

**ASME BOILER AND PRESSURE VESSEL CODE
AN INTERNATIONAL CODE**

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



CENTRO DE DOCUMENTAÇÃO
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**2005 Addenda
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**ASME BOILER AND
PRESSURE VESSEL
COMMITTEE
SUBCOMMITTEE ON
WELDING**

P-Numbers

04 QW-420 Material Groupings

QW-420.1 P-Numbers and S-Numbers. Base metals have been assigned P-Numbers or S-Numbers for the purpose of reducing the number of welding and brazing procedure qualifications required. In addition, ferrous base metals have been assigned Group Numbers creating subsets of P-Numbers and S-Numbers that are used when WPSs are required to be qualified by impact testing by other Sections or Codes. 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 that 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. The following table shows the assignment groups for various alloy systems:

| Base Metal | Welding | Brazing |
|-------------------------------------|---|---|
| Steel and steel alloys | P- or S-No. 1 through P- or S-No. 11 incl. P- or S-No. 5A, 5B, and 5C | P- or S-No. 101 through P- or S-No. 103 |
| Aluminum and aluminum-base alloys | P- or S-No. 21 through P- or S-No. 25 | P- or S-No. 104 and P- or S-No. 105 |
| Copper and copper-base alloys | P- or S-No. 31 through P- or S-No. 35 | P- or S-No. 107 and P- or S-No. 108 |
| Nickel and nickel-base alloys | P- or S-No. 41 through P- or S-No. 49 | P- or S-No. 110 through P- or S-No. 112 |
| Titanium and titanium-base alloys | P- or S-No. 51 through P- or S-No. 53 | P- or S-No. 115 |
| Zirconium and zirconium-base alloys | P- or S-No. 61 through P- or S-No. 62 | P- or S-No. 117 |

When a base metal with a UNS number designation is assigned a P- or S-Number or P- or S-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- or S-Number or P- or S-Number plus Group Number. For example, SB-163, UNS N08800 is P-No. 45; therefore, all ASME specifications listing a base metal with the UNS N08800 designation

shall be considered P-No. 45 (i.e., SB-407, SB-408, SB-514, etc.) whether or not these specifications are listed in table QW/QB-422. When utilizing this provision, only base metals listed in table QW/QB-422 may be used for test coupons since a minimum tensile value is required for procedure qualification.

There are instances where materials assigned to one P- or S-Number or Group Number have been reassigned to a different P- or S-Number or Group Number in later editions. Procedure and performance qualifications that were qualified under the previous P- or S-Numbers or Group Number assignment may continue to be used under the new P- or S-Number or Group Number assignment. See QW-200.2(e).

The values given in the column heading "Minimum Specified Tensile" of table QW/QB-422, are the acceptance values for the tensile tests of the welding or brazing procedure qualification, except as otherwise allowed in QW-153 or QB-153.

QW-420.2 S-Numbers. S-Numbers are assigned to materials that 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 Vessel Code Material Specifications (Section II).

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-No. 8, Group No. 1; therefore, A 240 Type 304 is considered S-No. 8, Group No. 1).

Some variables and figures may not specifically address S-Numbers. When this occurs, the requirements regarding P-Numbers and P-Number Group Numbers shall apply equally to materials that are assigned to corresponding S-Numbers and S-Number Group Numbers. However, if procedure qualification testing was done using material assigned an S-Number or S-Number Group Number, the range qualified is limited to materials that are assigned S-Numbers or S-Numbers Group Numbers (i.e., qualification using a P-Number material qualifies corresponding S-Number materials; qualification using an S-Number material qualifies corresponding S-Number materials but not corresponding P-Number materials; qualification of welders using a P-Number material qualifies them to weld on corresponding S-Number materials and vice versa).

