Mo	Welded tube	
SA-249	S31725	S31725	75	8	4	...	102	...	19Cr-15Ni-4Mo	Welded tube	
SA-249	S31726	S31726	80	8	4	...	102	...	19Cr-15.5Ni-4Mo	Welded tube	
SA-249	TP321	S32100	75	8	1	...	102	...	18Cr-10Ni-Ti	Welded tube	
SA-249	TP321H	S32109	75	8	1	...	102	...	18Cr-10Ni-Ti	Welded tube	
SA-249	TP347	S34700	75	8	1	...	102	...	18Cr-10Ni-Cb	Welded tube	
SA-249	TP347H	S34709	75	8	1	...	102	...	18Cr-10Ni-Cb	Welded tube	
SA-249	TP348	S34800	75	8	1	...	102	...	18Cr-10Ni-Cb	Welded tube	
SA-249	TP348H	S34809	75	8	1	...	102	...	18Cr-10Ni-Cb	Welded tube	
SA-249	TPXM-15	S38100	75	8	1	...	102	...	18Cr-18Ni-2Si	Welded tube	

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Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding				Brazing		Nominal Composition	Product Form
				P- No.	Group No.	S- No.	Group No.	P- No.	S- No.		
A 269	TP304	S30400	75	...	...	8	1	...	102	18Cr-8Ni	Smls. & welded tube
A 269	TP304L	S30403	70	...	...	8	1	...	102	18Cr-8Ni	Smls. & welded tube
A 271	TP304	S30400	75	...	...	8	1	...	102	18Cr-8Ni	Smls. tube
A 271	TP304L	S30403	70	...	...	8	1	...	102	18Cr-8Ni	Smls. tube
A 276	TP304	S30400	75	...	...	8	1	...	102	18Cr-8Ni	Bar
A 276	TP304L	S30403	70	...	...	8	1	...	102	18Cr-8Ni	Bar
A 276	TP316	S31600	75	...	...	8	1	...	102	16Cr-12Ni-2Mo	Bar
A 276	TP316L	S31603	70	...	...	8	1	...	102	16Cr-12Ni-2Mo	Bar
A 276	TP410	S41000	65	...	...	6	1	...	102	13Cr	Bar
SA-283	A	...	45	1	1	...	...	101	...	C	Plate
SA-283	B	...	50	1	1	...	...	101	...	C	Plate
SA-283	C	...	55	1	1	...	...	101	...	C	Plate
SA-283	D	...	60	1	1	...	...	101	...	C	Plate
SA-285	A	K01700	45	1	1	...	...	101	...	C	Plate
SA-285	B	K02200	50	1	1	...	...	101	...	C	Plate
SA-285	C	K02801	55	1	1	...	...	101	...	C	Plate
SA-299	...	K02803	75	1	2	...	...	101	...	C-Mn-Si	Plate
SA-302	A	K12021	75	3	2	...	...	101	...	Mn-0.5Mo	Plate
SA-302	B	K12022	80	3	3	...	...	101	...	Mn-0.5Mo	Plate
SA-302	C	K12039	80	3	3	...	...	101	...	Mn-0.5Mo-0.5Ni	Plate
SA-302	D	K12054	80	3	3	...	...	101	...	Mn-0.5Mo-0.75Ni	Plate
SA-312	TPXM-19	S20910	100	8	3	...	...	102	...	22Cr-13Ni-5Mn	Smls. & welded pipe
SA-312	TPXM-11	S21904	90	8	3	...	...	102	...	21Cr-6Ni-9Mn	Smls. & welded pipe
SA-312	TPXM-29	S24000	100	8	3	...	...	102	...	18Cr-3Ni-12Mn	Smls. & welded pipe
SA-312	TP304	S30400	75	8	1	...	...	102	...	18Cr-8Ni	Smls. & welded pipe
SA-312	TP304L	S30403	70	8	1	...	...	102	...	18Cr-8Ni	Smls. & welded pipe
SA-312	TP304H	S30409	75	8	1	...	...	102	...	18Cr-8Ni	Smls. & welded pipe
SA-312	TP304N	S30451	80	8	1	...	...	102	...	18Cr-8Ni-N	Smls. & welded pipe
SA-312	TP304LN	S30453	75	8	1	...	...	102	...	18Cr-8Ni-N	Smls. & welded pipe
SA-312	S30600	S30600	78	8	1	...	...	102	...	17Cr-14Ni-4Si	Smls. & welded pipe
SA-312	S30815	S30815	87	8	2	102	...	21Cr-11Ni-N	Smls. & welded pipe
SA-312	TP309S	S30908	75	8	2	102	...	23Cr-12Ni	Smls. & welded pipe

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Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding				Brazing		Nominal Composition	Product Form
				P- No.	Group No.	S- No.	Group No.	P- No.	S- No.		
SA-333	7	K21903	65	9A	1	...	...	101	...	2.5NI	Smls. & welded pipe
SA-333	9	K22035	63	9A	1	...	...	101	...	2NI-1Cu	Smls. & welded pipe
SA-333	3	K31918	65	9B	1	...	...	101	...	3.5NI	Smls. & welded pipe
SA-333	8	K81340	100	11A	1	...	...	101	...	9NI	Smls. & welded pipe
SA-334	6	K03006	60	1	1	...	...	101	...	C-Mn-Si	Welded tube
SA-334	1	K03008	55	1	1	...	...	101	...	C-Mn	Welded tube
SA-334	7	K21903	65	9A	1	...	...	101	...	2.5NI	Welded tube
SA-334	9	K22035	63	9A	1	...	...	101	...	2NI-1Cu	Welded tube
SA-334	3	K31918	65	9B	1	...	...	101	...	3.5NI	Welded tube
SA-334	8	K81340	100	11A	1	...	...	101	...	9NI	Welded tube
SA-335	P1	K11522	55	3	1	...	...	101	...	C-0.5Mo	Smls. pipe
SA-335	P2	K11547	55	3	1	...	...	101	...	0.5Cr-0.5Mo	Smls. pipe
SA-335	P12	K11562	60	4	1	...	...	102	...	1Cr-0.5Mo	Smls. pipe
SA-335	P15	K11578	60	3	1	...	...	101	...	1.5Si-0.5Mo	Smls. pipe
SA-335	P11	K11597	60	4	1	...	...	102	...	1.25Cr-0.5Mo-Si	Smls. pipe
SA-335	P22	K21590	60	5A	1	...	...	102	...	2.25Cr-1Mo	Smls. pipe
SA-335	P21	K31545	60	5A	1	...	...	102	...	3Cr-1Mo	Smls. pipe
SA-335	P5c	K41245	60	5B	1	...	...	102	...	5Cr-0.5Mo-Ti	Smls. pipe
SA-335	P5	K41545	60	5B	1	...	...	102	...	5Cr-0.5Mo	Smls. pipe
SA-335	P5b	K51545	60	5B	1	...	...	102	...	5Cr-0.5Mo-Si	Smls. pipe
SA-335	P9	K81590	60	5B	1	...	...	102	...	9Cr-1Mo	Smls. pipe
SA-335	P91	K91560	85	5B	2	...	...	102	...	9Cr-1Mo-V	Smls. pipe
SA-336	F6	...	85	6	3	...	...	102	...	13Cr	Forgings
SA-336	F12	K11564	70	4	1	...	...	102	...	1Cr-0.5Mo	Forgings
SA-336	F11, Cl. 1	K11597	60	4	1	...	...	102	...	1.25Cr-0.5Mo-Si	Forgings
SA-336	F11, Cl. 2	K11572	70	4	1	...	...	102	...	1.25Cr-0.5Mo-Si	Forgings
SA-336	F11, Cl. 3	K11572	75	4	1	...	...	102	...	1.25Cr-0.5Mo-Si	Forgings
SA-336	F1	K12520	70	3	2	...	...	101	...	C-0.5Mo	Forgings
SA-336	F22, Cl. 1	K21590	60	5A	1	...	...	102	...	2.25Cr-1Mo	Forgings
SA-336	F22, Cl. 3	K21590	75	5A	1	...	...	102	...	2.25Cr-1Mo	Forgings
SA-336	F21, Cl. 1	K31545	60	5A	1	...	...	102	...	3Cr-1Mo	Forgings
SA-336	F21, Cl. 3	K31545	75	5A	1	...	...	102	...	3Cr-1Mo	Forgings
SA-336	F3V	K31830	85	5C	1	...	...	102	...	3Cr-1Mo-V-Ti-B	Forgings
SA-336	F22V	K31835	85	5C	1	...	...	...	...	2.25Cr-1Mo-V	Forgings

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding			Brazing		Nominal Composition	Product Form
				P-Group No.	S-Group No.	Group No.	P-No.	S-No.		
SA-351	CF8A	J92600	77	8	1	...	102	...	18Cr-8Ni	Castings
SA-351	CF8C	J92710	70	8	1	...	102	...	18Cr-10Ni-Cb	Castings
SA-351	CF3M	J92800	70	8	1	...	102	...	18Cr-12Ni-2Mo	Castings
SA-351	CF8M	J92900	70	8	1	...	102	...	18Cr-12Ni-2Mo	Castings
SA-351	CF10	...	70	8	1	...	102	...	19Cr-9Ni-0.5Mo	Castings
SA-351	CF10M	...	70	8	1	...	102	...	19Cr-9Ni-2Mo	Castings
SA-351	CG8M	J93000	75	8	1	...	102	...	19Cr-10Ni-3Mo	Castings
SA-351	CK3McuN	J93254	80	8	4	...	102	...	20Cr-18Ni-6Mo	Castings
SA-351	CE8MN	J93345	95	10H	1	...	102	...	24Cr-10Ni-Mo-N	Castings
SA-351	CD4MCu	J93370	100	10H	1	...	102	...	25Cr-5Ni-2Mo-3Cu	Castings
SA-351	CD3MWCuN	J93380	100	...	...	10H	102	...	25Cr-7.5Ni-3.5Mo-N-Cu-W	Castings
SA-351	CH8	J93400	65	8	2	...	102	...	25Cr-12Ni	Castings
SA-351	CH20	J93402	70	8	2	...	102	...	25Cr-12Ni	Castings
SA-351	CG6MMN	J93790	85	8	3	...	102	...	22Cr-12Ni-5Mn	Castings
SA-351	CK20	J94202	65	8	2	...	102	...	25Cr-20Ni	Castings
SA-351	CN7M	N08007	62	45	...	...	111	...	28Ni-19Cr-Cu-Mo	Castings
SA-351	CT15C	N08151	63	45	...	...	111	...	32Ni-45Fe-20Cr-Cb	Castings
SA-351	CN3MN	...	80	45	...	...	...	...	24Ni-21Cr-6.5Mo-N	Castings
A 351	CA15	...	90	...	...	6	...	102	13Cr	Castings
A 351	CE20N	...	80	...	...	8	...	102	25Cr-8Ni-N	Castings
A 351	CF10MC	J92971	70	...	...	8	...	102	16Cr-14Ni-2Mo	Castings
A 351	CH10	J93401	70	...	...	8	...	102	25Cr-12Ni	Castings
A 351	HK40	J94204	62	...	...	8	...	102	25Cr-20Ni-5Mo	Castings
A 351	HT30	N08030	65	...	...	45	...	111	32Ni-45Fe-15Cr	Castings
SA-352	LCA	J02504	60	1	1	...	101	...	C-Si	Castings
SA-352	LCC	J02505	70	1	2	...	101	...	C-Mn-Si	Castings
SA-352	LCB	J03003	65	1	1	...	101	...	C-Si	Castings
SA-352	LC1	J12522	65	3	1	...	101	...	C-0.5Mo	Castings
SA-352	LC2	J22500	70	9A	1	...	101	...	2.5Ni	Castings
SA-352	LC3	J31550	70	9B	1	...	101	...	3.5Ni	Castings
SA-352	LC4	J41500	70	9C	1	...	101	...	4.5Ni	Castings
SA-352	LC2-1	J42215	105	11A	5	...	102	...	3Ni-1.5Cr-0.5Mo	Castings
SA-352	CA6NM	J91540	110	6	4	...	102	...	13Cr-4Ni	Castings
SA-353	...	K81340	100	11A	1	...	101	...	9Ni	Plate

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QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding			Brazing		Nominal Composition	Product Form	
				P- No.	Group No.	S- No.	Group No.	P- No.			S- No.
SA-372 A		K03002	60	1	1	...	...	101	...	C-Si	Forgings
SA-372 B		K04001	75	1	2	...	...	101	...	C-Mn-Si	Forgings
SA-376	16-8-2H	...	75	8	1	...	...	102	...	16Cr-8Ni-2Mo	Smls. pipe
SA-376	TP304	S30400	70	8	1	...	...	102	...	18Cr-8Ni	Smls. pipe ≥ 0.812 in.
SA-376	TP304	S30400	75	8	1	...	...	102	...	18Cr-8Ni	Smls. pipe < 0.812 in.
SA-376	TP304H	S30409	75	8	1	...	...	102	...	18Cr-8Ni	Smls. pipe
SA-376	TP304N	S30451	80	8	1	...	...	102	...	18Cr-8Ni-N	Smls. pipe
SA-376	TP304LN	S30453	75	8	1	...	...	102	...	18Cr-8Ni-N	Smls. pipe
SA-376	TP316	S31600	75	8	1	...	...	102	...	16Cr-12Ni-2Mo	Smls. pipe
SA-376	TP316H	S31609	75	8	1	...	...	102	...	16Cr-12Ni-2Mo	Smls. pipe
SA-376	TP316N	S31651	80	8	1	...	...	102	...	16Cr-12Ni-2Mo-N	Smls. pipe
SA-376	TP316LN	S31653	75	8	1	...	...	102	...	16Cr-12Ni-2Mo-N	Smls. pipe
SA-376	S31725	S31725	75	8	4	...	...	102	...	19Cr-15Ni-4Mo	Smls. pipe
SA-376	S31726	S31726	80	8	4	...	...	102	...	19Cr-15.5Ni-4Mo	Smls. pipe
SA-376	TP321	S32100	70	8	1	...	...	102	...	18Cr-10Ni-Ti	Smls. pipe > 3/8 in.
SA-376	TP321	S32100	75	8	1	...	...	102	...	18Cr-10Ni-Ti	Smls. pipe ≤ 3/8 in.
SA-376	TP321H	S32109	70	8	1	...	...	102	...	18Cr-10Ni-Ti	Smls. pipe > 3/8 in.
SA-376	TP321H	S32109	75	8	1	...	...	102	...	18Cr-10Ni-Ti	Smls. pipe ≤ 3/8 in.
SA-376	TP347	S34700	75	8	1	...	...	102	...	18Cr-10Ni-Cb	Smls. pipe
SA-376	TP347H	S34709	75	8	1	...	...	102	...	18Cr-10Ni-Cb	Smls. pipe
SA-376	TP348	S34800	75	8	1	...	...	102	...	18Cr-10Ni-Cb	Smls. pipe
A 381	Y35	K03013	60	...	...	1	...	101	...	C	Pipe
A 381	Y42	...	60	...	...	1	...	101	...	C	Pipe
A 381	Y48	...	62	...	...	1	...	101	...	C	Pipe > 3/8 in.
A 381	Y46	...	63	...	...	1	...	101	...	C	Pipe
A 381	Y50	...	64	...	...	1	...	101	...	C	Pipe > 3/8 in.
A 381	Y52b	...	66	...	...	1	...	101	...	C	Pipe > 3/8 in.
A 381	Y56b	...	71	...	...	1	...	101	...	C	Pipe > 3/8 in.
A 381	Y52a	...	72	...	...	1	...	101	...	C	Pipe, to 3/8 in.
A 381	Y56a	...	75	...	...	1	...	101	...	C	Pipe, to 3/8 in.
A 381	Y60b	...	75	...	...	1	...	101	...	C	Pipe > 3/8 in.
A 381	Y60a	...	78	...	...	1	...	101	...	C	Pipe > 3/8 in.
SA-387	12, Cl. 1	K11757	55	4	1	102	...	1Cr-0.5Mo	Plate
SA-387	12, Cl. 2	K11757	65	4	1	102	...	1Cr-0.5Mo	Plate

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Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding			Brazing		Nominal Composition	Product Form
				P- No.	Group No.	S- No.	Group No.	P- No.		
SA-409	S30815	87	8	2	...	...	102	...	21Cr-11Ni-N	Welded pipe
SA-409	TP309S	75	8	2	...	...	102	...	23Cr-12Ni	Welded pipe
SA-409	TP309Cb	75	8	2	...	...	102	...	23Cr-12Ni-Cb	Welded pipe
SA-409	TP310S	75	8	2	...	...	102	...	25Cr-20Ni	Welded pipe
SA-409	TP310Cb	75	8	2	...	...	102	...	25Cr-20Ni-Cb	Welded pipe
SA-409	S31254	94	8	4	...	...	102	...	20Cr-18Ni-6Mo	Welded pipe
SA-409	TP316	75	8	1	...	...	102	...	16Cr-12Ni-2Mo	Welded pipe
SA-409	TP316L	70	8	1	...	...	102	...	16Cr-12Ni-2Mo	Welded pipe
SA-409	TP317	75	8	1	...	...	102	...	18Cr-13Ni-3Mo	Welded pipe
SA-409	S31725	75	8	4	...	...	102	...	19Cr-15Ni-4Mo	Welded pipe
SA-409	S31726	80	8	4	...	...	102	...	19Cr-15.5Ni-4Mo	Welded pipe
SA-409	TP321	75	8	1	...	...	102	...	18Cr-10Ni-Ti	Welded pipe
SA-409	TP347	75	8	1	...	...	102	...	18Cr-10Ni-Cb	Welded pipe
SA-409	TP348	75	8	1	...	...	102	...	18Cr-10Ni-Cb	Welded pipe
SA-414	A	45	1	1	...	...	101	...	C	Sheet
SA-414	B	50	1	1	...	...	101	...	C	Sheet
SA-414	C	55	1	1	...	...	101	...	C	Sheet
SA-414	D	60	1	1	...	...	101	...	C-Mn	Sheet
SA-414	E	65	1	1	...	...	101	...	C-Mn	Sheet
SA-414	F	70	1	2	...	...	101	...	C-Mn	Sheet
SA-414	G	75	1	2	...	...	101	...	C-Mn	Sheet
SA-420	WPL6	60	1	1	...	...	101	...	C-Mn-Si	Piping fitting
SA-420	WPL9	63	9A	1	...	...	101	...	2Ni-1Cu	Piping fitting
SA-420	WPL3	65	9B	1	...	...	101	...	3.5Ni	Piping fitting
SA-420	WPL8	100	11A	1	...	...	101	...	9Ni	Piping fitting
SA-423	1	60	4	2	...	...	102	...	0.75Cr-0.5Ni-Cu	Smls. & welded tube
SA-423	2	60	4	2	...	...	102	...	0.75Ni-0.5Cu-Mo	Smls. & welded tube
SA-426	CP15	60	3	1	...	...	101	...	C-0.5Mo-Si	Centrifugal cast pipe
SA-426	CP2	60	3	1	...	...	101	...	0.5Cr-0.5Mo	Centrifugal cast pipe
SA-426	CP12	60	4	1	...	...	102	...	1Cr-0.5Mo	Centrifugal cast pipe
SA-426	CP11	70	4	1	...	...	102	...	1.25Cr-0.5Mo	Centrifugal cast pipe
SA-426	CP1	65	3	1	101	...	C-0.5Mo	Centrifugal cast pipe
SA-426	CP22	70	5A	1	102	...	2.25Cr-1Mo	Centrifugal cast pipe