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

WELDING DATA

| Ferrous | | | | | | | | | | | |
|-----------|---------------|---------|--------------------------------------|---------|-----------|--------|-----------|---------|--------|---------------------|------------------------|
| Spec. No. | Type or Grade | UNS No. | Minimum Specified Tensile, ksi (MPa) | Welding | | | | Brazing | | Nominal Composition | Product Form |
| | | | | P- No. | Group No. | S- No. | Group No. | P- No. | S- No. | | |
| SA-36 | ... | K02600 | 58 (400) | 1 | 1 | ... | ... | 101 | ... | C-Mn-Si | Plate, bar, & shapes |
| SA-53 | Type F | ... | 48 (330) | 1 | 1 | ... | ... | 101 | ... | C | Furnace welded pipe |
| SA-53 | Type S, Gr. A | K02504 | 48 (330) | 1 | 1 | ... | ... | 101 | ... | C | Smls. pipe |
| SA-53 | Type E, Gr. A | K02504 | 48 (330) | 1 | 1 | ... | ... | 101 | ... | C | Resistance welded pipe |
| SA-53 | Type E, Gr. B | K03005 | 60 (415) | 1 | 1 | ... | ... | 101 | ... | C-Mn | Resistance welded pipe |
| SA-53 | Type S, Gr. B | K03005 | 60 (415) | 1 | 1 | ... | ... | 101 | ... | C-Mn | Smls. pipe |
| SA-105 | ... | K03504 | 70 (485) | 1 | 2 | ... | ... | 101 | ... | C | Flanges & fittings |
| SA-106 | A | K02501 | 48 (330) | 1 | 1 | ... | ... | 101 | ... | C-Si | Smls. pipe |
| SA-106 | B | K03006 | 60 (415) | 1 | 1 | ... | ... | 101 | ... | C-Mn-Si | Smls. pipe |
| SA-106 | C | K03501 | 70 (485) | 1 | 2 | ... | ... | 101 | ... | C-Mn-Si | Smls. pipe |
| A 108 | 1015 CW | G10150 | 60 (415) | ... | ... | 1 | 1 | ... | 101 | C | Bar |
| A 108 | 1018 CW | G10180 | 60 (415) | ... | ... | 1 | 1 | ... | 101 | C | Bar |
| A 108 | 1020 CW | G10200 | 60 (415) | ... | ... | 1 | 1 | ... | 101 | C | Bar |
| SA-134 | SA283 Gr. A | ... | 45 (310) | 1 | 1 | ... | ... | 101 | ... | C | Welded pipe |
| SA-134 | SA283 Gr. B | ... | 50 (345) | 1 | 1 | ... | ... | 101 | ... | C | Welded pipe |
| SA-134 | SA283 Gr. C | K02401 | 55 (380) | 1 | 1 | ... | ... | 101 | ... | C | Welded pipe |
| SA-134 | SA283 Gr. D | K02702 | 60 (415) | 1 | 1 | ... | ... | 101 | ... | C | Welded pipe |
| SA-134 | SA285 Gr. A | K01700 | 45 (310) | 1 | 1 | ... | ... | 101 | ... | C | Welded pipe |
| SA-134 | SA285 Gr. B | K02200 | 50 (345) | 1 | 1 | ... | ... | 101 | ... | C | Welded pipe |
| SA-134 | SA285 Gr. C | K02801 | 55 (380) | 1 | 1 | ... | ... | 101 | ... | C | Welded pipe |
| SA-135 | A | ... | 48 (330) | 1 | 1 | ... | ... | 101 | ... | C | E.R.W. pipe |
| SA-135 | B | ... | 60 (415) | 1 | 1 | ... | ... | 101 | ... | C | E.R.W. pipe |
| A 139 | A | ... | 48 (330) | ... | ... | 1 | 1 | ... | 101 | C | Welded pipe |
| A 139 | B | K03003 | 60 (415) | ... | ... | 1 | 1 | ... | 101 | C | Welded pipe |
| A 139 | C | K03004 | 60 (415) | ... | ... | 1 | 1 | ... | 101 | C | Welded pipe |
| A 139 | D | K03010 | 60 (415) | ... | ... | 1 | 1 | ... | 101 | C | Welded pipe |
| A 139 | E | K03012 | 66 (455) | ... | ... | 1 | 1 | ... | 101 | C | Welded pipe |
| A 148 | 90-60 | ... | 90 (620) | ... | ... | 4 | 3 | ... | 103 | ... | Castings |
| A 167 | Type 301 | S30100 | 75 (515) | ... | ... | 8 | 1 | ... | 102 | 17Cr-7Ni | Plate, sheet, & strip |
| A 167 | Type 302 | S30200 | 75 (515) | ... | ... | 8 | 1 | ... | 102 | 18Cr-8Ni | Plate, sheet, & strip |
| A 167 | Type 302B | S30215 | 75 (515) | ... | ... | 8 | 1 | ... | 102 | 18Cr-8Ni-2Si | Plate, sheet, & strip |
| A 167 | Type 304 | S30400 | 75 (515) | ... | ... | 8 | 1 | ... | 102 | 18Cr-8Ni | Plate, sheet, & strip |
| A 167 | Type 304L | S30403 | 70 (485) | ... | ... | 8 | 1 | ... | 102 | 18Cr-8Ni | Plate, sheet, & strip |
| A 167 | Type 308 | S30800 | 75 (515) | ... | ... | 8 | 2 | ... | 102 | 20Cr-10Ni | Plate, sheet, & strip |

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

| Ferrous (CONT'D) | | | | | | | | | | | | |
|------------------|---------------|---------|--------------------------------------|---------|-----------|--------|---------|--------|---------------------|-----------------|------------------------|--|
| Spec. No. | Type or Grade | UNS No. | Minimum Specified Tensile, ksi (MPa) | Welding | | | Brazing | | Nominal Composition | | Product Form | |
| | | | | P- No. | Group No. | S- No. | P- No. | S- No. | | | | |
| A 167 | Type 309 | S30900 | 75 (515) | ... | ... | 8 | 2 | ... | 102 | 23Cr-12Ni | Plate, sheet, & strip | |
| A 167 | Type 309S | S30908 | 75 (515) | ... | ... | 8 | 2 | ... | 102 | 23Cr-12Ni | Plate, sheet, & strip | |
| A 167 | Type 310 | S31000 | 75 (515) | ... | ... | 8 | 2 | ... | 102 | 25Cr-20Ni | Plate, sheet, & strip | |
| A 167 | Type 310S | S31008 | 75 (515) | ... | ... | 8 | 2 | ... | 102 | 25Cr-20Ni | Plate, sheet, & strip | |
| A 167 | Type 316L | S31603 | 70 (485) | ... | ... | 8 | 1 | ... | 102 | 16Cr-12Ni-2Mo | Plate, sheet, & strip | |
| A 167 | Type 317 | S31700 | 75 (515) | ... | ... | 8 | 1 | ... | 102 | 18Cr-13Ni-3Mo | Plate, sheet, & strip | |
| A 167 | Type 317L | S31703 | 75 (515) | ... | ... | 8 | 1 | ... | 102 | 18Cr-13Ni-3Mo | Plate, sheet, & strip | |
| A 167 | Type 321 | S32100 | 75 (515) | ... | ... | 8 | 1 | ... | 102 | 18Cr-10Ni-Ti | Plate, sheet, & strip | |
| A 167 | Type 347 | S34700 | 75 (515) | ... | ... | 8 | 1 | ... | 102 | 18Cr-10Ni-Cb | Plate, sheet, & strip | |
| A 167 | Type 348 | S34800 | 75 (515) | ... | ... | 8 | 1 | ... | 102 | 18Cr-10Ni-Cb | Plate, sheet, & strip | |
| SA-178 | A | K01200 | 47 (325) | 1 | 1 | ... | ... | 101 | ... | C | E.R.W. tube | |
| SA-178 | C | K03503 | 60 (415) | 1 | 1 | ... | ... | 101 | ... | C | E.R.W. tube | |
| SA-178 | D | ... | 70 (485) | 1 | 2 | ... | ... | 101 | ... | C-Mn-Si | E.R.W. tube | |
| SA-179 | ... | K01200 | 47 (325) | 1 | 1 | ... | ... | 101 | ... | C | Smis. tube | |
| SA-181 | Cl. 60 | K03502 | 60 (415) | 1 | 1 | ... | ... | 101 | ... | C-Si | Pipe flange & fittings | |
| SA-181 | Cl. 70 | K03502 | 70 (485) | 1 | 2 | ... | ... | 101 | ... | C-Si | Pipe flange & fittings | |
| SA-182 | F12, Cl. 1 | K11562 | 60 (415) | 4 | 1 | ... | ... | 102 | ... | 1Cr-0.5Mo | Forgings | |
| SA-182 | F12, Cl. 2 | K11564 | 70 (485) | 4 | 1 | ... | ... | 102 | ... | 1Cr-0.5Mo | Forgings | |
| SA-182 | F11, Cl. 2 | K11572 | 70 (485) | 4 | 1 | ... | ... | 102 | ... | 1.25Cr-0.5Mo-Si | Forgings | |
| SA-182 | F11, Cl. 3 | K11572 | 75 (515) | 4 | 1 | ... | ... | 102 | ... | 1.25Cr-0.5Mo-Si | Forgings | |
| SA-182 | F11, Cl. 1 | K11597 | 60 (415) | 4 | 1 | ... | ... | 102 | ... | 1.25Cr-0.5Mo-Si | Forgings | |
| SA-182 | F2 | K12122 | 70 (485) | 3 | 2 | ... | ... | 101 | ... | 0.5Cr-0.5Mo | Forgings | |
| SA-182 | F1 | K12822 | 70 (485) | 3 | 2 | ... | ... | 101 | ... | C-0.5Mo | Forgings | |
| SA-182 | F22, Cl. 1 | K21590 | 60 (415) | 5A | 1 | ... | ... | 102 | ... | 2.25Cr-1Mo | Forgings | |
| SA-182 | F22, Cl. 3 | K21590 | 75 (515) | 5A | 1 | ... | ... | 102 | ... | 2.25Cr-1Mo | Forgings | |
| SA-182 | FR | K22035 | 63 (435) | 9A | 1 | ... | ... | 101 | ... | 2Ni-1Cu | Forgings | |
| SA-182 | F21 | K31545 | 75 (515) | 5A | 1 | ... | ... | 102 | ... | 3Cr-1Mo | Forgings | |
| SA-182 | F3V | K31830 | 85 (585) | 5C | 1 | ... | ... | 102 | ... | 3Cr-1Mo-V-Ti-B | Forgings | |
| SA-182 | F22V | K31835 | 85 (585) | 5C | 1 | ... | ... | 102 | ... | 2.25Cr-1Mo-V | Forgings | |
| SA-182 | F5 | K41545 | 70 (485) | 5B | 1 | ... | ... | 102 | ... | 5Cr-0.5Mo | Forgings | |
| SA-182 | F5a | K42544 | 90 (620) | 5B | 1 | ... | ... | 102 | ... | 5Cr-0.5Mo | Forgings | |
| SA-182 | F9 | K90941 | 85 (585) | 5B | 1 | ... | ... | 102 | ... | 9Cr-1Mo | Forgings | |
| SA-182 | F91 | K90901 | 85 (585) | 5B | 2 | ... | ... | 102 | ... | 9Cr-1Mo-V | Forgings | |
| SA-182 | F6a, Cl. 1 | S41000 | 70 (485) | 6 | 1 | ... | ... | 102 | ... | 13Cr | Forgings | |
| SA-182 | F6a, Cl. 2 | S41000 | 85 (585) | 6 | 3 | ... | ... | 102 | ... | 13Cr | Forgings | |
| SA-182 | FXM-19 | S20910 | 100 (690) | 8 | 3 | ... | ... | 102 | ... | 22Cr-13Ni-5Mn | Forgings | |