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QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding				Brazing		Nominal Composition	Product Form
				P- No.	Group No.	S- No.	Group No.	P- No.	S- No.		
SA-452	TP316H	S31609	75	8	1	...	...	102	...	16Cr-12Ni-2Mo	Centrifugal cast pipe
SA-452	TP347H	S34709	75	8	1	...	...	102	...	18Cr-10Ni-Cb	Centrifugal cast pipe
SA-455	...	K03300	70	1	2	...	...	101	...	C-Mn-Si	Plate > 0.580 in.-0.750 in.
SA-455	...	K03300	73	1	2	...	...	101	...	C-Mn-Si	Plate > 0.375 in.-0.580 in.
SA-455	...	K03300	75	1	2	...	...	101	...	C-Mn-Si	Plate, up to 0.375 in.
SA-479	XM-19	S20910	100	8	3	...	...	102	...	22Cr-13Ni-5Mn	Bar & shape
SA-479	XM-17	S21600	90	8	3	...	...	102	...	19Cr-8Mn-6Ni-Mo-N	Bar & shape
SA-479	XM-18	S21603	90	8	3	...	...	102	...	19Cr-8Mn-6Ni-Mo-N	Bar & shape
SA-479	S21800	S21800	95	8	3	...	...	102	...	18Cr-8Ni-4Si-N	Bar & shape
SA-479	XM-11	S21904	90	8	3	...	...	102	...	21Cr-6Ni-9Mn	Bar & shape
SA-479	XM-29	S24000	100	8	3	...	...	102	...	18Cr-3Ni-12Mn	Bar & shape
SA-479	302	S30200	75	8	1	...	...	102	...	18Cr-8Ni	Bar & shape
SA-479	304	S30400	75	8	1	...	...	102	...	18Cr-8Ni	Bar & shape
SA-479	304L	S30403	70	8	1	...	...	102	...	18Cr-8Ni	Bar & shape
SA-479	304H	S30409	75	8	1	...	...	102	...	18Cr-8Ni	Bar & shape
SA-479	304N	S30451	80	8	1	...	...	102	...	18Cr-8Ni-N	Bar & shape
SA-479	304LN	S30453	75	8	1	...	...	102	...	18Cr-8Ni-N	Bar & shape
SA-479	S30600	S30600	78	8	1	...	...	102	...	18Cr-15Ni-4Si	Bar & shape
SA-479	S30815	S30815	87	8	2	...	...	102	...	21Cr-11Ni-N	Bar & shape
SA-479	309S	S30908	75	8	2	...	...	102	...	23Cr-12Ni	Bar & shape
SA-479	309Cb	S30940	75	8	2	...	...	102	...	23Cr-12Ni-Cb	Bar & shape
SA-479	310S	S31008	75	8	2	...	...	102	...	25Cr-20Ni	Bar & shape
SA-479	310Cb	S31040	75	8	2	...	...	102	...	25Cr-20Ni-Cb	Bar & shape
SA-479	S31254	S31254	94	8	4	...	...	102	...	20Cr-18Ni-6Mo	Bar & shape
SA-479	316	S31600	75	8	1	...	...	102	...	16Cr-12Ni-2Mo	Bar & shape
SA-479	316L	S31603	70	8	1	...	...	102	...	16Cr-12Ni-2Mo	Bar & shape
SA-479	316H	S31609	75	8	1	...	...	102	...	16Cr-12Ni-2Mo	Bar & shape
SA-479	316Ti	S31635	75	8	1	...	...	102	...	16Cr-12Ni-2Mo-Ti	Bar & shape
SA-479	316Cb	S31640	75	8	1	...	...	102	...	16Cr-12Ni-2Mo-Cb	Bar & shape
SA-479	316N	S31651	80	8	1	...	...	102	...	16Cr-12Ni-2Mo-N	Bar & shape
SA-479	316LN	S31653	75	8	1	...	...	102	...	16Cr-12Ni-2Mo-N	Bar & shape
SA-479	S31725	S31725	75	8	4	...	...	102	...	19Cr-15Ni-4Mo	Bar & shape
SA-479	S31726	S31726	80	8	4	...	...	102	...	19Cr-15.5Ni-4Mo	Bar & shape
SA-479	321	S32100	75	8	1	...	...	102	...	18Cr-10Ni-Ti	Bar & shape

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding			Brazing		Nominal Composition	Product Form
				P-Group No.	S-Group No.	Group No.	P-No.	S-No.		
SA-487	CA6NM Cl. B	J91540	100	6	4	...	102	...	13Cr-4Ni	Castings
SA-487	CA6NM Cl. A	J91540	110	6	4	...	102	...	13Cr-4Ni	Castings
SA-494	CX2MW	N26022	80	44	...	...	112	...	59Ni-22Cr-14Mo-4Fe-3W	Castings
A 494	CW-6M	N30107	72	...	...	44	...	112	56Ni-19Mo-18Cr-2Fe	Castings
A 500	C	K02705	62	...	...	1	...	101	C	Tube
A 500	B	K03000	58	...	...	1	...	101	C	Tube
A 501	...	K03000	58	...	...	1	...	101	C	Tube
SA-508	3, Cl. 1	K12042	80	3	3	...	101	...	0.75Ni-0.5Mo-Cr-V	Forgings
SA-508	3, Cl. 2	K12042	90	3	3	...	102	...	0.75Ni-0.5Mo-Cr-V	Forgings
SA-508	2, Cl. 1	K12766	80	3	3	...	101	...	0.75Ni-0.5Mo-0.3Cr-V	Forgings
SA-508	2, Cl. 2	K12766	90	3	3	...	101	...	0.75Ni-0.5Mo-0.3Cr-V	Forgings
SA-508	1	K13502	70	1	2	...	101	...	C-Si	Forgings
SA-508	1A	...	70	1	2	...	101	...	C-Mn-Si	Forgings
SA-508	22, Cl. 3	K21590	85	5C	1	...	...	...	2.25Cr-1Mo	Forgings
SA-508	4N, Cl. 3	K22375	90	3	3	...	102	...	3.5Ni-1.75Cr-0.5Mo-V	Forgings
SA-508	4N, Cl. 1	K22375	105	11A	5	...	102	...	3.5Ni-1.75Cr-0.5Mo-V	Forgings
SA-508	4N, Cl. 2	K22375	115	11A	5	...	102	...	3.5Ni-1.75Cr-0.5Mo-V	Forgings
SA-508	3V	K31830	85	5C	1	...	102	...	3Cr-1Mo-V-Ti-B	Forgings
SA-508	5, Cl. 1	K42365	105	11A	5	...	102	...	3.5Ni-1.75Cr-0.5Mo-V	Forgings
SA-508	5, Cl. 2	K42365	115	11A	5	...	102	...	3.5Ni-1.75Cr-0.5Mo-V	Forgings
A 513	1015 CW	G10150	65	...	...	1	...	101	C	Tube
A 513	1020 CW	G10200	70	...	...	1	...	101	C	Tube
A 513	1025 CW	G10250	75	...	...	1	...	101	C	Tube
A 513	1026 CV	G10260	80	...	...	1	...	101	C	Tube
A 514	F	K11576	110	...	...	11B	101	...	0.75Ni-0.5Cr-0.5Mo-V	Plate, 2 1/2 in. max.
A 514	J	K11625	110	...	...	11B	101	...	C-0.5Mo	Plate, 1 1/4 in. max.
A 514	B	K11630	110	...	...	11B	101	...	0.5Cr-0.2Mo-V	Plate, 1 1/4 in. max.
A 514	D	K11662	110	...	...	11B	101	...	1Cr-0.2Mo-Si	Plate, 1 1/4 in. max.
A 514	A	K11856	110	...	...	11B	101	...	0.5Cr-0.25Mo-Si	Plate, 1 1/4 in. max.
A 514	E	K21604	100	11B	102	...	1.75Cr-0.5Mo-Cu	Plate > 2 1/2 in.-6 in., incl.
A 514	E	K21604	110	11B	102	...	1.75Cr-0.5Mo-Cu	Plate, 2 1/2 in. max.

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Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding			Brazing		Nominal Composition	Product Form
				P- No.	Group No.	S- No.	P- No.	S- No.		
A 521	Cl. CE	...	75	...	1	2	...	101	C	Forgings
SA-522	Type II	K71340	100	11A	1	...	101	...	8Ni	Forgings
SA-522	Type I	K81340	100	11A	1	...	101	...	9Ni	Forgings
SA-524	II	K02104	55	1	1	...	101	...	C-Mn-Si	Smls. pipe
SA-524	I	K02104	60	1	1	...	101	...	C-Mn-Si	Smls. pipe
SA-533	Type A, Cl. 1	K12521	80	3	3	...	101	...	Mn-0.5Mo	Plate
SA-533	Type A, Cl. 2	K12521	90	3	3	...	101	...	Mn-0.5Mo	Plate
SA-533	Type A, Cl. 3	K12521	100	11A	4	...	101	...	Mn-0.5Mo	Plate
SA-533	Type D, Cl. 1	K12529	80	3	3	...	101	...	Mn-0.5Mo-0.25Ni	Plate
SA-533	Type D, Cl. 2	K12529	90	3	3	...	101	...	Mn-0.5Mo-0.25Ni	Plate
SA-533	Type D, Cl. 3	K12529	100	11A	4	...	101	...	Mn-0.5Mo-0.25Ni	Plate
SA-533	Type B, Cl. 1	K12539	80	3	3	...	101	...	Mn-0.5Mo-0.5Ni	Plate
SA-533	Type B, Cl. 2	K12539	90	3	3	...	101	...	Mn-0.5Mo-0.5Ni	Plate
SA-533	Type B, Cl. 3	K12539	100	11A	4	...	101	...	Mn-0.5Mo-0.5Ni	Plate
SA-533	Type C, Cl. 1	K12554	80	3	3	...	101	...	Mn-0.5Mo-0.75Ni	Plate
SA-533	Type C, Cl. 2	K12554	90	3	3	...	101	...	Mn-0.5Mo-0.75Ni	Plate
SA-533	Type C, Cl. 3	K12554	100	11A	4	...	101	...	Mn-0.5Mo-0.75Ni	Plate
SA-537	Cl. 1	K12437	65	1	2	...	101	...	C-Mn-Si	Plate > 2 1/2 in.-4 in.
SA-537	Cl. 1	K12437	70	1	2	...	101	...	C-Mn-Si	Plate, 2 1/2 in. & under
SA-537	Cl. 2	K12437	70	1	3	...	101	...	C-Mn-Si	Plate > 4 in.-6 in., incl.
SA-537	Cl. 2	K12437	75	1	3	...	101	...	C-Mn-Si	Plate > 2 1/2 in.-4 in.
SA-537	Cl. 2	K12437	80	1	3	...	101	...	C-Mn-Si	Plate, 2 1/2 in. & under
SA-537	Cl. 3	K12437	70	1	3	...	101	...	C-Mn-Si	Plate > 4 in.
SA-537	Cl. 3	K12437	75	1	3	...	101	...	C-Mn-Si	Plate, 2 1/2 in. < t ≤ 4 in.
SA-537	Cl. 3	K12437	80	1	3	...	101	...	C-Mn-Si	Plate ≤ 2 1/2 in.
SA-541	1	K03506	70	1	2	...	101	...	C-Si	Forgings
SA-541	1A	...	70	1	2	...	101	...	C-Mn-Si	Forgings
SA-541	11, Cl. 4	K11572	80	4	1	...	102	...	1.25Cr-0.5Mo-Si	Forgings
SA-541	3, Cl. 1	K12045	80	3	3	...	101	...	0.5Ni-0.5Mo-V	Forgings
SA-541	3, Cl. 2	K12045	90	3	3	...	101	...	0.5Ni-0.5Mo-V	Forgings
SA-541	2, Cl. 1	K12765	80	3	3	...	101	...	0.75Ni-0.5Mo-0.3Cr-V	Forgings
SA-541	2, Cl. 2	K12765	90	3	3	...	101	...	0.75Ni-0.5Mo-0.3Cr-V	Forgings

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

WELDING DATA

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Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding			Brazing		Nominal Composition	Product Form	
				P- No.	Group No.	S- No.	Group No.	P- No.			S- No.
SA-562	...	K11224	55	1	1	...	...	101	...	C-Mn-Ti	Plate
A 570	30	K02502	49	...	...	1	1	...	101	C	Sheet & strip
A 570	33	K02502	52	...	...	1	1	...	101	C	Sheet & strip
A 570	36	K02502	53	...	...	1	1	...	101	C	Sheet & strip
A 570	40	K02502	55	...	...	1	1	...	101	C	Sheet & strip
A 570	45	K02507	60	...	...	1	1	...	101	C	Sheet & strip
A 570	50	K02507	65	...	...	1	1	...	101	C	Sheet & strip
A 572	42	...	60	...	...	1	1	...	101	C-Mn-Si	Plate & shapes
A 572	50	...	65	...	...	1	1	...	101	C-Mn-Si	Plate & shapes
A 572	60	...	75	...	...	1	2	...	101	C-Mn-Si	Plate & shapes
A 573	...	...	...	...	...	1	1	...	101	C	Plate
A 575	...	...	...	...	...	1	1	...	101	C	Bar
A 576	...	...	...	...	...	1	1	...	101	C	Bar
SA-587	...	K11500	48	1	1	...	...	101	...	C	E.R.W. pipe
A 588	A, a	K11430	63	...	...	3	1	...	101	Mn-0.5Cr-0.3Cu-Si-V	Plate & bar
A 588	A, b	K11430	67	...	...	3	1	...	101	Mn-0.5Cr-0.3Cu-Si-V	Plate & bar
A 588	A, c	K11430	70	...	...	3	1	...	101	Mn-0.5Cr-0.3Cu-Si-V	Plate & shapes
A 588	B, a	K12043	63	...	...	3	1	...	101	Mn-0.6Cr-0.3Cu-Si-V	Plate & bar
A 588	B, b	K12043	67	...	...	3	1	...	101	Mn-0.6Cr-0.3Cu-Si-V	Plate & bar
A 588	B, c	K12043	70	...	...	3	1	...	101	Mn-0.6Cr-0.3Cu-Si-V	Plate & shapes
SA-592	F	K11576	105	11B	3	...	...	101	...	0.75Ni-0.5Cr-0.5Mo-V	Forgings, 2 1/2 in.-4 in.
SA-592	F	K11576	115	11B	3	...	...	101	...	0.75Ni-0.5Cr-0.5Mo-V	Forgings, 2 1/2 in. & under
SA-592	E	K11695	105	11B	2	...	...	102	...	1.75Cr-0.5Mo-Cu	Forgings, 2 1/2 in.-4 in.
SA-592	E	K11695	115	11B	2	...	...	102	...	1.75Cr-0.5Mo-Cu	Forgings, 2 1/2 in. & under
SA-592	A	K11856	105	11B	1	...	...	101	...	0.5Cr-0.25Mo-Si	Forgings, 2 1/2 in.-4 in.
SA-592	A	K11856	115	11B	1	...	...	101	...	0.5Cr-0.25Mo-Si	Forgings, 2 1/2 in. & under
A 611	A	G10170	42	...	...	1	1	...	101	C	Sheet
A 611	B	G10170	45	...	...	1	1	...	101	C	Sheet
A 611	C	G10170	48	1	1	...	101	C	Sheet
SA-612	...	K02900	81	10C	1	101	...	C-Mn-Si	Plate > 1/2 in.-1 in.