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

WELDING DATA

| Ferrous (CONT'D) | | | | | | | | | |
|------------------|---------------|---------|--------------------------------------|-----------|--------------|-----------|--------------|---------------------|---------------------------|
| Spec. No. | Type or Grade | UNS No. | Minimum Specified Tensile, ksi (MPa) | Welding | | Brazing | | Nominal Composition | Product Form |
| | | | | P- No. | Group No. | S- No. | Group No. | | |
| SA-182 | FXM-11 | S21904 | 90 (620) | 8 | 3 | ... | ... | 21Cr-6Ni-9Mn | Forgings |
| SA-182 | F304 | S30400 | 70 (485) | 8 | 1 | ... | ... | 18Cr-8Ni | Forgings > 5 in. (127 mm) |
| SA-182 | F304 | S30400 | 75 (515) | 8 | 1 | ... | ... | 18Cr-8Ni | Forgings |
| SA-182 | F304L | S30403 | 65 (450) | 8 | 1 | ... | ... | 18Cr-8Ni | Forgings > 5 in. (127 mm) |
| SA-182 | F304L | S30403 | 70 (485) | 8 | 1 | ... | ... | 18Cr-8Ni | Forgings |
| SA-182 | F304H | S30409 | 70 (485) | 8 | 1 | ... | ... | 18Cr-8Ni | Forgings > 5 in. (127 mm) |
| SA-182 | F304H | S30409 | 75 (515) | 8 | 1 | ... | ... | 18Cr-8Ni | Forgings |
| SA-182 | F304N | S30451 | 80 (550) | 8 | 1 | ... | ... | 18Cr-8Ni-N | Forgings |
| SA-182 | F304LN | S30453 | 70 (485) | 8 | 1 | ... | ... | 18Cr-8Ni-N | Forgings > 5 in. (127 mm) |
| SA-182 | F304LN | S30453 | 75 (515) | 8 | 1 | ... | ... | 18Cr-8Ni-N | Forgings |
| SA-182 | F46 | S30600 | 78 (540) | 8 | 1 | ... | ... | 18Cr-15Ni-4Si | Forgings |
| SA-182 | F45 | S30815 | 87 (600) | 8 | 2 | ... | ... | 21Cr-11Ni-N | Forgings |
| SA-182 | F310 | S31000 | 70 (485) | 8 | 2 | ... | ... | 25Cr-20Ni | Forgings > 5 in. (127 mm) |
| SA-182 | F310 | S31000 | 75 (515) | 8 | 2 | ... | ... | 25Cr-20Ni | Forgings |
| SA-182 | F50 | S31200 | 100 (690) | 10H | 1 | ... | ... | 25Cr-6Ni-Mo-N | Forgings |
| SA-182 | F44 | S31254 | 94 (650) | 8 | 4 | ... | ... | 20Cr-18Ni-6Mo | Forgings |
| SA-182 | S31277 | S31277 | 112 (770) | 45 | ... | ... | ... | 27Ni-22Cr-7Mo-Mn-Cu | Forgings |
| SA-182 | F316 | S31600 | 70 (485) | 8 | 1 | ... | ... | 16Cr-12Ni-2Mo | Forgings > 5 in. (127 mm) |
| SA-182 | F316 | S31600 | 75 (515) | 8 | 1 | ... | ... | 16Cr-12Ni-2Mo | Forgings |
| SA-182 | F316L | S31603 | 65 (450) | 8 | 1 | ... | ... | 16Cr-12Ni-2Mo | Forgings > 5 in. (127 mm) |
| SA-182 | F316L | S31603 | 70 (485) | 8 | 1 | ... | ... | 16Cr-12Ni-2Mo | Forgings |
| SA-182 | F316H | S31609 | 70 (485) | 8 | 1 | ... | ... | 16Cr-12Ni-2Mo | Forgings > 5 in. (127 mm) |
| SA-182 | F316H | S31609 | 75 (515) | 8 | 1 | ... | ... | 16Cr-12Ni-2Mo | Forgings |
| SA-182 | F316N | S31651 | 80 (550) | 8 | 1 | ... | ... | 16Cr-12Ni-2Mo-N | Forgings |
| SA-182 | F316LN | S31653 | 70 (485) | 8 | 1 | ... | ... | 16Cr-12Ni-2Mo-N | Forgings > 5 in. (127 mm) |
| SA-182 | F316LN | S31653 | 75 (515) | 8 | 1 | ... | ... | 16Cr-12Ni-2Mo-N | Forgings |
| SA-182 | F317 | S31700 | 70 (485) | 8 | 1 | ... | ... | 18Cr-13Ni-3Mo | Forgings > 5 in. (127 mm) |
| SA-182 | F317 | S31700 | 75 (515) | 8 | 1 | ... | ... | 18Cr-13Ni-3Mo | Forgings |
| SA-182 | F317L | S31703 | 65 (450) | 8 | 1 | ... | ... | 18Cr-13Ni-3Mo | Forgings > 5 in. (127 mm) |
| SA-182 | F317L | S31703 | 70 (485) | 8 | 1 | ... | ... | 18Cr-13Ni-3Mo | Forgings |
| SA-182 | F51 | S31803 | 90 (620) | 10H | 1 | ... | ... | 22Cr-5Ni-3Mo-N | Forgings |
| SA-182 | F321 | S32100 | 70 (485) | 8 | 1 | ... | ... | 18Cr-10Ni-Ti | Forgings > 5 in. (127 mm) |
| SA-182 | F321 | S32100 | 75 (515) | 8 | 1 | ... | ... | 18Cr-10Ni-Ti | Forgings |
| SA-182 | F321H | S32109 | 70 (485) | 8 | 1 | ... | ... | 18Cr-10Ni-Ti | Forgings > 5 in. (127 mm) |
| SA-182 | F321H | S32109 | 75 (515) | 8 | 1 | ... | ... | 18Cr-10Ni-Ti | Forgings |
| SA-182 | F55 | S32760 | 109 (750) | ... | ... | 10H | 1 | 25Cr-8Ni-3Mo-W-Cu-N | Forgings |
| SA-182 | F10 | S33100 | 80 (550) | 8 | 2 | ... | ... | 20Ni-8Cr | Forgings |

QW/QB-422 FERROUS/NONFERROUS P-NUMBERS AND S-NUMBERS (CONT'D)

Grouping of Base Metals for Qualification

WELDING DATA

Ferrous (CONT'D)

| Spec. No. | Type or Grade | UNS No. | Minimum Specified Tensile, ksi (MPa) | Welding | | | Brazing | | Nominal Composition | Product Form |
|-----------|---------------|---------|--------------------------------------|-------------|-------------|-----------|-------------|-------------|--------------------------|-------------------------------------|
| | | | | P-Group No. | S-Group No. | Group No. | P-Group No. | S-Group No. | | |
| | | | | | | | | | | |
| SA-513 | 1010 | G10100 | 45 (310) | 1 | 1 | ... | 101 | ... | C | Tube |
| SA-513 | 1015 | G10150 | 48 (330) | 1 | 1 | ... | 101 | ... | C | Tube |
| A 513 | 1015 CW | G10150 | 65 (450) | ... | ... | 1 | ... | 101 | C | Tube |
| A 513 | 1020 CW | G10200 | 70 (485) | ... | ... | 1 | 2 | ... | 101 C | Tube |
| A 513 | 1025 CW | G10250 | 75 (515) | ... | ... | 1 | 2 | ... | 101 C | Tube |
| A 513 | 1026 CW | G10260 | 80 (550) | ... | ... | 1 | 3 | ... | 101 C | Tube |
| A 514 | F | K11576 | 110 (760) | ... | ... | 11B | 3 | ... | 101 0.75Ni-0.5Cr-0.5Mo-V | Plate, 2½ in. (64 mm) max. |
| A 514 | J | K11625 | 110 (760) | ... | ... | 11B | 6 | ... | 101 C-0.5Mo | Plate, 1¼ in. (32 mm) max. |
| A 514 | B | K11630 | 110 (760) | ... | ... | 11B | 4 | ... | 101 0.5Cr-0.2Mo-V | Plate, 1¼ in. (32 mm) max. |
| A 514 | D | K11662 | 110 (760) | ... | ... | 11B | 5 | ... | 101 1Cr-0.2Mo-Si | Plate, 1¼ in. (32 mm) max. |
| A 514 | A | K11856 | 110 (760) | ... | ... | 11B | 1 | ... | 101 0.5Cr-0.25Mo-Si | Plate, 1¼ in. (32 mm) max. |
| A 514 | E | K21604 | 100 (690) | ... | ... | 11B | 2 | ... | 102 1.75Cr-0.5Mo-Cu | Plate > 2½-6 in. (64-152 mm), incl. |
| A 514 | E | K21604 | 110 (760) | ... | ... | 11B | 2 | ... | 102 1.75Cr-0.5Mo-Cu | Plate, 2½ in. (64 mm) max. |
| A 514 | P | K21650 | 100 (690) | ... | ... | 11B | 8 | ... | 102 1.25Ni-1Cr-0.5Mo | Plate > 2½-6 in. (64-152 mm), incl. |
| A 514 | P | K21650 | 110 (760) | ... | ... | 11B | 8 | ... | 102 1.25Ni-1Cr-0.5Mo | Plate, 2½ in. (64 mm) max. |
| A 514 | Q | ... | 100 (690) | ... | ... | 11B | 9 | ... | 102 1.3Ni-1.3Cr-0.5Mo-V | Plate > 2½-6 in. (64-152 mm), incl. |
| A 514 | Q | ... | 110 (760) | ... | ... | 11B | 9 | ... | 102 1.3Ni-1.3Cr-0.5Mo-V | Plate, 2½ in. (64 mm) max. |
| SA-515 | 60 | K02401 | 60 (415) | 1 | 1 | ... | 101 | ... | C | Plate |
| SA-515 | 65 | K02800 | 65 (450) | 1 | 1 | ... | 101 | ... | C-Si | Plate |
| SA-515 | 70 | K03101 | 70 (485) | 1 | 2 | ... | 101 | ... | C-Si | Plate |
| SA-516 | 55 | K01800 | 55 (380) | 1 | 1 | ... | 101 | ... | C-Si | Plate |
| SA-516 | 60 | K02100 | 60 (415) | 1 | 1 | ... | 101 | ... | C-Mn-Si | Plate |
| SA-516 | 65 | K02403 | 65 (450) | 1 | 1 | ... | 101 | ... | C-Mn-Si | Plate |
| SA-516 | 70 | K02700 | 70 (485) | 1 | 2 | ... | 101 | ... | C-Mn-Si | Plate |
| SA-517 | F | K11576 | 115 (795) | 11B | 3 | ... | 101 | ... | 0.75Ni-0.5Cr-0.5Mo-V | Plate ≤ 2½ in. (64 mm) |
| SA-517 | J | K11625 | 115 (795) | 11B | 6 | ... | 101 | ... | C-0.5Mo | Plate ≤ 1¼ in. (32 mm) |
| SA-517 | B | K11630 | 115 (795) | 11B | 4 | ... | 101 | ... | 0.5Cr-0.2Mo-V | Plate ≤ 1¼ in. (32 mm) |
| SA-517 | A | K11856 | 115 (795) | 11B | 1 | ... | 101 | ... | 0.5Cr-0.25Mo-Si | Plate ≤ 1¼ in. (32 mm) |
| SA-517 | E | K21604 | 105 (725) | 11B | 2 | ... | 102 | ... | 1.75Cr-0.5Mo-Cu | Plate > 2½-6 in. (64-152 mm) |
| SA-517 | E | K21604 | 115 (795) | 11B | 2 | ... | 102 | ... | 1.75Cr-0.5Mo-Cu | Plate ≤ 2½ in. (64 mm) |
| SA-517 | P | K21650 | 105 (725) | 11B | 8 | ... | 102 | ... | 1.25Ni-1Cr-0.5Mo | Plate > 2½-4 in. (64-102 mm) |
| SA-517 | P | K21650 | 115 (795) | 11B | 8 | ... | 102 | ... | 1.25Ni-1Cr-0.5Mo | Plate ≤ 2½ in. (64 mm) |

F-Numbers

QW-423 Alternate Base Materials for Welder Qualification

- 04 **QW-423.1** Base metal used for welder qualification may be substituted for the metal specified in the WPS in accordance with the following table. When a base metal shown in the left column is used for welder qualification, the welder is qualified to weld all combinations of base metals shown in the right column, including unassigned metals of similar chemical composition to these metals.

| Base Metals for Welder Qualification | Qualified Production Base Metals |
|---|---|
| P- or S-No. 1 through P- or S-No. 11, P- or S-No. 34, and P- or S-No. 41 through P- or S-No. 49 | P- or S-No. 1 through P- or S-No. 11, P- or S-No. 34, and P- or S-No. 41 through P- or S-No. 49 |
| P- or S-No. 21 through P- or S-No. 25 | P- or S-No. 21 through P- or S-No. 25 |
| P- or S-No. 51 through P- or S-No. 53 or P- or S-No. 61 through P- or S-No. 62 | P- or S-No. 51 through P- or S-No. 53 and P- or S-No. 61 through P- or S-No. 62 |

- 04 **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

- 04 **QW-424.1** Base metals are assigned P- or S-Numbers in table QW/QB-422; metals that do not appear in table 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 that 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

One metal from a P-Number to any metal from the same P-Number

One metal from a P-Number to any metal from any other P-Number

One metal from P-No. 3 to any metal from P-No. 3

One metal from P-No. 4 to any metal from P-No. 4

One metal from P-No. 5A to any metal from P-No. 5A

One metal from P-No. 5A to a metal from 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 unassigned metal to the same unassigned metal

Any unassigned metal to any P-Number metal

Any unassigned metal to any other unassigned metal

Base Metals Qualified

Any metals assigned that P- or S-Number

Any metal assigned the first P- or S-Number to any metal assigned the second P- or S-Number

Any P- or S-No. 3 metal to any metal assigned P- or S-No. 3 or 1

Any P- or S-No. 4 metal to any metal assigned P- or S-No. 4, 3, or 1

Any P- or S-No. 5A metal to any metal assigned P- or S-No. 5A, 4, 3, or 1

Any P- or S-No. 5A metal to any metal assigned to P- or S-No. 4, 3, or 1

Any P- or S-No. 4 metal to any metal assigned to P- or S-No. 3 or 1

The unassigned metal to itself

The unassigned metal to any metal assigned to the same P- or S-Number as the qualified 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 table 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 that 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 |