WELDING DATA

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QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding				Brazing		Nominal Composition	Product Form
				P- No.	Group No.	S- No.	Group No.	P- No.	S- No.		
A 668	Cl. C	G10250	66	...	...	1	1	...	...	C	Forgings
A 668	Cl. D	G10300	75	...	...	1	2	...	...	C-Mn	Forgings
A 668	Cl. F b	...	85	...	...	1	3	...	...	C-Mn	Forgings > 4 in.-10 in.
A 668	Cl. F a	...	90	...	...	1	3	...	...	C-Mn	Forgings, to 4 in.
A 668	Cl. K b	...	100	...	...	4	3	...	...	C	Forgings > 7 in.-10 in.
A 668	Cl. K a	...	105	...	...	4	3	...	...	C	Forgings, to 7 in.
A 668	Cl. L c	...	110	...	...	4	3	...	...	C	Forgings > 7 in.-10 in.
A 668	Cl. L b	...	115	...	...	4	3	...	...	C	Forgings > 4 in.-7 in.
A 668	Cl. L a	...	125	...	...	4	3	...	...	C	Forgings, to 4 in.
SA-671	CC60	K02100	60	1	1	...	...	101	...	C-Mn-Si	Fusion welded pipe
SA-671	CE55	K02202	55	1	1	...	...	101	...	C-Mn-Si	Fusion welded pipe
SA-671	CD70	K12437	70	1	2	...	...	101	...	C-Mn-Si	Fusion welded pipe
SA-671	CD80	K12437	80	1	3	...	...	101	...	C-Mn-Si	Fusion welded pipe
SA-671	CB60	K02401	60	1	1	...	...	101	...	C-Si	Fusion welded pipe
SA-671	CE60	K02402	60	1	1	...	...	101	...	C-Mn-Si	Fusion welded pipe
SA-671	CC65	K02403	65	1	1	...	...	101	...	C-Mn-Si	Fusion welded pipe
SA-671	CC70	K02700	70	1	2	...	...	101	...	C-Mn-Si	Fusion welded pipe
SA-671	CB65	K02800	65	1	1	...	...	101	...	C-Si	Fusion welded pipe
SA-671	CA55	K02801	55	1	1	...	...	101	...	C	Fusion welded pipe
SA-671	CK75	K02803	75	1	2	...	...	101	...	C-Mn-Si	Fusion welded pipe
SA-671	CB70	K03101	70	1	2	...	...	101	...	C-Si	Fusion welded pipe
SA-672	A45	K01700	45	1	1	...	...	101	...	C	Fusion welded pipe
SA-672	C55	K01800	55	1	1	...	...	101	...	C-Si	Fusion welded pipe
SA-672	B55	K02001	55	1	1	...	...	101	...	C-Si	Fusion welded pipe
SA-672	C60	K02100	60	1	1	...	...	101	...	C-Mn-Si	Fusion welded pipe
SA-672	A50	K02200	50	1	1	...	...	101	...	C	Fusion welded pipe
SA-672	E55	K02202	55	1	1	...	...	101	...	C	Fusion welded pipe
SA-672	D70	K12437	70	1	2	...	...	101	...	C-Mn-Si	Fusion welded pipe
SA-672	D80	K12437	80	1	3	...	...	101	...	C-Mn-Si	Fusion welded pipe
SA-672	B60	K02401	60	1	1	...	...	101	...	C-Si	Fusion welded pipe
SA-672	E60	K02402	60	1	1	...	...	101	...	C-Mn-Si	Fusion welded pipe
SA-672	C65	K02403	65	1	1	...	...	101	...	C-Mn-Si	Fusion welded pipe
SA-672	C70	K02700	70	1	2	...	...	101	...	C-Mn-Si	Fusion welded pipe
SA-672	B65	K02800	65	1	1	...	...	101	...	C-Si	Fusion welded pipe

QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding			Brazing			Nominal Composition	Product Form
				P- No.	Group No.	S- No.	P- No.	S- No.			
SA-691	1.25CR, Cl. 1	K11789	60	4	1	...	...	102	...	1.25Cr-0.5Mo-Si	Fusion welded pipe
SA-691	1.25CR, Cl. 2	K11789	75	4	1	...	...	102	...	1.25Cr-0.5Mo-Si	Fusion welded pipe
SA-691	CM-65	K11820	65	3	1	...	...	101	...	C-0.5Mo	Fusion welded pipe
SA-691	CM-70	K12020	70	3	2	...	...	101	...	C-0.5Mo	Fusion welded pipe
SA-691	0.5CR, Cl. 1	K12143	55	3	1	...	...	101	...	0.5Cr-0.5Mo	Fusion welded pipe
SA-691	0.5CR, Cl. 2	K12143	70	3	2	...	...	101	...	0.5Cr-0.5Mo	Fusion welded pipe
SA-691	CM-75	K12320	75	3	2	...	...	101	...	C-0.5Mo	Fusion welded pipe
SA-691	2.25CR, Cl. 1	K21590	60	5A	1	...	...	102	...	2.25Cr-1Mo	Fusion welded pipe
SA-691	2.25CR, Cl. 2	K21590	75	5A	1	...	...	102	...	2.25Cr-1Mo	Fusion welded pipe
SA-691	3CR, Cl. 1	K31545	60	5A	1	...	...	102	...	3Cr-1Mo	Fusion welded pipe
SA-691	3CR, Cl. 2	K31545	75	5A	1	...	...	102	...	3Cr-1Mo	Fusion welded pipe
SA-691	5CR, Cl. 1	K41545	60	5B	1	...	...	102	...	5Cr-0.5Mo	Fusion welded pipe
SA-691	5CR, Cl. 2	K41545	75	5B	1	...	...	102	...	5Cr-0.5Mo	Fusion welded pipe
A 691	9CR, Cl. 2	...	85	...	...	5B	2	...	...	9Cr-1Mo-V	Fusion welded pipe
A 694	...	K03014	...	...	...	1	1	...	...	C	Forgings
SA-695	Type B, Gr. 35	K03504	60	1	1	...	...	101	...	C-Mn-Si	Bar
SA-695	Type B, Gr. 40	K03504	70	1	2	...	...	101	...	C-Mn-Si	Bar
SA-696	B	K03200	60	1	1	...	...	101	...	C-Mn-Si	Bar
SA-696	C	K03200	70	1	2	...	...	101	...	C-Mn-Si	Bar
A 714	Gr. V, Tp. E	K22035	65	...	...	9A	1	...	102	2Ni-1Cu	Smls. & welded pipe
A 714	Gr. V	K22035	65	...	...	9A	1	...	102	2Ni-1Cu	Smls. & welded pipe
SA-724	A	K11831	90	1	4	...	...	101	...	C-Mn-Si	Plate
SA-724	B	K12031	95	1	4	...	...	101	...	C-Mn-Si	Plate
SA-724	C	K12037	90	1	4	...	...	101	...	C-Mn-Si	Plate
SA-727	...	K02506	60	1	1	...	...	101	...	C-Mn-Si	Forgings
SA-731	S41500	S41500	115	6	4	...	...	102	...	13Cr-4.5Ni-Mo	Smls. & welded pipe
SA-731	TP439	S43035	60	7	2	...	...	102	...	18Cr-Ti	Smls. & welded pipe
SA-731	18Cr-2Mo	S44400	60	7	2	...	...	102	...	18Cr-2Mo	Smls. & welded pipe
SA-731	TPXM-33	S44626	65	10I	1	...	...	102	...	27Cr-1Mo-Ti	Smls. & welded pipe
SA-731	TPXM-27	S44627	65	10I	1	102	...	27Cr-1Mo	Smls. & welded pipe
SA-731	S44660	S44660	85	10K	1	102	...	26Cr-3Ni-3Mo	Smls. & welded pipe

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QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding			Brazing		Nominal Composition	Product Form
				P-Group No.	S-Group No.	S-No.	P-Group No.	S-No.		
SA-790	S32900	S32900	90	10H	1	...	102	...	26Cr-4Ni-Mo	Smls. & welded pipe
SA-790	S32950	S32950	100	10H	1	...	102	...	26Cr-4Ni-Mo-N	Smls. & welded pipe
SA-790	S32760	S32760	109	...	...	10H	...	102	25Cr-8Ni-3Mo-W-Cu-N	Smls. & welded tube
SA-803	TP439	S43035	70	7	2	...	102	...	17Cr-Ti	Welded tube
SA-803	26-3-3	S44660	85	10K	1	...	102	...	26Cr-3Ni-3Mo	Welded tube
SA-813	TPXM-19	S20910	100	8	3	...	102	...	22Cr-13Ni-5Mn	Welded pipe
SA-813	TPXM-11	S21904	90	8	3	...	102	...	21Cr-6Ni-9Mn	Welded pipe
SA-813	TPXM-29	S24000	100	8	3	...	102	...	18Cr-3Ni-12Mn	Welded pipe
SA-813	TP304	S30400	75	8	1	...	102	...	18Cr-8Ni	Welded pipe
SA-813	TP304L	S30403	70	8	1	...	102	...	18Cr-8Ni	Welded pipe
SA-813	TP304H	S30409	75	8	1	...	102	...	18Cr-8Ni	Welded pipe
SA-813	TP304N	S30451	80	8	1	...	102	...	18Cr-8Ni-N	Welded pipe
SA-813	TP304LN	S30453	75	8	1	...	102	...	18Cr-8Ni-N	Welded pipe
SA-813	S30815	S30815	87	8	2	...	102	...	21Cr-11Ni-N	Welded pipe
SA-813	TP309S	S30908	75	8	2	...	102	...	23Cr-12Ni	Welded pipe
SA-813	TP309Cb	S30940	75	8	2	...	102	...	23Cr-12Ni-Cb	Welded pipe
SA-813	TP310S	S31008	75	8	2	...	102	...	25Cr-20Ni	Welded pipe
SA-813	TP310Cb	S31040	75	8	2	...	102	...	25Cr-20Ni-Cb	Welded pipe
SA-813	S31254	S31254	94	8	4	...	102	...	20Cr-18Ni-6Mo	Welded pipe
SA-813	TP316	S31600	75	8	1	...	102	...	16Cr-12Ni-2Mo	Welded pipe
SA-813	TP316L	S31603	70	8	1	...	102	...	16Cr-12Ni-2Mo	Welded pipe
SA-813	TP316H	S31609	75	8	1	...	102	...	16Cr-12Ni-2Mo	Welded pipe
SA-813	TP316N	S31651	80	8	1	...	102	...	16Cr-12Ni-2Mo-N	Welded pipe
SA-813	TP316LN	S31653	75	8	1	...	102	...	16Cr-12Ni-2Mo-N	Welded pipe
SA-813	TP317	S31700	75	8	1	...	102	...	18Cr-13Ni-3Mo	Welded pipe
SA-813	TP317L	S31703	75	8	1	...	102	...	18Cr-13Ni-3Mo	Welded pipe
SA-813	TP321	S32100	75	8	1	...	102	...	18Cr-10Ni-Ti	Welded pipe
SA-813	TP321H	S32109	75	8	1	...	102	...	18Cr-10Ni-Ti	Welded pipe
SA-813	TP347	S34700	75	8	1	...	102	...	18Cr-10Ni-Cb	Welded pipe
SA-813	TP347H	S34709	75	8	1	...	102	...	18Cr-10Ni-Cb	Welded pipe
SA-813	TP348	S34800	75	8	1	...	102	...	18Cr-10Ni-Cb	Welded pipe
SA-813	TP348H	S34809	75	8	1	...	102	...	18Cr-10Ni-Cb	Welded pipe
SA-813	TPXM-15	S38100	75	8	1	...	102	...	18Cr-18Ni-2Si	Welded pipe

WELDING DATA

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QW/QB-422 FERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi	Welding				Brazing		Nominal Composition	Product Form
				P-Group No.	S-Group No.	Group No.	P-No.	S-No.			
SA-836	...	...	55	1	1	...	101	...	C-Si-Ti	Forgings
SA-841	...	...	65	10C	1	...	101	...	C-Mn-Si	Plate > 2 1/2 in.
SA-841	...	...	70	10C	1	...	101	...	C-Mn-Si	Plate, 2 1/2 in. & under
A 890	CD3MWCuN	J93380	100	...	10H	1	...	102	25Cr-8Ni-3Mo-W-Cu-N	Castings	
A 928	...	S32760	109	...	10H	1	...	102	25Cr-8Ni-3Mo-W-Cu-N	Welded pipe	
API 5L	A25, Cl. I	...	45	...	1	1	...	101	C-Mn	Smls. & welded pipe & tubes	
API 5L	A25, Cl. II	...	45	...	1	1	...	101	C-Mn	Smls. & welded pipe & tubes	
API 5L	A	...	48	...	1	1	...	101	C-Mn	Smls. & welded pipe & tubes	
API 5L	B	...	60	...	1	1	...	101	C-Mn	Smls. & welded pipe & tubes	
API 5L	X42	...	60	...	1	1	...	101	C-Mn	Smls. & welded pipe & tubes	
API 5L	X46	...	63	...	1	1	...	101	C-Mn	Smls. & welded pipe & tubes	
API 5L	X52	...	66	...	1	1	...	101	C-Mn	Smls. & welded pipe & tubes	
API 5L	X56	...	71	...	1	2	...	101	C-Mn	Smls. & welded pipe & tubes	
API 5L	X60	...	75	...	1	2	...	101	C-Mn	Smls. & welded pipe & tubes	
API 5L	X65	...	77	...	1	2	...	101	C-Mn	Smls. & welded pipe & tubes	
API 5L	X70	...	82	...	1	3	...	101	C-Mn	Smls. & welded pipe & tubes	
API 5L	X80	...	90	...	1	4	...	101	C-Mn	Smls. & welded pipe & tubes	
MSS SP-75	WPHY-42	...	60	...	1	1	...	101	C-Mn	Smls./welded fittings	
MSS SP-75	WPHY-46	...	63	...	1	1	...	101	C-Mn	Smls./welded fittings	
MSS SP-75	WPHY-52	...	66	...	1	1	...	101	C-Mn	Smls./welded fittings	
MSS SP-75	WPHY-56	...	71	...	1	2	...	101	C-Mn	Smls./welded fittings	
MSS SP-75	WPHY-60	...	75	...	1	2	...	101	C-Mn	Smls./welded fittings	
MSS SP-75	WPHY-65	...	77	...	1	2	...	101	C-Mn	Smls./welded fittings	
MSS SP-75	WPHY-70	...	82	...	1	3	...	101	C-Mn	Smls./welded fittings	
SA/CSA-G 40.21	Gr. 38W	...	60	1	1	...	101	...	C-Mn-Si	Plate, bar, & shapes	
SA/CSA-G 40.21	Gr. 44W	...	60	1	1	...	101	...	C-Mn-Si	Plate, bar, & shapes	

WELDING DATA

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QW/QB-422 NONFERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
 (Grouping of Base Metals for Qualification)

WELDING DATA

QW/QB-422

Spec. No.	UNS No.	Type or Grade	Alloy	Minimum Specified Tensile, ksi		Welding		Brazing		Condition	Size(s) or Thickness, in.	Nominal Composition	Product Form
				P. No.	S. No.	P. No.	S. No.	P. No.	S. No.				
SB-98	C65100	...	...	33	...	...	...	107	...	Soft	...	1.6Si	Rod, bar, & shapes
SB-98	C65100	...	...	33	...	...	...	107	...	Half hard	To 2 diam.	1.6Si	Rod, bar, & shapes
SB-98	C65100	...	...	33	...	...	...	107	...	Bolt temper	Over 1-1.5	1.6Si	Rod, bar, & shapes
SB-98	C65100	...	...	33	...	...	...	107	...	Bolt temper	0.5 to 1	1.6Si	Rod, bar, & shapes
SB-98	C65100	...	...	33	...	...	...	107	...	Bolt temper	Up to 0.5	1.6Si	Rod, bar, & shapes
SB-98	C65500	...	...	33	...	...	...	107	...	Quarter hard	...	3.2Si	Rod, bar, & shapes
SB-98	C65500	...	...	33	...	...	...	107	...	Half hard	To 2 diam.	3.2Si	Rod, bar, & shapes
SB-98	C65500	...	...	33	...	...	...	107	...	Soft	...	3.2Si	Rod, bar, & shapes
SB-98	C66100	...	...	33	...	...	...	107	...	Soft	...	3.2Si	Rod, bar, & shapes
SB-98	C66100	...	...	33	...	...	...	107	...	Quarter hard	...	3.2Si	Rod, bar, & shapes
SB-98	C66100	...	...	33	...	...	...	107	...	Half hard	To 2 diam.	3.2Si	Rod, bar, & shapes
SB-111	C10200	...	...	31	...	...	...	107	...	Light drawn	...	99.95Cu + Ag	Smls. tube
SB-111	C10200	...	...	31	...	...	...	107	...	Hard drawn	...	99.95 ^u + Ag	Smls. tube
SB-111	C12000	...	...	31	...	...	...	107	...	Light drawn	...	99.9Cu + Ag	Smls. tube
SB-111	C12000	...	...	31	...	...	...	107	...	Hard drawn	...	99.9Cu + Ag	Smls. tube
SB-111	C19200	...	...	31	...	...	...	107	...	Hard drawn	...	99.9Cu + Ag	Smls. tube
SB-111	C12200	...	...	31	...	...	...	107	...	Light drawn	...	99.90Cu + Ag	Smls. tube
SB-111	C12200	...	...	31	...	...	...	107	...	Hard drawn	...	99.9Cu + Ag	Smls. tube
SB-111	C14200	...	...	31	...	...	...	107	...	Light drawn	...	99.4Cu + Ag	Smls. tube
SB-111	C14200	...	...	31	...	...	...	107	...	Hard drawn	...	99.4Cu + Ag	Smls. tube
SB-111	C19200	...	...	31	...	...	...	107	...	Annealed	...	99.7Cu + Fe	Smls. tube
SB-111	C23000	...	...	32	...	...	...	107	...	Annealed	...	15Zn	Smls. tube
SB-111	C28000	...	...	32	...	...	...	107	...	Annealed	...	40Zn	Smls. tube
SB-111	C44300	...	...	32	...	...	...	107	...	Annealed	...	28Zn-1Sn-0.06As	Smls. tube
SB-111	C44400	...	...	32	...	...	...	107	...	Annealed	...	28Zn-1Sn-0.06Sb	Smls. tube
SB-111	C44500	...	...	32	...	...	...	107	...	Annealed	...	28Zn-1Sn-0.06P	Smls. tube
SB-111	C60800	...	...	35	...	...	...	108	...	Annealed	...	5.8Al	Smls. tube
SB-111	C66700	...	...	32	...	...	...	108	...	Annealed	...	20Zn-2Al	Smls. tube
SB-111	C70400	...	...	34	...	...	...	107	...	Annealed	...	5.5Ni	Smls. tube
SB-111	C70400	...	...	34	...	...	...	107	...	Annealed	...	5.5Ni	Smls. tube
SB-111	C70600	...	...	34	...	...	...	107	...	Annealed	...	10Ni	Smls. tube
SB-111	C70600	...	...	34	...	...	...	107	...	Light drawn	...	10Ni	Smls. tube
SB-111	C71000	...	...	34	...	...	...	107	...	Annealed	...	20Ni	Smls. tube
SB-111	C71500	...	...	34	...	...	...	107	...	Annealed	...	30Ni	Smls. tube
SB-111	C71500	...	...	34	...	...	...	107	...	Drawn & stress rel.	...	30Ni	Smls. tube
SB-111	C71640	...	061	34	...	...	...	107	...	Annealed	...	30.5Ni-2Fe-2Mn	Smls. tube
SB-111	C71640	...	HR50	34	...	...	...	107	...	Drawn & stress rel.	...	30.5Ni-2Fe-2Mn	Smls. tube
SB-111	C72200	...	061	34	...	...	...	107	...	Annealed	...	16.5Ni-0.75Fe-0.5Cr	Smls. tube
SB-111	C72200	...	H55	34	...	...	...	107	...	Light drawn	...	16.5Ni-0.75Fe-0.5Cr	Smls. tube
SB-127	N04400	...	...	42	...	...	...	110	...	Annealed	...	67Ni-30Cu	Plate, sheet, & strip
SB-127	N04400	...	...	42	...	...	...	110	...	Hot rolled	...	67Ni-30Cu	Plate, sheet, & strip
SB-135	C23000	...	...	32	...	...	...	107	...	Annealed	...	15Zn	Smls. tube

QW/QB-422 NONFERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
(Grouping of Base Metals for Qualification)