WELDING DATA

QW-432

F-NUMBERS

Grouping of Electrodes and Welding Rods for Qualification

04

| F-No. | ASME Specification | AWS Classification | UNS No. |
|------------------------|--|---------------------|---------|
| Steel and Steel Alloys | | | |
| 1 | SFA-5.1 | EXX20 | ... |
| 1 | SFA-5.1 | EXX22 | ... |
| 1 | SFA-5.1 | EXX24 | ... |
| 1 | SFA-5.1 | EXX27 | ... |
| 1 | SFA-5.1 | EXX28 | ... |
| 1 | SFA-5.4 | EXXX(X)-25 | ... |
| 1 | SFA-5.4 | EXXX(X)-26 | ... |
| 1 | SFA-5.5 | EXX20-X | ... |
| 1 | SFA-5.5 | EXX27-X | ... |
| 2 | SFA-5.1 | EXX12 | ... |
| 2 | SFA-5.1 | EXX13 | ... |
| 2 | SFA-5.1 | EXX14 | ... |
| 2 | SFA-5.1 | EXX19 | ... |
| 2 | SFA-5.5 | E(X)XX13-X | ... |
| 3 | SFA-5.1 | EXX10 | ... |
| 3 | SFA-5.1 | EXX11 | ... |
| 3 | SFA-5.5 | E(X)XX10-X | ... |
| 3 | SFA-5.5 | E(X)XX11-X | ... |
| 4 | SFA-5.1 | EXX15 | ... |
| 4 | SFA-5.1 | EXX16 | ... |
| 4 | SFA-5.1 | EXX18 | ... |
| 4 | SFA-5.1 | EXX18M | ... |
| 4 | SFA-5.1 | EXX48 | ... |
| 4 | SFA-5.4 other than austenitic and duplex | EXXX(X)-15 | ... |
| 4 | SFA-5.4 other than austenitic and duplex | EXXX(X)-16 | ... |
| 4 | SFA-5.4 other than austenitic and duplex | EXXX(X)-17 | ... |
| 4 | SFA-5.5 | E(X)XX15-X | ... |
| 4 | SFA-5.5 | E(X)XX16-X | ... |
| 4 | SFA-5.5 | E(X)XX18-X | ... |
| 4 | SFA-5.5 | E(X)XX18M | ... |
| 4 | SFA-5.5 | E(X)XX18M1 | ... |
| 5 | SFA-5.4 austenitic and duplex | EXXX(X)-15 | ... |
| 5 | SFA-5.4 austenitic and duplex | EXXX(X)-16 | ... |
| 5 | SFA-5.4 austenitic and duplex | EXXX(X)-17 | ... |
| 6 | SFA-5.2 | All classifications | ... |
| 6 | SFA-5.9 | All classifications | ... |
| 6 | SFA-5.17 | All classifications | ... |
| 6 | SFA-5.18 | All classifications | ... |
| 6 | SFA-5.20 | All classifications | ... |
| 6 | SFA-5.22 | All classifications | ... |
| 6 | SFA-5.23 | All classifications | ... |
| 6 | SFA-5.25 | All classifications | ... |
| 6 | SFA-5.26 | All classifications | ... |
| 6 | SFA-5.28 | All classifications | ... |
| 6 | SFA-5.29 | All classifications | ... |
| 6 | SFA-5.30 | INMs-X | ... |
| 6 | SFA-5.30 | IN5XX | ... |
| 6 | SFA-5.30 | IN3XX(X) | ... |

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F-NUMBERS (CONT'D)

Grouping of Electrodes and Welding Rods for Qualification

| F-No. | ASME Specification | AWS Classification | UNS No. |
|------------------------------|--------------------|--------------------|---------|
| Aluminum and Aluminum Alloys | | | |
| 21 | SFA-5.3 | E1100 | A91100 |
| 21 | SFA-5.3 | E3003 | A93003 |
| 21 | SFA-5.10 | ER1100 | A91100 |
| 21 | SFA-5.10 | ER1188 | A91188 |
| 21 | SFA-5.10 | R1100 | A91100 |
| 21 | SFA-5.10 | R1188 | A91188 |
| 22 | SFA-5.10 | ER5183 | A95183 |
| 22 | SFA-5.10 | ER5356 | A95356 |
| 22 | SFA-5.10 | ER5554 | A95554 |
| 22 | SFA-5.10 | ER5556 | A95556 |
| 22 | SFA-5.10 | ER5654 | A95654 |
| 22 | SFA-5.10 | R5183 | A95183 |
| 22 | SFA-5.10 | R5356 | A95356 |
| 22 | SFA-5.10 | R5554 | A95554 |
| 22 | SFA-5.10 | R5556 | A95556 |
| 22 | SFA-5.10 | R5654 | A95654 |
| 23 | SFA-5.3 | E4043 | A94043 |
| 23 | SFA-5.10 | ER4009 | A94009 |
| 23 | SFA-5.10 | ER4010 | A94010 |
| 23 | SFA-5.10 | ER4043 | A94043 |
| 23 | SFA-5.10 | ER4047 | A94047 |
| 23 | SFA-5.10 | ER4145 | A94145 |
| 23 | SFA-5.10 | ER4643 | A94643 |
| 23 | SFA-5.10 | R4009 | A94009 |
| 23 | SFA-5.10 | R4010 | A94010 |
| 23 | SFA-5.10 | R4011 | A94011 |
| 23 | SFA-5.10 | R4043 | A94043 |
| 23 | SFA-5.10 | R4047 | A94047 |
| 23 | SFA-5.10 | R4145 | A94145 |
| 23 | SFA-5.10 | R4643 | A94643 |
| 24 | SFA-5.10 | R-A356.0 | A13560 |
| 24 | SFA-5.10 | R-A357.0 | A13570 |
| 24 | SFA-5.10 | R-C355.0 | A33550 |
| 24 | SFA-5.10 | R206.0 | A02060 |
| 24 | SFA-5.10 | R357.0 | A03570 |
| 25 | SFA-5.10 | ER2319 | A92319 |
| 25 | SFA-5.10 | R2319 | A92319 |
| Copper and Copper Alloys | | | |
| 31 | SFA-5.6 | ECu | W60189 |
| 31 | SFA-5.7 | ERCu | C18980 |
| 32 | SFA-5.6 | ECuSi | W60656 |
| 32 | SFA-5.7 | ERCuSi-A | C65600 |
| 33 | SFA-5.6 | ECuSn-A | W60518 |
| 33 | SFA-5.6 | ECuSn-C | W60521 |
| 33 | SFA-5.7 | ERCuSn-A | WC51800 |
| 34 | SFA-5.6 | ECuNi | W60715 |
| 34 | SFA-5.7 | ERCuNi | C71580 |
| 34 | SFA-5.30 | IN67 | C71581 |
| 35 | SFA-5.8 | RBCuZn-A | C47000 |
| 35 | SFA-5.8 | RBCuZn-B | C68000 |
| 35 | SFA-5.8 | RBCuZn-C | C68100 |
| 35 | SFA-5.8 | RBCuZn-D | C77300 |
| 36 | SFA-5.6 | ECuAl-A2 | W60614 |
| 36 | SFA-5.6 | ECuAl-B | W60619 |
| 36 | SFA-5.7 | ERCuAl-A1 | C61000 |