Spec. No.	UNS No.	Type or Grade	Alloy	Minimum Specified Tensile, ksi	Welding		Brazing		Condition	Size(s) or Thickness, in.	Nominal Composition	Product Form
					P-No.	S-No.	P-No.	S-No.				
SB-152	C14200	...	...	30	31	...	...	107	Hot rolled & annealed	...	99.4Cu + Ag	Pit, sht, strip, & bar
SB-160	N02200	...	...	55	41	...	...	110	Annealed	...	99.0Ni	Rod & bar
SB-160	N02200	...	...	60	41	...	...	110	Hot worked	...	99.0Ni	Rod & bar
SB-160	N02200	...	...	65	41	...	...	110	Cold worked	All	99.0Ni	Rod & bar
SB-160	N02200	...	...	75	41	...	...	110	Cold worked	> 1-4	99.0Ni	Rod & bar
SB-160	N02200	...	...	80	41	...	...	110	Cold worked	1 & under	99.0Ni	Rod & bar
SB-160	N02201	...	...	50	41	...	...	110	Hot worked	All	Low C-99.0Ni	Rod & bar
SB-160	N02201	...	...	50	41	...	...	110	Annealed	All	Low C-99.0Ni	Rod & bar
SB-161	N02200	...	...	55	41	...	...	110	Annealed	...	99.0Ni	Smis. pipe & tube
SB-161	N02200	...	...	65	41	...	...	110	Stress relieved	...	99.0Ni	Smis. pipe & tube
SB-161	N02201	...	...	50	41	...	...	110	Annealed	...	Low C-99.0Ni	Smis. pipe & tube
SB-161	N02201	...	...	60	41	...	...	110	Stress relieved	...	Low C-99.0Ni	Smis. pipe & tube
SB-162	N02200	...	...	55	41	...	...	110	Annealed	...	99.0Ni	Plate, sheet, & strip
SB-162	N02200	...	...	55	41	...	...	110	Hot rolled	...	99.0Ni	Plate, sheet, & strip
SB-162	N02201	...	...	50	41	...	...	110	Hot rolled	...	Low C-99.0Ni	Plate, sheet, & strip
SB-162	N02201	...	...	50	41	...	...	110	Annealed	...	Low C-99.0Ni	Plate, sheet, & strip
SB-163	N02200	...	...	55	41	...	...	110	Annealed	...	99.0Ni	Smis. tube
SB-163	N02200	...	...	65	41	...	...	110	Stress relieved	...	99.0Ni	Smis. tube
SB-163	N02201	...	...	50	41	...	...	110	Annealed	...	Low C-99.0Ni	Smis. tube
SB-163	N02201	...	...	60	41	...	...	110	Stress relieved	...	Low C-99.0Ni	Smis. tube
SB-163	N04400	...	...	70	42	...	...	110	Annealed	...	67Ni-30Cu	Smis. tube
SB-163	N04400	...	...	85	42	...	...	110	Stress relieved	...	67Ni-30Cu	Smis. tube
SB-163	N06600	...	...	80	43	...	...	111	Annealed	...	72Ni-15Cr-8Fe	Smis. tube
SB-163	N06690	...	...	85	43	...	...	111	Annealed	...	58Ni-29Cr-9Fe	Smis. tube
SB-163	N08800	...	...	75	45	...	...	111	Annealed	...	33Ni-42Fe-21Cr	Smis. tube
SB-163	N08810	...	...	65	45	...	...	111	Annealed	...	33Ni-21Cr-1 (Al+Ti)	Smis. tube
SB-163	N08811	...	...	65	45	...	...	111	Annealed	...	33Ni-21Cr-1 (Al+Ti)	Smis. tube
SB-163	N08825	...	...	85	45	...	...	111	Annealed	...	42Ni-21.5Cr-3Mo-2.3Cu	Smis. tube
SB-164	N04400	...	...	80	42	...	...	110	Cold worked (stress-rel.)	> 2-3 ¹ / ₁₆ , incl.	67Ni-30Cu	Rod, bar, & wire
SB-164	N04400	...	...	110	42	...	...	110	Cold worked	Rds. under 0.5	67Ni-30Cu	Rod, bar, & wire
SB-164	N04400	...	...	70	42	...	...	110	Annealed	Hex > 2 ¹ / ₁₆ -4, incl.	67Ni-30Cu	Rod, bar, & wire
SB-164	N04400	...	...	75	42	...	...	110	Hot worked	> 12-14, incl.	67Ni-30Cu	Rod, bar, & wire
SB-164	N04400	...	...	75	42	...	...	110	Hot worked	> 12-14, incl.	67Ni-30Cu	Rod, bar, & wire
SB-164	N04400	...	...	80	42	...	...	110	Hot worked	Ex. hex > 2.125	67Ni-30Cu	Rod, bar, & wire
SB-164	N04400	...	...	84	42	...	...	110	Cold worked (stress-rel.)	Rds. > 3.5-4, incl.	67Ni-30Cu	Rod, bar, & wire
SB-164	N04400	...	...	84	42	...	...	110	Cold worked (stress-rel.)	2 & under	67Ni-30Cu	Rod, bar, & wire
SB-164	N04400	...	...	84	42	...	...	110	Cold worked (stress-rel.)	Under 0.5	67Ni-30Cu	Rod, bar, & wire
SB-164	N04400	...	...	85	42	...	...	110	Cold worked	Under 0.5	67Ni-30Cu	Rod, bar, & wire
SB-164	N04400	...	...	87	42	...	...	110	Cold worked (stress-rel.)	0.5-3.5, incl.	67Ni-30Cu	Rod, bar, & wire
SB-164	N04405	...	...	75	42	...	...	110	Hot worked	Rds. 3 & less	67Ni-30Cu	Rod, bar, & wire
SB-164	N04405	...	...	80	42	...	...	110	Cold worked (stress-rel.)	> 2-3 ¹ / ₁₆ , incl.	67Ni-30Cu	Rod, bar, & wire
SB-164	N04405	80	42	110	Cold worked (stress-rel.)	> 3-4, incl.	67Ni-30Cu	Rod, bar, & wire

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QW/QB-422 NONFERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
(Grouping of Base Metals for Qualification)

Spec. No.	UNS No.	Type or Grade	Alloy	Minimum Specified Tensile, ksi	Welding		Brazing		Condition	Sizes or Thickness, in.	Nominal Composition	Product Form
					P. No.	S. No.	P. No.	S. No.				
SB-171	C63000	...	...	85	35	...	108	...	Annealed	> 2-3.5, incl. 2 & under	10Al-5Ni-3Fe	Plate & sheet
SB-171	C63000	...	...	90	35	...	108	...	Annealed	To 2.5, incl.	10Al-5Ni-3Fe	Plate & sheet
SB-171	C70600	...	...	40	34	...	107	...	Annealed	> 2.5-5, incl.	10Ni	Plate & sheet
SB-171	C71500	...	...	45	34	...	107	...	Annealed	To 2.5, incl.	30Ni	Plate & sheet
SB-171	C71500	...	...	50	34	...	107	...	Annealed	To 2.5, incl.	30Ni	Plate & sheet
SB-187	C10200	...	060	30	31	...	...	...	...	All	99.95Cu + Ag	Rod & bar
SB-187	C11000	...	060	30	31	...	...	...	...	All	99.90Cu + Ag	Rod & bar
SB-209	A91060	...	1060	8	21	...	104	...	...	0.051-3.000	99.6 min. Al	Plate & sheet
SB-209	A91100	...	1100	11	21	...	104	...	...	0.006-3.000	99.0 min. Al	Plate & sheet
SB-209	A93003	...	3003	14	21	...	104	...	...	0.006-3.000	1.2Mn	Plate & sheet
SB-209	A93004	...	3004	22	22	...	104	...	...	0.006-3.000	1.2Mn-1.0Mg	Plate & sheet
SB-209	A95052	...	5052	25	22	...	105	...	...	0.051-3.000	2.5Mg-0.25Cr	Plate & sheet
SB-209	A95083	...	5083	36	25	...	105	...	...	7.001-8.000	4.5Mg-0.8Mn-0.15Cr	Plate & sheet
SB-209	A95083	...	5083	37	25	...	105	...	...	5.001-7.000	4.5Mg-0.8Mn-0.15Cr	Plate & sheet
SB-209	A95083	...	5083	38	25	...	105	...	...	3.001-5.000	4.5Mg-0.8Mn-0.15Cr	Plate & sheet
SB-209	A95083	...	5083	39	25	...	105	...	...	1.501-3.000	4.5Mg-0.8Mn-0.15Cr	Plate & sheet
SB-209	A95083	...	5083	40	25	...	105	...	...	0.051-1.500	4.5Mg-0.8Mn-0.15Cr	Plate & sheet
SB-209	A95086	...	5086	34	25	...	105	...	...	2.001-3.000	4.0Mg-0.5Mn-0.15Cr	Plate & sheet
SB-209	A95086	...	5086	35	25	...	105	...	...	0.051-2.000	4.0Mg-0.5Mn-0.15Cr	Plate & sheet
SB-209	A95154	...	5154	30	22	...	105	...	...	0.051-3.000	3.5Mg-0.25Cr	Plate & sheet
SB-209	A95254	...	5254	30	22	...	105	...	...	0.051-3.000	3.5Mg-0.25Cr	Plate & sheet
SB-209	A95454	...	5454	31	22	...	105	...	...	0.051-3.000	2.75Mg-0.8Mn-0.1Cr	Plate & sheet
SB-209	A95456	...	5456	38	25	...	105	...	...	7.001-8.000	5.1Mg-0.8Mn-0.1Cr	Plate & sheet
SB-209	A95456	...	5456	39	25	...	105	...	...	5.001-7.000	5.1Mg-0.8Mn-0.1Cr	Plate & sheet
SB-209	A95456	...	5456	40	25	...	105	...	...	3.000-5.000	5.1Mg-0.8Mn-0.1Cr	Plate & sheet
SB-209	A95456	...	5456	41	25	...	105	...	...	1.501-3.000	5.1Mg-0.8Mn-0.1Cr	Plate & sheet
SB-209	A95456	...	5456	42	25	...	105	...	...	0.051-1.500	5.1Mg-0.8Mn-0.1Cr	Plate & sheet
SB-209	A95652	...	5652	25	22	...	105	...	...	0.051-3.000	2.5Mg-0.25Cr-0.01Mn	Plate & sheet
SB-209	A96061	...	6061	24	23	...	105	...	...	0.051-6.000	1Mg-0.65I-0.25Cr	Plate & sheet
SB-209	...	...	Alclad	13	21	...	104	...	...	0.051-0.499	1.2Mn	Plate & sheet
SB-209	...	...	Alclad	14	21	...	104	...	...	0.500-3.000	1.2Mn	Plate & sheet
SB-209	...	...	Alclad	21	22	...	104	...	...	0.051-0.499	1.2Mn-1.0Mg	Plate & sheet
SB-209	...	...	Alclad	22	22	...	104	...	...	0.500-3.000	1.2Mn-1.0Mg	Plate & sheet
SB-209	...	...	Alclad	24	23	...	105	...	...	0.051-5.000	1Mg-0.65I-0.25Cr	Plate & sheet
B 209	A95050	...	5050	18	...	21	...	105	Al-1.5Mg	Plate & sheet
SB-210	A91060	...	1060	8.5	21	...	104	All	99.6 min. Al	Smls. tube

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QW/QB-422 NONFERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
(Grouping of Base Metals for Qualification)

Spec. No.	UNS No.	Type or Grade	Alloy	Minimum Specified Tensile, ksi	Welding		Brazing		Condition	Size(s) or Thickness, in.	Nominal Composition	Product Form
					P- No.	S- No.	P- No.	S- No.				
SB-247	A93003	...	3003	14	21	...	104	...	...	Up thru 4.000	1.2Mn	Forgings
SB-247	A95083	...	5083	38	25	...	105	...	...	Up thru 4.000	4.5Mg-0.8Mn-0.15Cr	Forgings
SB-247	A96061	...	6061	24	23	...	105	...	...	Up thru 8.000	1Mg-0.6Si-0.25Cr	Forgings
SB-265	R50250	1	...	35	51	...	115	...	...	...	Unalloyed Ti	Plate, sheet, & strip
SB-265	R50400	2	...	50	51	...	115	...	...	...	Unalloyed Ti	Plate, sheet, & strip
SB-265	R50550	3	...	65	52	...	115	...	...	...	Unalloyed Ti	Plate, sheet, & strip
SB-265	R52400	7	...	50	51	...	115	...	...	...	Alloyed 0.18Pd	Plate, sheet, & strip
SB-265	R53400	12	...	70	52	...	115	...	...	...	Alloyed 0.3Mo-0.8Ni	Plate, sheet, & strip
SB-265	R56320	9	...	90	53	...	115	...	...	...	Alloyed 3Al-2.5V	Plate, sheet, & strip
SB-265	R52402	16	...	50	51	...	115	...	...	...	Ti-Pd	Plate, sheet, & strip
SB-265	R52250	11	...	35	51	...	115	...	...	...	Low Fe-Low 0-0.18Pd	Plate, sheet, & strip
SB-265	R52252	17	...	35	51	...	...	...	...	...	Ti-Pd	Plate, sheet, & strip
SB-271	C95200	...	...	65	35	...	108	...	As cast	...	9Al	Castings
SB-271	C95400	...	...	75	35	...	108	...	As cast	...	11Al	Castings
B 280	C10200	102	...	30	...	31	...	107	...	...	99.95Cu+Ag	Smis. tube
B 280	C12000	120	...	30	...	31	...	107	...	...	99.9Cu+Ag	Smis. tube
B 280	C12200	122	...	30	...	31	...	107	...	...	99.9Cu+Ag	Smis. tube
B 283	C11000	...	Cu	33	...	31	...	107	...	...	Cu	Forgings
B 283	C37700	...	Forging brass	46	...	...	...	107	...	Over 1 1/2	60Cu-38Zn-2Pb	Forgings
B 283	C37700	...	Forging brass	50	...	...	...	107	...	Up to 1 1/2, incl.	60Cu-38Zn-2Pb	Forgings
B 283	C46400	...	Naval brass	64	...	32	...	107	...	...	60Cu-39Zn-Sn	Forgings
B 283	C65500	...	High Si bronze	52	...	33	...	107	...	...	97Cu-3Si	Forgings
B 283	C67500	...	Min bronze	72	...	32	...	107	...	...	59Cu-39Zn-Fe-Sn	Forgings
B 302	C12000	...	...	36	...	31	...	107	...	...	Drawn, 99.9Cu+Ag	Pipe
B 302	C12200	...	...	36	...	31	...	107	...	...	Drawn, 99.9Cu+Ag	Pipe
SB-308	A96061	...	6061	24	23	...	105	...	...	All	1Mg-0.6Si-0.25Cr	Shapes
SB-315	C65500	...	...	50	33	...	107	...	...	...	3-3Si	Pipe & tube
SB-333	N10001	...	...	100	44	...	112	...	Annealed	0.1875-2.5 incl.	62Ni-28Mo-5Fe	Plate, sheet, & strip
SB-333	N10001	...	...	115	44	...	112	...	Annealed	Under 0.1875	62Ni-28Mo-5Fe	Plate, sheet, & strip
SB-333	N10665	...	...	110	44	...	112	...	Annealed	Under 0.1875	65Ni-28Mo-2Fe	Plate, sheet, & strip
SB-333	N10665	...	...	110	44	...	112	...	Annealed	0.1875-2.5 incl.	65Ni-28Mo-2Fe	Plate, sheet, & strip
SB-335	N10001	...	...	100	44	...	112	...	Annealed	1.5-3.5 incl.	62Ni-28Mo-5Fe	Rod
SB-335	N10001	...	...	115	44	...	112	...	Annealed	0.3125-1.5 incl.	62Ni-28Mo-5Fe	Rod
SB-335	N10665	...	...	110	44	...	112	...	Annealed	0.3125-3.5 incl.	65Ni-28Mo-2Fe	Rod
SB-337	R50250	1	...	35	51	...	115	...	...	...	Unalloyed Ti	Smis. & welded pipe
SB-337	R50400	2	...	50	51	...	115	...	...	...	Unalloyed Ti	Smis. & welded pipe
SB-337	R50550	3	...	65	52	...	115	...	...	...	Unalloyed Ti	Smis. & welded pipe
SB-337	R52400	7	...	50	51	...	115	Alloyed 0.18Pd	Smis. & welded pipe
SB-337	R53400	1	...	70	52	...	115	Alloyed 0.3Mo-0.8Ni	Smis. & welded pipe

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QW/QB-422 NONFERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
(Grouping of Base Metals for Qualification)

Spec. No.	UNS No.	Type or Grade	Alloy	Minimum Specified Tensile, ksi	Welding		Brazing		Condition	Size(s) or Thickness, in.	Nominal Composition	Product Form
					P-No.	S-No.	P-No.	S-No.				
SB-359	C70600	...	...	40	34	...	107	...	Annealed	...	10Ni	Smls. tube
SB-359	C71000	...	...	45	34	...	107	...	Annealed	...	20Ni	Smls. tube
SB-359	C71500	...	...	52	34	...	107	...	Annealed	...	30Ni	Smls. tube
B 361	A91060	...	WP1060	8	...	21	...	104	...	...	99.5Al	Fittings
B 361	A91100	...	WP1100	11	...	21	...	104	...	...	99.0Al-Si	Fittings
B 361	...	...	WP Alclad 3003	13	...	21	...	104	...	...	Al-Mg-1Cu	Fittings
B 361	A93003	...	WP3003	14	...	21	...	104	...	...	Al-Mg-1Cu	Fittings
B 361	A95083	...	5083	39	...	25	...	105	...	...	4.5Mg-0.8Mn-0.15Cr	Fittings
B 361	A95154	...	5154	30	...	22	...	105	...	...	3.5Mg-0.25Cr	Fittings
B 361	A96061	...	WP6061	24	...	23	...	105	...	...	Al-Mg-1Si-Cu	Fittings
B 361	A96063	...	WP6063	17	...	23	...	105	...	...	Al-Mg-Si	Fittings
SB-363	R50250	WPT 1	...	35	51	...	115	...	...	...	Unalloyed Ti	Smls. & welded fittings
SB-363	R50400	WPT 2	...	50	51	...	115	...	...	...	Unalloyed Ti	Smls. & welded fittings
SB-363	R50550	WPT 3	...	65	52	...	115	...	...	...	Unalloyed Ti	Smls. & welded fittings
SB-363	R52400	7	...	60	51	...	115	...	...	...	Alloyed 18Pd	Smls. & welded pipe
SB-363	R53400	12	...	70	52	...	115	...	...	...	Alloyed 0.3Mo-0.8Ni	Smls. & welded pipe
SB-363	R56320	WPT-9	...	90	53	...	115	...	...	...	Alloyed 3Al-2.5V	Smls. & welded fittings
SB-366	N02200	...	...	55	41	...	...	...	Annealed	...	99Ni	Fittings
SB-366	N02201	...	...	50	41	...	...	...	Annealed	...	99Ni	Fittings
SB-366	N04400	...	...	70	42	...	...	...	Annealed	...	67Ni-30Cu	Fittings
SB-366	N06002	...	...	100	43	...	...	...	Annealed	...	47Ni-22Cr-18Fe-9Mo	Fittings
SB-366	N06007	...	...	90	45	...	...	...	Solution annealed	...	47Ni-22Cr-19Fe-6Mo	Fittings
SB-366	N06022	...	...	100	44	...	112	...	Solution annealed	...	55Ni-21Cr-13.5Mo	Fittings
SB-366	N06030	...	...	85	45	...	...	...	Annealed	...	40Ni-29Cr-13Fe-5Mo	Fittings
SB-366	N06059	...	...	100	44	...	...	...	Annealed	...	59Ni-23Cr-16Mo	Fittings
SB-366	N06455	...	...	100	44	...	...	...	Annealed	...	61Ni-15Mo-16Cr	Fittings
SB-366	N06600	...	...	80	43	...	...	...	Annealed	...	72Ni-15Cr-8Fe	Fittings
SB-366	N06625	...	...	110	43	...	...	...	Annealed	...	60Ni-22Cr-9Mo-3.5Cb	Fittings
SB-366	N06985	...	...	90	45	...	...	...	Annealed	...	47Ni-22Cr-20Fe-7Mo	Fittings
SB-366	N08020	...	...	80	44	...	...	...	Annealed	...	35Ni-35Fe-20Cr-Cb	Fittings
SB-366	N08330	...	...	70	46	...	...	...	Annealed	...	35Ni-19Cr-1.25Si	Fittings
SB-366	N08800	...	...	100	44	...	...	...	Annealed	...	33Ni-42Fe-21Cr	Fittings
SB-366	N08925	...	...	87	45	...	111	...	Annealed	...	25Ni-20Cr-6Mo-Cu-N	Fittings
SB-366	N10001	...	...	100	44	...	...	...	Annealed	...	62Ni-28Mo-5Fe	Fittings

QW/QB-422 NONFERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
(Grouping of Base Metals for Qualification)

Spec. No.	UNS No.	Type or Grade	Alloy	Minimum Specified Tensile, ksi	Welding		Brazing		Condition	Size(s) or Thickness, in.	Nominal Composition	Product Form
					P. No.	S. No.	P. No.	S. No.				
SB-408	N08811	...	...	65	45	...	111	...	Annealed	...	33Ni-21Cr-1 (Al + Ti)	Rod & bar
SB-409	N08800	...	...	75	45	...	111	...	Annealed	...	33Ni-21Cr	Plate, sheet, & strip
SB-409	N08810	...	...	65	45	...	111	...	Annealed	...	33Ni-21Cr	Plate, sheet, & strip
SB-409	N08811	...	...	65	45	...	111	...	Annealed	...	33Ni-21Cr-1 (Al + Ti)	Plate, sheet, & strip
SB-423	N08825	...	...	75	45	...	111	...	Annealed	Hot finished	42Ni-21.5Cr-3Mo-2.3Cu	Smis. pipe & tube
SB-423	N08825	...	...	85	45	...	111	...	Annealed	Cold worked	42Ni-21.5Cr-3Mo-2.3Cu	Smis. pipe & tube
SB-424	N08825	...	...	85	45	...	111	...	Annealed	...	42Ni-21.5Cr-3Mo-2.3Cu	Plate, sheet, & strip
SB-425	N08825	...	...	85	45	...	111	...	Annealed	...	42Ni-21.5Cr-3Mo-2.3Cu	Rod & bar
SB-434	N10003	...	...	100	44	...	112	...	Annealed	...	70Ni-16Mo-7Cr-5Fe	Plate, sheet, & strip
SB-435	N06002	...	...	95	43	...	111	...	Annealed	...	47Ni-22Cr-9Mo-18Fe	Plate, sheet, & strip
SB-435	N06230	...	...	110	47	...	111	...	...	...	53Ni-22Cr-14W-Co-Fe-Mo	Plate, sheet, & strip
SB-435	R30556	...	...	100	45	...	111	...	...	...	21Ni-30Fe-22Cr-18Co-3Mo-3W	Plate, sheet, & strip
SB-443	N06625	2	...	100	43	...	111	...	Solution annealed	...	60Ni-22Cr-9Mo-3.5Cb	Plate, sheet, & strip
SB-443	N06625	1	...	120	43	...	111	...	Annealed	...	60Ni-22Cr-9Mo-3.5Cb	Plate, sheet, & strip
SB-443	N06625	1	...	110	43	...	111	...	Annealed	...	60Ni-22Cr-9Mo-3.5Cb	Plate, sheet, & strip
SB-444	N06625	1	...	120	43	...	111	...	Annealed	...	60Ni-22Cr-9Mo-3.5Cb	Pipe & tube
SB-444	N06625	2	...	100	43	...	111	...	Solution annealed	...	60Ni-22Cr-9Mo-3.5Cb	Pipe & tube
SB-446	N06625	1	...	120	43	...	111	...	Annealed	...	60Ni-22Cr-9Mo-3.5Cb	Rod & bar
SB-446	N06625	2	...	100	43	...	111	...	Solution annealed	...	60Ni-22Cr-9Mo-3.5Cb	Rod & bar
SB-462	N08020	...	...	80	45	...	111	...	Annealed	...	35Ni-35Fe-20Cr-Cb	Forgings
SB-463	N08020	...	...	80	45	...	111	...	Annealed	...	35Ni-35Fe-20Cr-Cb	Plate, sheet, & strip
SB-463	N08024	...	...	80	45	...	111	...	Annealed	...	37Ni-33Fe-23Cr-4Mo-1Cu	Plate, sheet, & strip
SB-463	N08026	...	...	80	45	...	111	...	Annealed	...	35Ni-24Cr-5Mo-2Cu	Plate, sheet, & strip
SB-464	N08020	...	...	80	45	...	111	...	Annealed	...	35Ni-35Fe-20Cr-Cb	Welded pipe
SB-464	N08024	...	...	80	45	...	111	...	Annealed	...	37Ni-33Fe-23Cr-4Mo-1Cu	Welded pipe
SB-464	N08026	...	...	80	45	...	111	...	Annealed	...	35Ni-24Cr-5Mo-2Cu	Welded pipe
SB-466	C70600	...	...	38	34	...	107	...	Annealed	...	10Ni	Pipe & tube
SB-466	C71000	...	...	45	34	...	107	...	Annealed	...	20Ni	Pipe & tube
SB-466	C71500	...	...	50	34	...	107	...	Annealed	...	30Ni	Pipe & tube
SB-467	C70600	...	...	38	34	...	107	...	Annealed	> 4.5 O.D.	10Ni	Pipe
SB-467	C70600	...	...	40	34	...	107	...	Annealed	To 4.5 O.D.	10Ni	Pipe
SB-467	C70600	...	...	45	34	...	107	...	From an/d. strip	To 4.5 O.D.	10Ni	Pipe
SB-467	C70600	...	...	54	34	...	107	...	From cid. rid. strip	To 4.5 O.D.	10Ni	Pipe
SB-467	C71500	...	...	45	34	...	107	...	Annealed	> 4.5 O.D.	30Ni	Pipe
SB-467	C71500	50	34	...	107	...	Annealed	To 4.5 O.D.	30Ni	Pipe

WELDING DATA

QW/QB-422

WELDING DATA

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QW/QB-422 NONFERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
(Grouping of Base Metals for Qualification)

Spec. No.	UNS No.	Type or Grade	Alloy	Minimum Specified Tensile, ksi		Welding		Brazing		Condition	Size(s) or Thickness, in.	Nominal Composition	Product Form
				P. No.	S. No.	P. No.	S. No.	P. No.	S. No.				
SB-543	C70600	...	...	34	...	107	...	...	...	Light cold worked	...	10Ni	Welded tube
SB-543	C71500	...	...	34	...	107	...	...	...	Annealed	...	30Ni	Welded tube
SB-543	C71640	...	...	34	...	107	...	...	...	Annealed	...	30.5Ni-2Fe-2Mn	Welded tube
SB-543	C71640	...	...	34	...	107	...	...	...	Light cold worked	...	30.5Ni-2Fe-2Mn	Welded tube
B 547	...	Alclad 3003	...	...	...	...	...	...	...	...	...	1.2Mn	Welded tube
B 547	...	Alclad 3003	...	...	...	...	...	...	...	...	...	1.2Mn	Welded tube
B 547	A93003	3003 O	...	...	...	...	...	...	...	...	...	1.2Mn	Welded tube
B 547	A93003	3003 H112	...	...	...	...	...	...	...	...	...	1.2Mn	Welded tube
B 547	A95083	5083 O	...	...	...	...	...	...	...	...	...	4.5Mg-0.8Mn-0.15Cr	Welded tube
B 547	A95454	5454 O	...	...	...	...	...	...	...	...	...	2.75Mg-0.8Mn-0.1Cr	Welded tube
B 547	A95454	5454 H112	...	...	...	...	...	...	...	...	...	2.75Mg-0.8Mn-0.1Cr	Welded tube
B 547	A96061	6061 T4	...	...	...	...	...	...	...	...	...	1Mg-0.6Si-0.25Cr	Welded tube
B 547	A96061	6061 T451	...	...	...	...	...	...	...	...	...	1Mg-0.6Si-0.25Cr	Welded tube
B 547	A96061	6061 T6	...	...	...	...	...	...	...	...	...	1Mg-0.6Si-0.25Cr	Welded tube
B 547	A96061	6061 T651	...	...	...	...	...	...	...	...	...	1Mg-0.6Si-0.25Cr	Welded tube
SB-550	R60702	R60702	...	...	61	...	117	...	...	...	...	Unalloyed Zr	Bar & wire
SB-550	R60705	R60705	...	...	62	...	117	...	...	...	...	99.5Zr-2.5Nb	Bar & wire
SB-551	R60702	R60702	...	...	61	...	117	...	...	...	...	Unalloyed Zr	Plate, sheet, & strip
SB-551	R60705	R60705	...	...	62	...	117	...	...	...	...	99.5Zr-2.5Nb	Plate, sheet, & strip
SB-564	N04400	...	...	42	...	110	...	...	...	Annealed	...	67Ni-30Cu	Forgings
SB-564	N06022	...	...	44	...	112	...	...	...	Solution annealed	...	55Ni-21Cr-13.5Mo	Forgings
SB-564	N06059	...	...	44	...	111	...	...	...	Annealed	...	59Ni-23Cr-16Mo	Forgings
SB-564	N06060	...	...	43	...	111	...	...	...	Annealed	...	72Ni-15Cr-8Fe	Forgings
SB-564	N06625	...	...	43	...	111	...	...	...	Annealed	...	60Ni-22Cr-9Mo-3.5Cb	Forgings
SB-564	N06625	...	...	43	...	111	...	...	...	Annealed	> 4-10, incl. To 4, incl.	60Ni-22Cr-9Mo-3.5Cb	Forgings
SB-564	N06690	...	...	43	...	111	...	...	...	Annealed	...	58Ni-29Cr-9Fe	Forgings
SB-564	N08800	...	...	45	...	111	...	...	...	Annealed	...	33Ni-21Cr	Forgings
SB-564	N08810	...	...	45	...	111	...	...	...	Annealed	...	33Ni-21Cr	Forgings
SB-564	N08811	...	...	45	...	111	...	...	...	Annealed	...	33Ni-21Cr-1 (Al + Ti)	Forgings
SB-564	N10276	...	...	44	...	112	...	...	...	Annealed	...	54Ni-16Mo-15Cr	Forgings
B 564	N02200	...	...	...	...	41	...	110	...	...	...	99.0Ni	Forgings
B 564	N08031	...	...	...	...	45	...	111	...	Solution annealed	...	31Ni-27Cr-5.5Mo	Forgings
B 564	N08811	...	...	...	...	45	...	111	...	Annealed	...	33Ni-21Cr-1 (Al+Ti)	Forgings
SB-572	N06002	...	...	43	...	111	...	...	...	Annealed	...	47Ni-22Cr-9Mo-18Fe	Rod
SB-572	N06230	...	...	47	...	111	...	...	...	...	...	53Ni-22Cr-14W-Co-Fe-Mo	Rod
SB-572	R30556	...	...	45	...	111	...	...	...	...	...	21Ni-30Fe-22Cr-18Co-3Mo-3W	Rod
SB-573	N10003	...	...	44	...	112	...	...	...	Annealed	...	70Ni-16Mo-7Cr-5Fe	Rod
SB-574	N06022	...	...	44	...	112	...	...	...	Annealed	...	55Ni-21Cr-13.5Mo	Rod
SB-574	N06059	...	...	44	...	112	...	...	...	Annealed	...	59Ni-23Cr-16Mo	Rod
SB-574	N06455	...	...	44	...	112	...	...	...	Annealed	...	61Ni-16Mo-16Cr	Rod

QW/QB-422 NONFERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
(Grouping of Base Metals for Qualification)

Spec. No.	UNS No.	Type or Grade	Alloy	Minimum Specified Tensile, ksi	Welding		Brazing		Condition	Size(s) or Thickness, in.	Nominal Composition	Product Form
					P. No.	S. No.	P. No.	S. No.				
SB-621	N08320	...	...	75	45	...	111	...	Annealed	...	26Ni-22Cr-5Mo-Ti	Rod
SB-622	N06002	...	...	100	43	...	111	...	Annealed	...	47Ni-22Cr-9Mo-18Fe	Sms. pipe & tube
SB-622	N06007	...	...	90	45	...	111	...	Annealed	...	47Ni-22Cr-19Fe-6Mo	Sms. pipe & tube
SB-622	N06022	...	...	100	44	...	112	...	Annealed	...	55Ni-21Cr-13.5Mo	Sms. pipe & tube
SB-622	N06030	...	...	85	45	...	111	...	Annealed	...	40Ni-29Cr-15Fe-5Mo	Sms. pipe & tube
SB-622	N06059	...	...	100	44	...	112	...	Annealed	...	59Ni-23Cr-16Mo	Sms. pipe & tube
SB-622	N06230	...	...	110	47	...	111	...	Annealed	...	53Ni-22Cr-14W-Co-Fe-Mo	Sms. pipe & tube
SB-622	N06455	...	...	100	44	...	112	...	Annealed	...	61Ni-16Mo-16Cr	Sms. pipe & tube
SB-622	N06975	...	...	85	45	...	111	...	Annealed	...	49Ni-25Cr-18Fe-6Mo	Sms. pipe & tube
SB-622	N06985	...	...	90	45	...	111	...	Annealed	...	47Ni-22Cr-20Fe-7Mo	Sms. pipe & tube
SB-622	N08320	...	...	75	45	...	111	...	Annealed	...	26Ni-22Cr-5Mo-Ti	Sms. pipe & tube
SB-622	N10001	...	...	100	44	...	112	...	Annealed	...	62Ni-28Mo-5Fe	Sms. pipe & tube
SB-622	N10276	...	...	100	44	...	112	...	Annealed	...	54Ni-16Mo-15Cr	Sms. pipe & tube
SB-622	N10665	...	...	110	44	...	112	...	Annealed	...	65Ni-28Mo-2Fe	Sms. pipe & tube
SB-622	R30556	...	...	100	45	...	111	...	Annealed	...	21Ni-30Fe-22Cr-18Co-3Mo-3W	Sms. pipe & tube
B 622	N06059	...	...	100	...	44	...	112	Solution annealed	...	59Ni-23Cr-16Mo	Sms. pipe & tube
B 622	N08031	...	...	94	...	45	...	111	Solution annealed	...	31Ni-27Cr-5.5Mo	Sms. pipe & tube
B 625	N08926	...	...	87	...	45	...	111	Annealed	...	25Ni-20Cr-6Mo-Co-N	Plate, sheet, & strip
SB-625	N08904	...	...	71	45	...	111	...	Annealed	...	44Fe-25Ni-21Cr-Mo	Plate, sheet, & strip
SB-625	N08925	...	...	87	45	...	111	...	Annealed	...	25Ni-20Cr-6Mo-Cu-N	Plate, sheet, & strip
SB-626	N06002	...	...	100	43	...	111	...	Annealed	...	47Ni-22Cr-9Mo-18Fe	Welded tube
SB-626	N06007	...	...	90	45	...	111	...	Annealed	...	47Ni-22Cr-19Fe-6Mo	Welded tube
SB-626	N06022	...	...	100	44	...	112	...	Solution annealed	...	55Ni-21Cr-13.5Mo	Welded tube
SB-626	N06030	...	...	85	45	...	111	...	Annealed	...	40Ni-29Cr-15Fe-5Mo	Welded tube
SB-626	N06230	...	...	110	47	...	111	...	Annealed	...	53Ni-22Cr-14W-Co-Fe-Mo	Welded tube
SB-626	N06059	...	...	100	44	...	112	...	Annealed	...	59Ni-23Cr-16Mo	Welded tube
SB-626	N06455	...	...	100	44	...	112	...	Annealed	...	61Ni-16Mo-16Cr	Welded tube
SB-626	N06975	...	...	85	45	...	111	...	Annealed	...	49Ni-25Cr-18Fe-6Mo	Welded tube
SB-626	N06985	...	...	90	45	...	111	...	Annealed	...	47Ni-22Cr-20Fe-7Mo	Welded tube
SB-626	N08320	...	...	75	45	...	111	...	Annealed	...	26Ni-22Cr-5Mo-Ti	Welded tube
SB-626	N10001	...	...	100	44	...	112	...	Annealed	...	62Ni-28Mo-5Fe	Welded tube
SB-626	N10276	...	...	100	44	...	112	...	Annealed	...	54Ni-16Mo-15Cr	Welded tube
SB-626	N10665	...	...	110	44	...	112	...	Annealed	...	65Ni-28Mo-2Fe	Welded tube
SB-626	R30556	...	...	100	45	...	111	...	Annealed	...	21Ni-30Fe-22Cr-18Co-3Mo-3W	Welded tube
B 649	N08926	...	...	87	...	45	...	111	Solution treated	...	25Ni-20Cr-6Mo-Cu-N	Bar & wire
SB-649	N08904	...	...	71	45	...	111	...	Solution treated	...	44Fe-25Ni-21Cr-Mo	Bar & wire
SB-649	N08925	...	...	87	45	...	111	...	Solution treated	...	25Ni-20Cr-6Mo-Cu-N	Bar & wire

WELDING DATA

QW/QB-422

QW/QB-422 NONFERROUS P-NUMBERS AND S-NUMBERS (CONT'D)
(Grouping of Base Metals for Qualification)

Spec. No.	UNS No.	Type or Grade	Alloy	Minimum Specified Tensile, ksi	Welding		Brazing		Condition	Size(s) or Thickness, in.	Nominal Composition	Product Form
					P. No.	S. No.	P. No.	S. No.				
SB-729	N06020	...	...	80	45	...	...	...	Annealed	...	35Ni-35Fe-20Cr-Cb	Sms. pipe & tube
B 725	N02200	...	...	55	...	41	...	110	Annealed	...	99.0Ni	Welded pipe
B 819	C12200	C12200	...	30	...	...	...	107	...	...	99.9Cu+Ag	Wrought pipe
B 16.18	C83600	...	...	40	...	...	...	107	...	...	55n-5Zn-5Pb	Cast fittings
B 16.18	C83800	...	...	40	...	...	...	107	...	...	45n-6.5Zn-6Pb	Cast fittings
B 16.18	C84400	...	...	40	...	...	...	107	...	...	2.55n-8.5Zn-7Pb	Cast fittings
B 16.22	C10200	...	...	30	...	...	...	107	...	...	99.95Cu+Ag	Wrought pipe
B 16.22	C12000	...	...	...	...	...	...	107	...	...	99.9Cu+Ag	Wrought pipe
B 16.22	C12200	...	...	...	...	...	...	107	...	...	99.9Cu+Ag	Wrought pipe
B 16.22	C23000	...	...	...	...	...	...	107	...	...	85Cu-15Zn	Wrought pipe

QW-423 Alternate Base Materials for Welder Qualification

A99 QW-423.1 Base material used for welder qualification may be substituted for the P-Number material specified in the WPS in accordance with the following.