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F-NUMBERS (CONT'D)

Grouping of Electrodes and Welding Rods for Qualification

| F-No. | ASME Specification | AWS Classification | UNS No. |
|-----------------------------------|--------------------|--------------------|---------|
| Copper and Copper Alloys (CONT'D) | | | |
| 36 | SFA-5.7 | ERCuAl-A2 | C61800 |
| 36 | SFA-5.7 | ERCuAl-A3 | C62400 |
| 37 | SFA-5.6 | ECuMnNiAl | C60633 |
| 37 | SFA-5.6 | ECuNiAl | C60632 |
| 37 | SFA-5.7 | ERCuMnNiAl | C63380 |
| 37 | SFA-5.7 | ERCuNiAl | C63280 |
| Nickel and Nickel Alloys | | | |
| 41 | SFA-5.11 | ENi-1 | W82141 |
| 41 | SFA-5.14 | ERNi-1 | N02061 |
| 41 | SFA-5.30 | IN61 | N02061 |
| 42 | SFA-5.11 | ENiCu-7 | W84190 |
| 42 | SFA-5.14 | ERNiCu-7 | N04060 |
| 42 | SFA-5.14 | ERNiCu-8 | N05504 |
| 42 | SFA-5.30 | IN60 | N04060 |
| 43 | SFA-5.11 | ENiCrCoMo-1 | W86117 |
| 43 | SFA-5.11 | ENiCrFe-1 | W86132 |
| 43 | SFA-5.11 | ENiCrFe-2 | W86133 |
| 43 | SFA-5.11 | ENiCrFe-3 | W86182 |
| 43 | SFA-5.11 | ENiCrFe-4 | W86134 |
| 43 | SFA-5.11 | ENiCrFe-7 | W86152 |
| 43 | SFA-5.11 | ENiCrFe-9 | W86094 |
| 43 | SFA-5.11 | ENiCrFe-10 | W86095 |
| 43 | SFA-5.11 | ENiCrMo-2 | W86002 |
| 43 | SFA-5.11 | ENiCrMo-3 | W86112 |
| 43 | SFA-5.11 | ENiCrMo-4 | W80276 |
| 43 | SFA-5.11 | ENiCrMo-5 | W80002 |
| 43 | SFA-5.11 | ENiCrMo-6 | W86620 |
| 43 | SFA-5.11 | ENiCrMo-7 | W86455 |
| 43 | SFA-5.11 | ENiCrMo-10 | W86022 |
| 43 | SFA-5.11 | ENiCrMo-12 | W86032 |
| 43 | SFA-5.11 | ENiCrMo-13 | W86059 |
| 43 | SFA-5.11 | ENiCrMo-14 | W86026 |
| 43 | SFA-5.14 | ERNiCr-3 | N06082 |
| 43 | SFA-5.14 | ERNiCr-4 | N06072 |
| 43 | SFA-5.14 | ERNiCr-6 | N06076 |
| 43 | SFA-5.14 | ERNiCrCoMo-1 | N06617 |
| 43 | SFA-5.14 | ERNiCrFe-5 | N06062 |
| 43 | SFA-5.14 | ERNiCrFe-6 | N07092 |
| 43 | SFA-5.14 | ERNiCrFe-7 | N06052 |
| 43 | SFA-5.14 | ERNiCrFe-8 | N07069 |
| 43 | SFA-5.14 | ERNiCrFe-11 | N06601 |
| 43 | SFA-5.14 | ERNiCrMo-2 | N06002 |
| 43 | SFA-5.14 | ERNiCrMo-3 | N06625 |
| 43 | SFA-5.14 | ERNiCrMo-4 | N10276 |
| 43 | SFA-5.14 | ERNiCrMo-7 | N06455 |
| 43 | SFA-5.14 | ERNiCrMo-10 | N06022 |
| 43 | SFA-5.14 | ERNiCrMo-13 | N06059 |
| 43 | SFA-5.14 | ERNiCrMo-14 | N06686 |
| 43 | SFA-5.14 | ERNiCrWMo-1 | N06231 |
| 43 | SFA-5.30 | IN52 | N06052 |
| 43 | SFA-5.30 | IN62 | N06062 |
| 43 | SFA-5.30 | IN6A | N07092 |
| 43 | SFA-5.30 | IN82 | N06082 |
| 44 | SFA-5.11 | ENiMo-1 | W80001 |

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F-NUMBERS (CONT'D)