Base Metal(s) for Welder Qualification	Qualified Production Base Metal(s)
P-No. 1 through P-No. 11, P-No. 34, or P-No. 41 through P-No. 47	P-No. 1 through P-No. 11, P-No. 34, P-No. 41 through P-No. 47 and unassigned metals of similar chemical composition to these metals
P-No. 21 through P-No. 25 P-No. 51 through P-No. 53 or P-No. 61 through P-No. 62	P-No. 21 through P-No. 25 P-No. 51 through P-No. 53 and P-No. 61 through P-No. 62

98 QW-423.2 Metals used for welder qualification conforming to national or international standards or specifications may be considered as having the same P- or S-Number as an assigned metal provided it meets the mechanical and chemical requirements of the assigned metal. The base metal specification and corresponding P- or S-Number shall be recorded on the qualification record.

QW-424 Base Metals Used for Procedure Qualification

QW-424.1 Base metals are assigned P-Numbers in QW/QB-422; metals which do not appear in QW/QB-422 are considered to be unassigned metals except as otherwise defined in QW-420.1 for base metals having

the same UNS numbers. Unassigned metals shall be identified in the WPS and on the PQR by specification, type and grade, or by chemical analysis and mechanical properties. The minimum tensile strength shall be defined by the organization which specified the unassigned metal if the tensile strength of that metal is not defined by the material specification.

Base Metal(s) Used for Procedure Qualification Coupon	Base Metals Qualified
One metal from a P-Number to any metal from the same P-Number	Any metals assigned that P-Number
One metal from a P-Number to any metal from any other P-Number	Any metal assigned the first P-Number to any metal assigned the second P-Number
One metal from P-No. 3 to any metal from P-No. 3	Any P-No.3 metal to any metal from P-No. 3 or P-No. 1
One metal from P-No. 4 to any metal from P-No. 4	Any P-No. 4 metal to any metal from P-Nos. 4, 3, or 1
One metal from P-No. 5A to any metal from P-No. 5A	Any P-No. 5A metal to any metal from P-Nos. 5A, 4, 3, or 1 metals
One metal from P-No. 5A to a metal from P-No. 4, or P-No. 3, or P-No. 1	Any P-No. 5A metal to any metal assigned to P-No. 4, or P-No. 3, or P-No. 1
One metal from P-No. 4 to a metal from P-No. 3 or P-No. 1	Any P-No. 4 metal to any metal assigned to P-No. 3 or P-No. 1
Any unassigned metal to the same unassigned metal	The unassigned metal to itself
Any unassigned metal to any P-Number metal	The unassigned metal to any metal assigned to the same P-Number as the qualified metal
Any unassigned metal to any other unassigned metal	The first unassigned metal to the second unassigned metal

QW-432 (CONT'D)

F-NUMBERS

Grouping of Electrodes and Welding Rods for Qualification

QW	F-No.	ASME Specification No.	AWS Classification No.
Copper and Copper-Base Alloys			
432.3	31	SFA-5.6	ECu
	31	SFA-5.7	ER Cu
432.3	32	SFA-5.6	ECuSi
	32	SFA-5.7	ERCuSi-A
	33	SFA-5.6	ECuSn-A, ECuSn-C
	33	SFA-5.7	ERCuSn-A
	34	SFA-5.6	ECuNi
	34	SFA-5.7	ERCuNi
	34	SFA-5.30	IN67
	35	SFA-5.8	RBCuZn-A
	35		RBCuZn-B
	35		RBCuZn-C
	35		RBCuZn-D
	36	SFA-5.6	ECuAl-A2
	36		ECuAl-B
	36	SFA-5.7	ERCuAl-A1
	36		ERCuAl-A2
	36		ERCuAl-A3
	37	SFA-5.6	ECuNiAl
	37		ECuMnNiAl
	37	SFA-5.7	ERCuNiAl
	37		ERCuMnNiAl
Nickel and Nickel-Base Alloys			
432.4	41	SFA-5.11	ENi-1
	41	SFA-5.14	ERNi-1
	41	SFA-5.30	IN61
	42	SFA-5.11	ENiCu-7
	42	SFA-5.14	ERNiCu-7
	42	SFA-5.14	ERNiCu-8
	42	SFA-5.30	IN60
	43	SFA-5.11	ENiCrFe-1
	43	SFA-5.11	ENiCrFe-2
	43	SFA-5.11	ENiCrFe-3
	43	SFA-5.11	ENiCrFe-4
	43	SFA-5.11	ENiCrFe-7
	43	SFA-5.11	ENiCrFe-9
	43	SFA-5.11	ENiCrFe-10
	43	SFA-5.11	ENiCrCoMo-1
	43	SFA-5.11	ENiCrMo-2
	43	SFA-5.11	ENiCrMo-3
	43	SFA-5.11	ENiCrMo-6
	43	SFA-5.11	ENiCrMo-12
	43	SFA-5.14	ERNiCr-3
	43	SFA-5.14	ERNiCr-4
	43	SFA-5.14	ERNiCr-6

**QW-451.3
FILLET-WELD TESTS¹**

A99

Type of Joint	Thickness of Test Coupons as Welded, in.	Range Qualified	Type and Number of Tests Required [[QW-462.4(a) or QW-462.4(d)]] Macro
Fillet	Per QW-462.4(a)	All fillet sizes on all base metal thicknesses and all diameters	5
Fillet	Per QW-462.4(d)		4

NOTE:

(1) A production assembly mockup may be substituted in accordance with QW-181.1.1. When a production assembly mockup is used, the range qualified shall be limited to the fillet weld size, base metal thickness, and configuration of the mockup. Alternatively, multiple production assembly mockups may be qualified. The range of thickness of the base metal qualified shall be no less than the thickness of the thinner member tested and no greater than the thickness of the thicker member tested. The range for fillet weld sizes qualified shall be limited to no less than the smallest fillet weld tested and no greater than the largest fillet weld tested. The configuration of production assemblies shall be the same as that used in the production assembly mockup.

**QW-451.4
FILLET WELDS QUALIFIED BY GROOVE-WELD TESTS**

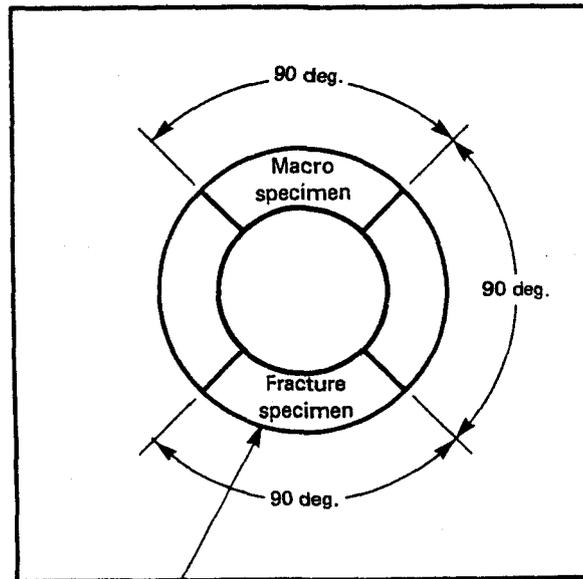
Thickness <i>T</i> of Test Coupon (Plate or Pipe) as Welded	Range Qualified	Type and Number of Tests Required
All groove tests	All fillet sizes on all base metal thicknesses and all diameters	Fillet welds are qualified when the groove weld is qualified in accordance with either QW-451.1 or QW-451.2 (see QW-202.2)

QW-462.10
SHEAR STRENGTH REQUIREMENTS FOR SPOT OR PROJECTION WELD SPECIMENS

A99

P-No. 1 Through P-No. 11 and P-No. 41 Through P-No. 47 Metals

Nominal Thickness of Thinner Sheet, in.	Ultimate Strength 90,000 to 149,000 psi		Ultimate Strength below 90,000 psi	
	lb per spot		lb per spot	
	min	min avg	min	min avg
0.009	130	160	100	125
0.010	160	195	115	140
0.012	200	245	150	185
0.016	295	365	215	260
0.018	340	415	250	305
0.020	390	480	280	345
0.022	450	550	330	405
0.025	530	655	400	495
0.028	635	785	465	575
0.032	775	955	565	695
0.036	920	1,140	690	860
0.040	1,065	1,310	815	1,000
0.045	1,285	1,585	1,005	1,240
0.050	1,505	1,855	1,195	1,475
0.056	1,770	2,185	1,460	1,800
0.063	2,110	2,595	1,760	2,170
0.071	2,535	3,125	2,080	2,560
0.080	3,005	3,705	2,455	3,025
0.090	3,515	4,335	2,885	3,560
0.100	4,000	4,935	3,300	4,070
0.112	4,545	5,610	3,795	4,675
0.125	5,065	6,250	4,300	5,310



Fracture specimen to be removed from lower 90 deg. section in position 5 f

QW-463.2(h) PERFORMANCE QUALIFICATION

QW-470 ETCHING — PROCESSES AND REAGENTS

QW-471 General

The surfaces to be etched should be smoothed by filing, machining, or grinding on metallographic papers. With different alloys and tempers, the etching period will vary from a few seconds to several minutes, and should be continued until the desired contrast is obtained. As a protection from the fumes liberated during the etching process, this work should be done under a hood. After etching, the specimens should be thoroughly rinsed and then dried with a blast of warm air. Coating the surface with a thin clear lacquer will preserve the appearance.

QW-472 For Ferrous Metals

Etching solutions suitable for carbon and low alloy steels, together with directions for their use, are suggested as follows.

QW-472.1 Hydrochloric Acid. Hydrochloric (muriatic) acid and water, equal parts, by volume. The solution should be kept at or near the boiling temperature during the etching process. The specimens are to be immersed in the solution for a sufficient period of time to reveal all lack of soundness that might exist at their cross-sectional surfaces.

QW-472.2 Ammonium Persulfate. One part of ammonium persulfate to nine parts of water, by weight. The solution should be used at room temperature, and should be applied by vigorously rubbing the surface to be etched with a piece of cotton saturated with the solution. The etching process should be continued until there is a clear definition of the structure in the weld.

QW-472.3 Iodine and Potassium Iodide. One part of powdered iodine (solid form), two parts of powdered potassium iodide, and ten parts of water, all by weight. The solution should be used at room temperature, and brushed on the surface to be etched until there is a clear definition or outline of the weld.

QW-472.4 Nitric Acid. One part of nitric acid and three parts of water, by volume.

CAUTION: Always pour the acid into the water. Nitric acid causes bad stains and severe burns.

The solution may be used at room temperature and applied to the surface to be etched with a glass stirring rod. The specimens may also be placed in a boiling solution of the acid, but the work should be done in a well-ventilated room. The etching process should be continued for a sufficient period of time to reveal all

lack of soundness that might exist at the cross-sectional surfaces of the weld.

QW-473 For Nonferrous Metals

The following etching reagents and directions for their use are suggested for revealing the macrostructure.

QW-473.1 Aluminum and Aluminum-Base Alloys

Hydrochloric acid (concentrated)	15 ml
Hydrofluoric acid (48%)	10 ml
Water	85 ml

This solution is to be used at room temperature, and etching is accomplished by either swabbing or immersing the specimen.

QW-473.2 For Copper and Copper-Base Alloys: Cold Concentrated Nitric Acid. Etching is accomplished by either flooding or immersing the specimen for several seconds under a hood. After rinsing with a flood of water, the process is repeated with a 50-50 solution of concentrated nitric acid and water.

In the case of the silicon bronze alloys, it may be necessary to swab the surface to remove a white (SiO₂) deposit.

QW-473.3 For Nickel and Nickel-Base Alloys

Material	Formula
Nickel	Nitric Acid or Lepito's Etch
Low Carbon Nickel	Nitric Acid or Lepito's Etch
Nickel-Copper (400)	Nitric Acid or Lepito's Etch
Nickel-Chromium-Iron (600 and 800)	Aqua Regia or Lepito's Etch

MAKEUP OF FORMULAS FOR AQUA REGIA AND LEPITO'S ETCH

	Aqua Regia [(1), (3)]	Lepito's Etch [(2), (3)]
Nitric Acid, Concentrated — HNO ₃	1 part	3 ml
Hydrochloric Acid, Concentrated — HCL	2 parts	10 ml
Ammonium Sulfate — (NH ₄) ₂ (SO ₄)	...	1.5 g
Ferric Chloride — FeCl ₃	...	2.5 g
Water	...	7.5 ml

NOTES:

- Warm the parts for faster action.
- Mix solution as follows:
 - Dissolve (NH₄)₂(SO₄) in H₂O.
 - Dissolve powdered FeCl₃ in warm HCL.
 - Mix (a) and (b) above and add HNO₃.
- Etching is accomplished by either swabbing or immersing the specimen.

brazing, block (BB) — a brazing process that uses heat from heated blocks applied to the joint. This is an obsolete or seldom used process.

brazing, dip (DB) — a brazing process in which the heat required is furnished by a molten chemical or metal bath. When a molten chemical bath is used, the bath may act as a flux; when a molten metal bath is used, the bath provides the filler metal.

brazing, furnace (FB) — a brazing process in which the workpieces are placed in a furnace and heated to the brazing temperature

brazing, induction (IB) — a brazing process that uses heat from the resistance of the workpieces to induced electric current

brazing, machine — brazing with equipment which performs the brazing operation under the constant observation and control of a brazing operator. The equipment may or may not perform the loading and unloading of the work.

brazing, manual — a brazing operation performed and controlled completely by hand. See automatic brazing and machine brazing.

brazing, resistance (RB) — a brazing process that uses heat from the resistance to electric current flow in a circuit of which the workpieces are a part

brazing, semiautomatic — brazing with equipment which controls only the brazing filler metal feed. The advance of the brazing is manually controlled.

brazing, torch (TB) — a brazing process that uses heat from a fuel gas flare

brazing operator — one who operates machine or automatic brazing equipment

brazing temperature — the temperature to which the base metal(s) is heated to enable the filler metal to wet the base metal(s) and form a brazed joint

brazing temperature range — the temperature range within which brazing can be conducted

build-up of base metal/restoration of base metal thickness — this is the application of a weld material to a base metal so as to restore the design thickness and/or structural integrity. This build-up may be with a chemistry different from the base metal chemistry which has been qualified via a standard butt welded test coupon. Also, may be called base metal repair or buildup.

butt joint — a joint between two members aligned approximately in the same plane

buttering — the addition of material, by welding, on one or both faces of a joint, prior to the preparation of the joint for final welding, for the purpose of providing a suitable transition weld deposit for the subsequent completion of the joint

clad brazing sheet — a metal sheet on which one or both sides are clad with brazing filler metal

coalescence — the growing together or growth into one body of the materials being welded

complete fusion — fusion which has occurred over the entire base material surfaces intended for welding, and between all layers and passes

composite — a material consisting of two or more discrete materials with each material retaining its physical identity

consumable insert — filler metal that is placed at the joint root before welding, and is intended to be completely fused into the root to become part of the weld

contact tube — a device which transfers current to a continuous electrode

corner joint — a joint between two members located approximately at right angles to each other in the form of an L

coupon — see test coupon

crack — a fracture-type discontinuity characterized by a sharp tip and high ratio of length and width to opening displacement

defect — a discontinuity or discontinuities that by nature or accumulated effect (for example, total crack length) render a part or product unable to meet minimum applicable acceptance standards or specifications. This term designates rejectability. See also discontinuity and flaw.

direct current electrode negative (DCEN) — the arrangement of direct current arc welding leads in which the electrode is the negative pole and the workpiece is the positive pole of the welding arc

direct current electrode positive (DCEP) — the arrangement of direct current arc welding leads in which the electrode is the positive pole and the workpiece is the negative pole of the welding arc

discontinuity — an interruption of the typical structure of a material, such as a lack of homogeneity in its mechanical, metallurgical, or physical characteristics. A discontinuity is not necessarily a defect. See also defect and flaw.

double-welded joint — a joint that is welded from both sides

flux (brazing) — material used to prevent, dissolve, or facilitate removal of oxides and other undesirable surface substances

flux (welding) — a fusible mineral material which is melted by the welding heat. Fluxes may be granular or solid coatings. Fluxes serve to stabilize the welding arc, shield all or part of the molten weld pool from the atmosphere, and may or may not evolve shielding gas by decomposition. Flux melted during welding is called slag.

flux, active (SAW) — a flux from which the amount of elements deposited in the weld metal is dependent upon the welding conditions, primarily arc voltage

flux, alloy (SAW) — a flux which provides alloying elements in the weld metal deposit

flux, neutral (SAW) — a flux which will not cause a significant change in the weld metal composition when there is a large change in the arc voltage

flux cover — metal bath dip brazing and dip soldering. A layer of molten flux over the molten filler metal bath.

forehand welding — a welding technique in which the welding torch or gun is directed toward the progress of welding

frequency — the completed number of cycles which the oscillating head makes in 1 min or other specified time increment

fuel gas — a gas such as acetylene, natural gas, hydrogen, propane, stabilized methylacetylene propadiene, and other fuels normally used with oxygen in one of the oxyfuel processes and for heating

fused spray deposit (thermal spraying) — a self-fluxing thermal spray deposit which is subsequently heated to coalescence within itself and with the substrate

fusion (fusion welding) — the melting together of filler metal and base metal, or of base metal only, to produce a weld

fusion line — in a weldment, the interface between weld metal and base metal, or between base metal parts when filler metal is not used

gas backing — see backing gas

globular transfer (arc welding) — a type of metal transfer in which molten filler metal is transferred across the arc in large droplets

groove weld — a weld made in a groove formed within a single member or in the groove between two members to be joined. The standard types of groove weld are as follows:

square groove weld
single-V groove weld
single-bevel groove weld
single-U groove weld
single-J groove weld
single-flare-bevel groove weld
single-flare-V groove weld
double-V groove weld
double-bevel groove weld
double-U groove weld
double-J groove weld
double-flare-bevel groove weld
double-flare-V groove weld

heat-affected zone — that portion of the base metal which has not been melted, but whose mechanical properties or microstructures have been altered by the heat of welding or cutting

interpass temperature — the highest temperature in the weld joint immediately prior to welding, or in the case of multiple pass welds, the highest temperature in the section of the previously deposited weld metal, immediately before the next pass is started

joint — the junction of members or the edges of members which are to be joined or have been joined

joint penetration — the distance the weld metal extends from the weld face into a joint, exclusive of weld reinforcement

keyhole welding — a technique in which a concentrated heat source penetrates partially or completely through a workpiece, forming a hole (keyhole) at the leading edge of the weld pool. As the heat source progresses, the molten metal fills in behind the hole to form the weld bead.

lap or overlap — the distance measured between the edges of two plates when overlapping to form the joint

lap joint — a joint between two overlapping members in parallel planes

lower transformation temperature — the temperature at which austenite begins to form during heating

melt-in — a technique of welding in which the intensity of a concentrated heat source is so adjusted that a weld pass can be produced from filler metal added to the leading edge of the molten weld metal

overlay, corrosion-resistant weld metal — deposition of one or more layers of weld metal to the surface of a base material in an effort to improve the corrosion resistance properties of the surface. This would be applied at a level above the minimum design thickness as a nonstructural component of the overall wall thickness.

short-circuiting transfer (gas metal-arc welding) — metal transfer in which molten metal from a consumable electrode is deposited during repeated short circuits. See also globular transfer and spray transfer.

single-welded joint — a joint welded from one side only

single-welded lap joint — a lap joint in which the overlapped edges of the members to be joined are welded along the edge of one member only

slag inclusion — nonmetallic solid material entrapped in weld metal or between weld metal and base metal

specimen — refer to test specimen

spot weld — a weld made between or upon overlapping members in which coalescence may start and occur on the faying surfaces or may proceed from the outer surface of one member. The weld cross section (plan view) is approximately circular.

spray-fuse — a method of surfacing consisting of depositing finely divided particles of material in the molten or semimolten condition onto a base metal surface followed by the application of heat to fuse the particles and form a metallurgical bond with the base metal

spray transfer (arc welding) — metal transfer in which molten metal from a consumable electrode is propelled axially across the arc in small droplets

stringer bead — a type of weld bead made without appreciable weaving motion. See also weave bead.

surfacing — the application by welding, brazing, or thermal spraying of a layer(s) of material to a surface to obtain desired properties or dimensions, as opposed to making a joint

tee joint (T) — a joint between two members located approximately at right angles to each other in the form of a T

test coupon — a weld or braze assembly for procedure or performance qualification testing. The coupon may be any product from plate, pipe, tube, etc., and may be a fillet weld, overlay, deposited weld metal, etc.

test specimen — a sample of a test coupon for specific test. The specimen may be a bend test, tension test, impact test, chemical analysis, macrotest, etc. A specimen may be a complete test coupon, for example, in radiographic testing or small diameter pipe tension testing.

thermal cutting (TC) — a group of cutting processes that severs or removes metal by localized melting, burning, or vaporizing of the workpieces

throat, actual (of fillet) — the shortest distance from the root of a fillet weld to its face

throat, effective (of fillet) — the minimum distance minus any reinforcement from the root of a weld to its face

throat, theoretical (of fillet) — the distance from the beginning of the root of the joint perpendicular to the hypotenuse of the largest right triangle that can be inscribed within the fillet-weld cross section

undercut — a groove melted into the base metal adjacent to the weld toe or weld root and left unfilled by weld metal

upper transformation temperature — the temperature at which transformation of the ferrite to austenite is completed during heating

usability — a measure of the relative ease of application of a filler metal to make a sound weld or braze joint

weave bead — a type of weld bead made with transverse of a T oscillation

weld — a localized coalescence of metals or nonmetals produced either by heating the materials to the welding temperature, with or without the application of pressure, or by the application of pressure alone and with or without the use of filler material

weld, autogenous — a fusion weld made without filler metal

weld bead — a weld deposit resulting from a pass. See stringer bead and weave bead.

weld face — the exposed surface of a weld on the side from which welding was done

weld metal — that portion of a weld which has been melted during welding

weld reinforcement — weld metal on the face or root of a groove weld in excess of the metal necessary for the specified weld size

weld size: groove welds — the depth of chamfering plus any penetration beyond the chamfering, resulting in the strength carrying dimension of the weld

weld size: for equal leg fillet welds — the leg lengths of the largest isosceles right triangle which can be inscribed within the fillet weld cross section

weld size: for unequal leg fillet welds — the leg lengths of the largest right triangle which can be inscribed within the fillet weld cross section

welder — one who performs manual or semiautomatic welding

from the application of a concentrated coherent light beam impinging upon the members to be joined

welding, machine — welding with equipment which performs the welding operation under the constant observation and control of a welding operator. The equipment may or may not perform the loading and unloading of the work. See automatic welding.

welding, manual — welding wherein the entire welding operation is performed and controlled by hand

welding, operator — one who operates machine or automatic welding equipment

welding, oxyfuel gas (OFW) — a group of welding processes which produces coalescence by heating materials with an oxyfuel gas flame or flames, with or without the application of pressure, and with or without the use of filler metal

welding, plasma-arc (PAW) — an arc welding process which produces coalescence of metals by heating them with a constricted arc between an electrode and the workpiece (transferred arc), or the electrode and the constricting nozzle (nontransferred arc). Shielding is obtained from the hot, ionized gas issuing from the torch orifice which may be supplemented by an auxiliary source of shielding gas. Shielding gas may be an inert gas or a mixture of gases. Pressure may or may not be used, and filler metal may or may not be supplied.

welding, projection (PW) — a resistance welding process that produces coalescence by the heat obtained from the resistance of the flow of welding current. The resulting welds are localized at predetermined points by projections, embossments, or intersections. The metals to be joined lap over each other.

welding, resistance (RW) — a group of welding processes that produces coalescence of the faying surfaces with the heat obtained from resistance of the workpieces to the flow of the welding current in a circuit of which the workpieces are a part, and by the application of pressure

welding, resistance seam (RSEW) — a resistance welding process that produces a weld at the faying surfaces

of overlapped parts progressively along a length of a joint. The weld may be made with overlapping weld nuggets, a continuous weld nugget, or by forging the joint as it is heated to the welding temperature by resistance to the flow of the welding current.

welding, resistance spot (RSW) — a resistance welding process that produces a weld at the faying surfaces of a joint by the heat obtained from resistance to the flow of welding current through the workpieces from electrodes that serve to concentrate the welding current and pressure at the weld area

welding, resistance stud — a resistance welding process wherein coalescence is produced by the heat obtained from resistance to electric current at the interface between the stud and the workpiece, until the surfaces to be joined are properly heated, when they are brought together under pressure

welding, semiautomatic arc — arc welding with equipment which controls only the filler metal feed. The advance of the welding is manually controlled.

welding, shielded metal-arc (SMAW) — an arc welding process with an arc between a covered electrode and the weld pool. The process is used with shielding from the decomposition of the electrode covering, without the application of pressure, and with filler metal from the electrode

welding, stud — a general term for the joining of a metal stud or similar part to a workpiece. Welding may be accomplished by arc, resistance, friction, or other suitable process with or without external gas shielding.

welding, submerged-arc (SAW) — an arc welding process that uses an arc or arcs between a bare metal electrode or electrodes and the weld pool. The arc and molten metal are shielded by a blanket of granular flux on the workpieces. The process is used without pressure and with filler metal from the electrode and sometimes from a supplemental source (welding rod, flux, or metal granules).

weldment — an assembly whose constituent parts are joined by welding, or parts which contain weld metal overlay

QB-140 TYPES AND PURPOSES OF TESTS AND EXAMINATIONS

QB-141 Tests

Tests used in brazing procedure and performance qualifications are as follows.

QB-141.1 Tension Tests. Tension tests, as described in QB-150, are used to determine the ultimate strength of brazed butt, scarf, lap, and rabbet joints.

QB-141.2 Guided-Bend Tests. Guided-bend tests, as described in QB-160, are used to determine the degree of soundness and ductility of butt and scarf joints.

QB-141.3 Peel Tests. Peel tests, as described in QB-170, are used to determine the quality of the bond and the amount of defects in lap joints.

QB-141.4 Sectioning Tests. Sectioning tests, i.e., the sectioning of test coupons, as described in QB-180, are used to determine the soundness of workmanship coupons or test specimens. Sectioning tests are also used as a substitute for the peel test where the strength of brazing filler material is equal to or greater than the strength of the base metals.

QB-141.5 Workmanship Coupons. Workmanship coupons, as described in QB-182, are used to determine the soundness of joints other than the standard butt, scarf, lap, and rabbet joints.

QB-141.6 Visual Examination. Visual examination of brazed joints is used for estimating the soundness by external appearance, such as continuity of the brazing filler metal, size, contour, and wetting of fillet along the joint and, where appropriate, to determine if filler metal flowed through the joint from the side of application to the opposite side.

QB-150 TENSION TESTS

QB-151 Specimens

Tension test specimens shall conform to one of the types illustrated in QB-462.1(a) through QB-462.1(f), and shall meet the requirements of QB-153.

QB-151.1 Reduced Section — Plate. Reduced-section specimens conforming to the requirements given in QB-462.1(a) and QB-462.1(c) may be used for tension tests on all thicknesses of plate. The specimens may be tested in a support fixture in substantial accordance with QB-462.1(f).

(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 thicknesses greater than 1 in. (25 mm), full thickness specimens or multiple specimens may be used, provided QB-151.1(c) and QB-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 brazed joint 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 QB-153.

QB-151.2 Reduced Section — Pipe. Reduced-section specimens conforming to the requirements given in QB-462.1(b) may be used for tension tests on all thicknesses of pipe or tube having an outside diameter greater than 3 in. (76 mm). The specimens may be tested in a support fixture in substantial accordance with QB-462.1(f).

(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 QB-151.2(c) and QB-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 brazed joint 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 QB-153.

QB-151.3 Full-Section Specimens for Pipe. Tension specimens conforming to the dimensions given in QB-462.1(e) may be used for testing pipe with an outside diameter of 3 in. (76 mm) or less.

QB-152 Tension Test Procedure

The tension test specimen shall be ruptured under tensile load. The tensile strength shall be computed by

ARTICLE XIV

BRAZING DATA

QB-400 VARIABLES

QB-401 General

QB-401.1 Each brazing variable described in this Article is applicable as an essential or nonessential variable for procedure qualification when referenced in QB-250 for each specific process. Essential variables for performance qualification are referenced in QB-350 for each specific brazing process. A change from one brazing process to another brazing process is an essential variable and requires requalification.

QB-402 Base Metal

QB-402.1 A change from a base metal listed under one P-Number in QW/QB-422 to any of the following:

- (a) a metal listed under another P-Number;
- (b) any other base metal not listed in QW/QB-422;
- (c) as permitted in QW-420.2 (for S-Numbers).

The brazing of dissimilar metal joints need not be requalified if each base metal involved is qualified individually for the same brazing filler metal, flux, atmosphere, and process. Similarly, the brazing of dissimilar metal joints qualifies for the individual base metal brazed to itself and for the same brazing filler metal, flux, atmosphere, and process, provided the requirements of QB-153.1(a) are met.

QB-402.2 A change in either or both of the base metals from an alloy listed under one P-Number in QW/QB-422 to any of the following:

- (a) an alloy listed under another P-Number;
- (b) a base metal not listed in QW/QB-422;
- (c) as permitted in QW-420.2 (for S-Numbers).

QB-402.3 A change in base metal thickness beyond the range qualified in QB-451.

QB-403 Brazing Filler Metal

QB-403.1 A change from one F-Number in QB-432 to any other F-Number, or to any other filler metal not listed in QB-432.

QB-403.2 A change in filler metal from one product form to another (for example, from preformed ring to paste).

QB-404 Brazing Temperature

QB-404.1 A change in brazing temperature to a value outside the range specified in the BPS.

QB-406 Brazing Flux, Fuel Gas, or Atmosphere

QB-406.1 The addition or deletion of brazing flux, or a change in the nominal chemical composition of brazing flux.

QB-406.2 A change in the furnace atmosphere from one basic type to another type. For example:

- (1) reducing to inert
- (2) carburizing to decarburizing
- (3) hydrogen to disassociated ammonia

QB-406.3 A change in the type of fuel gas(es).

QB-407 Flow Position

QB-407.1 The addition of other brazing positions than those already qualified (see QB-120 through QB-124, QB-203 for procedure, and QB-303 for performance).

(a) If the brazing filler metal is preplaced or faced from outside the joint, then requalification is required in accordance with the positions defined in QB-461 under the conditions of QB-120 through QB-124.

(b) If the brazing filler metal is preplaced in a joint in a manner that major flow does occur, then requalification is required in accordance with the posi-

QB-416
BRAZING VARIABLES
Brazer and Brazing Operator Performance

A99

Paragraph		Brief of Variables	Essential					DB (Salt/Flux) QB-356	DB (Molten Metal) QB-357
			TB QB-352	FB QB-353	IB QB-354	RB QB-355			
QB-402 Base Metal	.2	ϕ P-Number	X	X	X	X	X	X	
	.3	ϕ T Qualified	X	X	X	X	X	X	
QB-403 Filler Metal	.1	ϕ F-Number	X	X	X	X	X	X	
	.2	ϕ Filler product form	X	X	X	X	X	X	
QB-407 Flow Position	.1	+ Those qualified	X	X	X	X	X	X	
QB-408 Joint Design	.1	ϕ Joint details	X	X	X	X	X	X	
	.3	\pm Clearance specified in BPS	X	X	X	X	X	X	
QB-410 Technique	.5	ϕ Method	X						

Legend:

ϕ Change
+ Addition or greater
- Deletion or less
T Thickness

Welding Processes:

TB Torch brazing
FB Furnace brazing
IB Induction brazing
RB Resistance brazing
DB Dip brazing

BRAZING DATA

QB-432

QB-432 (CONT'D)
F-NUMBERS

Grouping of Brazing Filler Metals for Procedure and Performance Qualification SFA-5.8

QB	F-No.	AWS Classification No.
432.3	103	BCuP-1 BCuP-2 BCuP-3 BCuP-4 BCuP-5 BCuP-6 BCuP-7
432.4	104	BAISi-2 BAISi-3 BAISi-4 BAISi-5 BAISi-7 BAISi-9 BAISi-11
432.5	105	BCu-1 BVCu-1x BCu-1a BCu-2
432.6	106	RBCuZn-A RBCuZn-B RBCuZn-C RBCuZn-D
432.7	107	BNI-1 BNI-1a BNI-2 BNI-3 BNI-4 BNI-5 BNI-5a BNI-6 BNI-7 BNI-8 BNI-9 BNI-10 BNI-11
432.8	108	BAu-1 BAu-2 BAu-3 BAu-4 BAu-5 BAu-6 BVAu-2 BVAu-4 BVAu-7 BVAu-8
432.9	109	BMg-1
432.10	110	BCo-1
432.11	111	BVPd-1

QB-451.4
TENSION TESTS AND SECTION TESTS — RABBET JOINTS

A99

Thickness T of Test Coupon as Brazed, in.	Range of Thickness of Materials Qualified by Test Plate or Pipe, in.		Type and Number of Test Specimens Required	
	Min.	Max.	Tension QB-462.1	Section QB-462.4
Less than $\frac{1}{8}$	$0.5T$	$2T$	2	2
$\frac{1}{8}$ to $\frac{3}{8}$, incl.	$\frac{1}{16}$	$2T$	2	2
Over $\frac{3}{8}$	$\frac{3}{16}$	$2T$	2	2

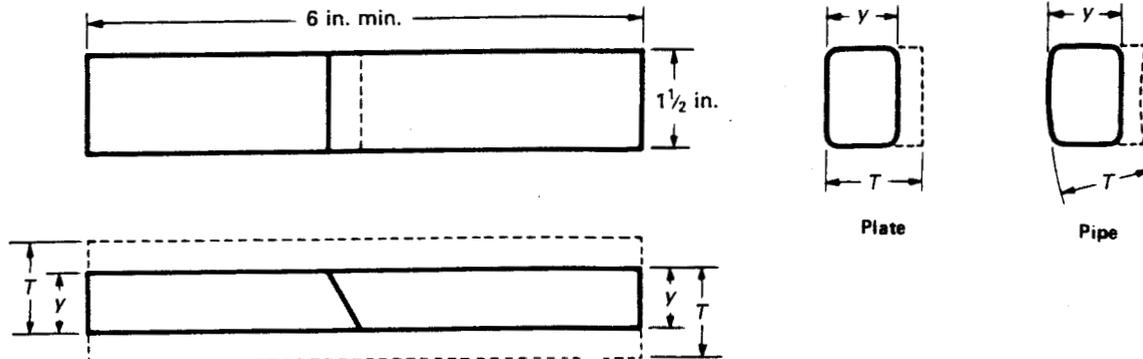
QB-451.5
SECTION TESTS — WORKMANSHIP COUPON JOINTS

A99

Thickness T of Test Coupon as Brazed, in.	Range of Thickness of Materials Qualified by Test Plate or Pipe, in.		Type and Number of Test Specimens Required
	Min.	Max.	Section QB-462.5 [Note (1)]
Less than $\frac{1}{8}$	$0.5T$	$2T$	2
$\frac{1}{8}$ to $\frac{3}{8}$, incl.	$\frac{1}{16}$	$2T$	2
Over $\frac{3}{8}$	$\frac{3}{16}$	$2T$	2

NOTE:

- (1) This test in itself does not constitute procedure qualification but must be validated by conductance of tests of butt or lap joints as appropriate. For joints connecting tension members, such as the stay or partition type in QB-462.5, the validation data may be based upon butt joints; for joints connecting members in shear, such as saddle or spud joints, the validation data may be based on lap joints.

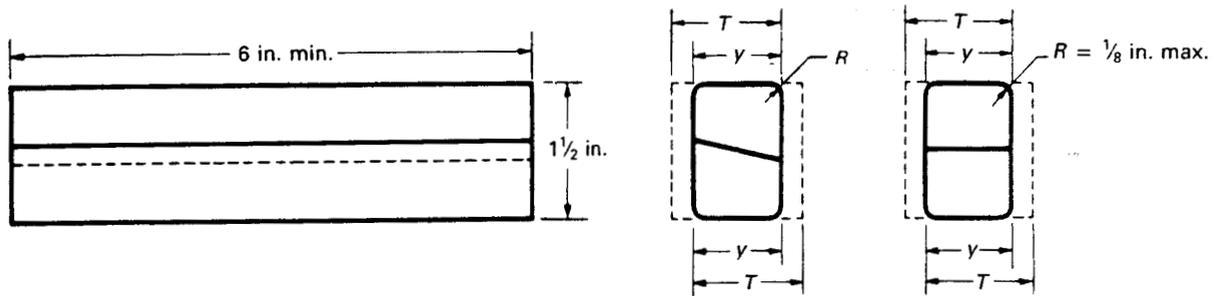


T, in.	y, in.
	All ferrous and nonferrous materials
1/16-3/8	T
> 3/8	3/8

GENERAL NOTE:
 For the first surface bend specimens, machine from the second surface as necessary until the required thickness is obtained. For second surface bend specimens, machine from the first surface as necessary until the required thickness is obtained.

QB-462.2(a) TRANSVERSE FIRST AND SECOND SURFACE BENDS — PLATE AND PIPE

A99

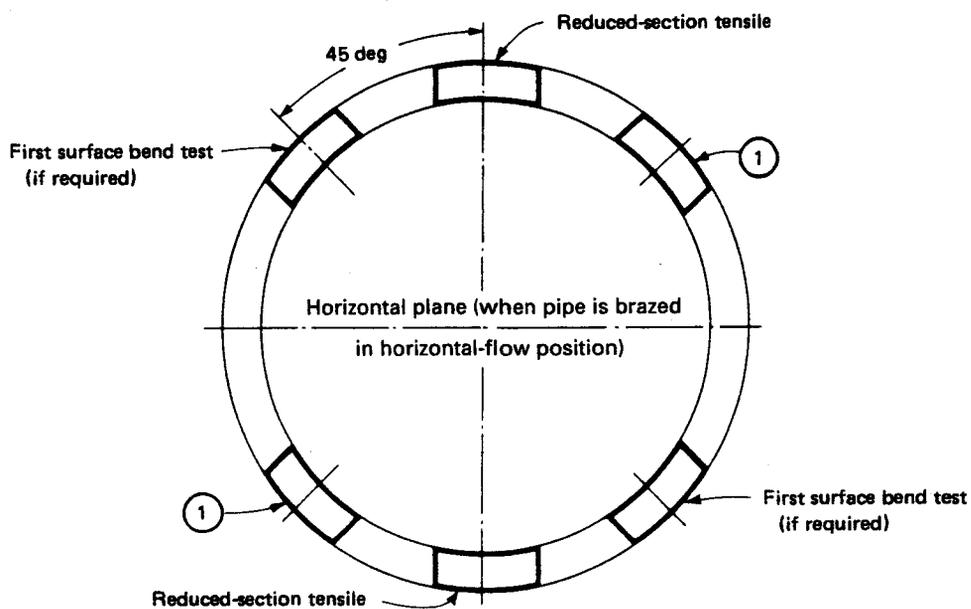


T, in.	y, in.
	All ferrous and nonferrous materials
1/16-3/8	T
> 3/8	3/8

GENERAL NOTE:
 For the first surface bend specimens, machine from the second surface as necessary until the required thickness is obtained. For second surface bend specimens, machine from the first surface as necessary until the required thickness is obtained.

QB-462.2(b) LONGITUDINAL FIRST AND SECOND SURFACE BENDS — PLATE

A99



GENERAL NOTES:

- (a) Figure shown is for coupons over 3 in. O. D.
- (b) For coupons 3 in. O. D. or less, two coupons are required for peel or section tests. One specimen shall be removed from each coupon. For coupons under 1 in. O. D., the specimen width shall be a one-half section of the test coupon.
- (c) Location ① specimens to be:
 - Second surface bend specimens for butt and scarf joints
 - Peel or sectioning specimens for lap joints
 - Sectioning specimens for rabbet joints

QB-463.1(e) PIPE — PROCEDURE QUALIFICATION

A99

Discard		this piece
Peel test		specimen
Spare		section
Peel test		specimen
Discard		this piece



Lap Joint
[Note (1)]

NOTE:
(1) Required when peel test can be used.

QB-463.2(b) PLATES PERFORMANCE
QUALIFICATION

QB-490

BRAZING DATA

QB-492

A99

QB-490 DELETED

A99

QB-491 DELETED

A99

QB-492 DELETED

QW-483 (Back)

Tensile Test (QW-150)

PQR No. _____

Specimen No.	Width	Thickness	Area	Ultimate Total Load lb	Ultimate Unit Stress psi	Type of Failure & Location

Guided-Bend Tests (QW-160)

Type and Figure No.	Result

Toughness Tests (QW-170)

Specimen No.	Notch Location	Specimen Size	Test Temp.	Impact Values		Drop Weight Break (Y/N)
				Ft. lbs	Shear Mils	

Comments: _____

Fillet-Weld Test (QW-180)

Result — Satisfactory: Yes _____ No _____ Penetration into Parent Metal: Yes _____ No _____

Macro — Results _____

Other Tests

Type of Test _____

Deposit Analysis _____

Other _____

Welder's Name _____ Clock No. _____ Stamp No. _____

Tests conducted by: _____ Laboratory Test No. _____

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Manufacturer _____

Date _____ By _____

(Detail of record of tests are illustrative only and may be modified to conform to the type and number of tests required by the Code.)

NONMANDATORY APPENDIX D

APPENDIX D — NONMANDATORY P-NUMBER LISTING (CONT'D)

98
A5

P- No.	Grp. No.	Spec. No.	Type, Grade, or UNS No.	P- No.	Grp. No.	Spec. No.	Type, Grade, or UNS No.
Steel and Steel Alloys (Cont'd)				Steel and Steel Alloys (Cont'd)			
3	2	SA-672	L75	4	1	SA-335	P11
3	2	SA-691	½CR, Cl. 2	4	1	SA-335	P12
3	2	SA-691	CM-70	4	1	SA-336	F11, Cl. 2
3	2	SA-691	CM-75	4	1	SA-336	F11, Cl. 3
3	3	SA-302	B	4	1	SA-336	F11, Cl. 1
3	3	SA-302	C	4	1	SA-336	F12
3	3	SA-302	D	4	1	SA-369	FP11
3	3	SA-487	Gr. 2, Cl. A	4	1	SA-369	FP12
3	3	SA-487	Gr. 2, Cl. B	4	1	SA-387	11, Cl. 1
3	3	SA-487	Gr. 4, Cl. A	4	1	SA-387	11, Cl. 2
3	3	SA-508	2, Cl. 1	4	1	SA-387	12, Cl. 1
3	3	SA-508	2, Cl. 2	4	1	SA-387	12, Cl. 2
3	3	SA-508	3, Cl. 1	4	1	SA-426	CP11
3	3	SA-508	3, Cl. 2	4	1	SA-426	CP12
3	3	SA-508	4N, Cl. 3	4	1	SA-541	11, Cl. 4
3	3	SA-533	Type A, Cl. 1	4	1	SA-691	1CR
3	3	SA-533	Type A, Cl. 2	4	1	SA-691	1½CR
3	3	SA-533	Type B, Cl. 1	4	1	SA-739	B11
3	3	SA-533	Type B, Cl. 2	4	2	SA-333	4
3	3	SA-533	Type C, Cl. 1	4	2	SA-423	1
3	3	SA-533	Type C, Cl. 2	4	2	SA-423	2
3	3	SA-533	Type D, Cl. 1	5A	1	SA-182	F21
3	3	SA-533	Type D, Cl. 2	5A	1	SA-182	F22, Cl. 1
3	3	SA-541	2, Cl. 1	5A	1	SA-182	F22, Cl. 3
3	3	SA-541	2, Cl. 2	5A	1	SA-199	T4
3	3	SA-541	3, Cl. 1	5A	1	SA-199	T21
3	3	SA-541	3, Cl. 2	5A	1	SA-199	T22
3	3	SA-672	H80	5A	1	SA-213	T21
3	3	SA-672	J80	5A	1	SA-213	T22
3	3	SA-672	J90	5A	1	SA-217	WC9
4	1	SA-182	F11, Cl. 1	5A	1	SA-234	WP22, Cl. 1
4	1	SA-182	F11, Cl. 2	5A	1	SA-250	T22
4	1	SA-182	F11, Cl. 3	5A	1	SA-335	P21
4	1	SA-182	F12, Cl. 1	5A	1	SA-335	P22
4	1	SA-182	F12, Cl. 2	5A	1	SA-336	F21, Cl. 3
4	1	SA-199	T11	5A	1	SA-336	F21, Cl. 1
4	1	SA-202	A	5A	1	SA-336	F22, Cl. 3
4	1	SA-202	B	5A	1	SA-336	F22, Cl. 1
4	1	SA-213	T11	5A	1	SA-369	FP21
4	1	SA-213	T12	5A	1	SA-369	FP22
4	1	SA-217	WC4	5A	1	SA-387	21, Cl. 1
4	1	SA-217	WC5	5A	1	SA-387	21, Cl. 2
4	1	SA-217	WC6	5A	1	SA-387	22, Cl. 1
4	1	SA-234	WP11, Cl. 1	5A	1	SA-387	22, Cl. 2
4	1	SA-234	WP12, Cl. 1	5A	1	SA-426	CP21
4	1	SA-250	T11	5A	1	SA-426	CP22

NONMANDATORY APPENDIX D

APPENDIX D — NONMANDATORY P-NUMBER LISTING (CONT'D)

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P- No.	Grp. No.	Spec. No.	Type, Grade, or UNS No.	P- No.	Grp. No.	Spec. No.	Type, Grade, or UNS No.
Steel and Steel Alloys (Cont'd)				Steel and Steel Alloys (Cont'd)			
6	4	SA-487	CA6NM Cl. B	8	1	SA-213	TP304H
6	4	SA-731	S41500	8	1	SA-213	TP304L
6	4	SA-815	S41500	8	1	SA-213	TP304LN
				8	1	SA-213	TP304N
7	1	SA-240	Type 405	8	1	SA-213	TP316
7	1	SA-240	Type 409	8	1	SA-213	TP316H
7	1	SA-240	Type 410S	8	1	SA-213	TP316L
7	1	SA-268	S40800	8	1	SA-213	TP316LN
7	1	SA-268	TP405	8	1	SA-213	TP316N
7	1	SA-268	TP409	8	1	SA-213	TP321
7	1	SA-268	TP430Ti	8	1	SA-213	TP321H
7	1	SA-479	405	8	1	SA-213	TP347
				8	1	SA-213	TP347H
7	2	SA-182	F430	8	1	SA-213	TP348
7	2	SA-240	S44400				
7	2	SA-240	Type 430	8	1	SA-213	TP348H
7	2	SA-240	Type 439	8	1	SA-213	XM-15
7	2	SA-268	18Cr-2Mo	8	1	SA-240	S30500
				8	1	SA-240	S30600
7	2	SA-268	TP430	8	1	SA-240	S31753
7	2	SA-268	TP439	8	1	SA-240	Type 302
7	2	SA-479	430				
7	2	SA-479	439	8	1	SA-240	Type 304
7	2	SA-479	S44400	8	1	SA-240	Type 304H
				8	1	SA-240	Type 304L
7	2	SA-731	18Cr-2Mo	8	1	SA-240	Type 304LN
7	2	SA-731	TP439	8	1	SA-240	Type 304N
7	2	SA-803	TP439				
				8	1	SA-240	Type 316
8	1	SA-182	S30600	8	1	SA-240	Type 316Cb
8	1	SA-182	F304	8	1	SA-240	Type 316H
8	1	SA-182	F304H	8	1	SA-240	Type 316L
8	1	SA-182	F304L	8	1	SA-240	Type 316LN
8	1	SA-182	F304LN				
				8	1	SA-240	Type 316N
8	1	SA-182	F304N	8	1	SA-240	Type 316Ti
8	1	SA-182	F316	8	1	SA-240	Type 317
8	1	SA-182	F316H	8	1	SA-240	Type 317L
8	1	SA-182	F316L	8	1	SA-240	Type 321
8	1	SA-182	F316LN				
				8	1	SA-240	Type 321H
8	1	SA-182	F316	8	1	SA-240	Type 347
8	1	SA-182	F317	8	1	SA-240	Type 347H
8	1	SA-182	F317L	8	1	SA-240	Type 348
8	1	SA-182	F321	8	1	SA-240	Type 348H
8	1	SA-182	F321H				
				8	1	SA-240	Type XM-15
8	1	SA-182	F347	8	1	SA-240	Type XM-21
8	1	SA-182	F347H	8	1	SA-249	TP304
8	1	SA-182	F348	8	1	SA-249	TP304H
8	1	SA-182	F348H	8	1	SA-249	TP304L
8	1	SA-213	TP304	8	1	SA-249	TP304LN

NONMANDATORY APPENDIX D

APPENDIX D — NONMANDATORY P-NUMBER LISTING (CONT'D)

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P- No.	Grp. No.	Spec. No.	Type, Grade, or UNS No.	P- No.	Grp. No.	Spec. No.	Type, Grade, or UNS No.
Copper and Copper-Base Alloys (Cont'd)				Nickel and Nickel-Base Alloys (Cont'd)			
35		SB-271	C95200	43		SB-704	N06625
35		SB-271	C95400	43		SB-705	N06625
35		SB-359	C60800				
35		SB-395	C60800	44		SB-333	N10001
35		SB-505	C95200	44		SB-333	N10665
				44		SB-335	N10001
				44		SB-335	N10665
				44		SB-366	N06022
				44		SB-366	N06059
				44		SB-366	N06645
Nickel and Nickel-Base Alloys							
41		SB-160	N02200	44		SB-366	N10001
41		SB-160	N02201	44		SB-366	N10003
41		SB-161	N02200	44		SB-366	N10276
41		SB-161	N02201	44		SB-366	N10665
41		SB-162	N02200	44		SB-434	N10003
				44		SA-494	N26022
41		SB-162	N02201				
41		SB-163	N02200	44		SB-564	N06022
41		SB-163	N02201	44		SB-564	N06059
41		SB-366	N02200	44		SB-564	N10276
41		SB-366	N02201	44		SB-573	N10003
				44		SB-574	N06022
42		SB-127	N04400	44		SB-574	N06059
42		SB-163	N04400	44		SB-574	N06455
42		SB-164	N04400	44		SB-574	N10276
42		SB-164	N04405				
42		SB-165	N04400	44		SB-575	N06022
42		SB-366	N04400	44		SB-575	N06059
42		SB-564	N04400	44		SB-574	N06455
				44		SB-574	N10276
43		SB-163	N06600	44		SB-575	N06022
43		SB-163	N06690	44		SB-575	N06059
43		SB-166	N06600	44		SB-575	N06455
43		SB-166	N06690	44		SB-575	N10276
43		SB-167	N06600	44		SB-619	N06022
				44		SB-619	N06059
43		SB-167	N06690	44		SB-619	N06455
43		SB-168	N06600				
43		SB-168	N06690				
43		SB-366	N06002	44		SB-619	N10001
43		SB-366	N06600	44		SB-619	N10276
43		SB-366	N06625	44		SB-619	N10665
43		SB-435	N06002	44		SB-622	N06022
43		SB-443	N06625	44		SB-622	N06059
				44		SB-622	N06455
43		SB-444	N06625				
43		SB-446	N06625	44		SB-622	N10001
43		SB-516	N06600	44		SB-622	N10276
43		SB-517	N06600	44		SB-622	N10665
43		SB-564	N06600	44		SB-626	N06022
				44		SB-626	N06059
43		SB-564	N06625	44		SB-626	N06455
43		SB-564	N06690				
43		SB-572	N06002				
43		SB-619	N06002	44		SB-626	N10001
43		SB-622	N06002	44		SB-626	N10276
43		SB-626	N06002	44		SB-626	N10665

NONMANDATORY APPENDIX D

APPENDIX D — NONMANDATORY P-NUMBER LISTING (CONT'D)

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P-No.	Grp. No.	Spec. No.	Type, Grade, or UNS No.	P-No.	Grp. No.	Spec. No.	Type, Grade, or UNS No.
Nickel and Nickel-Base Alloys (Cont'd)				Titanium and Titanium-Base Alloys (Cont'd)			
45		SB-688	N08367	51		SB-363	R50250
45		SB-690	N08366	51		SB-363	R50400
45		SB-690	N08367	51		SB-363	R52400
45		SB-691	N08366	51		SB-367	R50400
				51		SB-381	R50250
45		SB-691	N08367	51		SB-381	R50400
45		SB-704	N08825	51		SB-381	R50402
45		SB-705	N08825	51		SB-381	R52400
45		SB-709	N08028				
45		SB-729	N08020	52		SB-265	R50550
				52		SB-265	R53400
46		SB-366	N08330	52		SB-337	R50550
46		SB-511	N08330	52		SB-337	R53400
46		SB-535	N08330	52		SB-338	R50550
46		SB-536	N08330	52		SB-338	R53400
46		SB-710	N08330				
47		SB-435	N06230	52		SB-348	R50550
47		SB-572	N06230	52		SB-348	R53400
47		SB-619	N06230	52		SB-363	R50550
47		SB-622	N06230	52		SB-363	R53400
47		SB-626	N06230	52		SB-367	R50550
				52		SB-381	R50550
				52		SB-381	R53400
Titanium and Titanium-Base Alloys				53		SB-265	R56320
51		SB-265	R50250	53		SB-337	R56320
51		SB-265	R50400	53		SB-338	R56320
51		SB-265	R52250	53		SB-348	R56320
51		SB-265	R52252	53		SB-363	R56320
51		SB-265	R52400				
51		SB-265	R52402	53		SB-381	R56320
51		SB-337	R50250	Zirconium and Zirconium-Base Alloys			
51		SB-337	R50400	61		SB-493	R60702
51		SB-337	R50400	61		SB-523	R60702
51		SB-337	R50400	61		SB-550	R60702
51		SB-337	R50400	61		SB-551	R60702
51		SB-337	R50400	61		SB-658	R60702
51		SB-337	R50400				
51		SB-338	R50250	62		SB-493	R60705
51		SB-338	R50400	62		SB-523	R60705
51		SB-338	R52400	62		SB-550	R60705
51		SB-338	R52402	62		SB-551	R60705
51		SB-348	R50250	62		SB-658	R60705
51		SB-348	R50400				
51		SB-348	R50402				
51		SB-348	R50400				
51		SB-348	R52400				