Grouping of Electrodes and Welding Rods for Qualification

| F-No. | ASME Specification | AWS Classification | UNS No. |
|-----------------------------------|--------------------|--------------------|---------|
| Nickel and Nickel Alloys (CONT'D) | | | |
| 44 | SFA-5.11 | ENiMo-3 | W80004 |
| 44 | SFA-5.11 | ENiMo-7 | W80665 |
| 44 | SFA-5.11 | ENiMo-8 | W80008 |
| 44 | SFA-5.11 | ENiMo-9 | W80009 |
| 44 | SFA-5.11 | ENiMo-10 | W80675 |
| 44 | SFA-5.14 | ERNiMo-1 | N10001 |
| 44 | SFA-5.14 | ERNiMo-2 | N10003 |
| 44 | SFA-5.14 | ERNiMo-3 | N10004 |
| 44 | SFA-5.14 | ERNiMo-7 | N10665 |
| 44 | SFA-5.14 | ERNiMo-8 | N10008 |
| 44 | SFA-5.14 | ERNiMo-9 | N10009 |
| 44 | SFA-5.14 | ERNiMo-10 | N10675 |
| 45 | SFA-5.11 | ENiCrMo-1 | W86007 |
| 45 | SFA-5.11 | ENiCrMo-9 | W86985 |
| 45 | SFA-5.11 | ENiCrMo-11 | W86030 |
| 45 | SFA-5.14 | ERNiCrMo-1 | N06007 |
| 45 | SFA-5.14 | ERNiCrMo-8 | N06975 |
| 45 | SFA-5.14 | ERNiCrMo-9 | N06985 |
| 45 | SFA-5.14 | ERNiCrMo-11 | N06030 |
| 45 | SFA-5.14 | ERNiFeCr-1 | N08065 |
| Titanium and Titanium Alloys | | | |
| 51 | SFA-5.16 | ERTi-1 | R50100 |
| 51 | SFA-5.16 | ERTi-2 | R50120 |
| 51 | SFA-5.16 | ERTi-3 | R50125 |
| 51 | SFA-5.16 | ERTi-4 | R50130 |
| 52 | SFA-5.16 | ERTi-7 | R52401 |
| 53 | SFA-5.16 | ERTi-9 | R56320 |
| 53 | SFA-5.16 | ERTi-9ELI | R56321 |
| 54 | SFA-5.16 | ERTi-12 | R53400 |
| 55 | SFA-5.16 | ERTi-5 | R56400 |
| 55 | SFA-5.16 | ERTi-5ELI | R56402 |
| 55 | SFA-5.16 | ERTi-6 | R54522 |
| 55 | SFA-5.16 | ERTi-6ELI | R54523 |
| 55 | SFA-5.16 | ERTi-15 | R56210 |
| Zirconium and Zirconium Alloys | | | |
| 61 | SFA-5.24 | ERZr2 | R60702 |
| 61 | SFA-5.24 | ERZr3 | R60704 |
| 61 | SFA-5.24 | ERZr4 | R60705 |
| Hard-Facing Weld Metal Overlay | | | |
| 71 | SFA-5.13 | ECoCr-A | W73006 |
| 71 | SFA-5.13 | ECoCr-B | W73012 |
| 71 | SFA-5.13 | ECoCr-C | W73001 |
| 71 | SFA-5.13 | ECoCr-E | W73021 |
| 71 | SFA-5.13 | ECuAl-A2 | W60617 |
| 71 | SFA-5.13 | ECuAl-B | W60619 |
| 71 | SFA-5.13 | ECuAl-C | W60625 |
| 71 | SFA-5.13 | ECuAl-D | W61625 |
| 71 | SFA-5.13 | ECuAl-E | W62625 |
| 71 | SFA-5.13 | ECuMnNiAl | W60633 |
| 71 | SFA-5.13 | ECuNi | W60715 |
| 71 | SFA-5.13 | ECuNiAl | W60632 |

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F-NUMBERS (CONT'D)

Grouping of Electrodes and Welding Rods for Qualification

| F-No. | ASME Specification | AWS Classification | UNS No. |
|---|--------------------|--------------------|---------|
| Hard-Facing Weld Metal Overlay (CONT'D) | | | |
| 71 | SFA-5.13 | ECuSi | W60656 |
| 71 | SFA-5.13 | ECuSn-A | W60518 |
| 71 | SFA-5.13 | ECuSn-C | W60521 |
| 71 | SFA-5.13 | EFe1 | W74001 |
| 71 | SFA-5.13 | EFe2 | W74002 |
| 71 | SFA-5.13 | EFe3 | W74003 |
| 71 | SFA-5.13 | EFe4 | W74004 |
| 71 | SFA-5.13 | EFe5 | W75110 |
| 71 | SFA-5.13 | EFe6 | W77510 |
| 71 | SFA-5.13 | EFe7 | W77610 |
| 71 | SFA-5.13 | EFeCr-A1A | W74011 |
| 71 | SFA-5.13 | EFeCr-A2 | W74012 |
| 71 | SFA-5.13 | EFeCr-A3 | W74013 |
| 71 | SFA-5.13 | EFeCr-A4 | W74014 |
| 71 | SFA-5.13 | EFeCr-A5 | W74015 |
| 71 | SFA-5.13 | EFeCr-A6 | W74016 |
| 71 | SFA-5.13 | EFeCr-A7 | W74017 |
| 71 | SFA-5.13 | EFeCr-A8 | W74018 |
| 71 | SFA-5.13 | EFeCr-E1 | W74211 |
| 71 | SFA-5.13 | EFeCr-E2 | W74212 |
| 71 | SFA-5.13 | EFeCr-E3 | W74213 |
| 71 | SFA-5.13 | EFeCr-E4 | W74214 |
| 71 | SFA-5.13 | EFeMn-A | W79110 |
| 71 | SFA-5.13 | EFeMn-B | W79310 |
| 71 | SFA-5.13 | EFeMn-C | W79210 |
| 71 | SFA-5.13 | EFeMn-D | W79410 |
| 71 | SFA-5.13 | EFeMn-E | W79510 |
| 71 | SFA-5.13 | EFeMn-F | W79610 |
| 71 | SFA-5.13 | EFeMnCr | W79710 |
| 71 | SFA-5.13 | ENiCr-C | W89606 |
| 71 | SFA-5.13 | ENiCrFeCo | W83002 |
| 71 | SFA-5.13 | ENiCrMo-5A | W80002 |
| 71 | SFA-5.13 | EWCX-12/30 | ... |
| 71 | SFA-5.13 | EWCX-20/30 | ... |
| 71 | SFA-5.13 | EWCX-30/40 | ... |
| 71 | SFA-5.13 | EWCX-40 | ... |
| 71 | SFA-5.13 | EWCX-40/120 | ... |
| 72 | SFA-5.21 | ERCCoCr-A | W73036 |
| 72 | SFA-5.21 | ERCCoCr-B | W73042 |
| 72 | SFA-5.21 | ERCCoCr-C | W73031 |
| 72 | SFA-5.21 | ERCCoCr-E | W73041 |
| 72 | SFA-5.21 | ERCCoCr-G | W73032 |
| 72 | SFA-5.21 | ERCCuAl-A2 | W60618 |
| 72 | SFA-5.21 | ERCCuAl-A3 | W60624 |
| 72 | SFA-5.21 | ERCCuAl-C | W60626 |
| 72 | SFA-5.21 | ERCCuAl-D | W61626 |
| 72 | SFA-5.21 | ERCCuAl-E | W62626 |
| 72 | SFA-5.21 | ERCCuSi-A | W60657 |
| 72 | SFA-5.21 | ERCCuSn-A | W60518 |
| 72 | SFA-5.21 | ERCCuSn-D | W60524 |
| 72 | SFA-5.21 | ERCFE-1 | W74030 |
| 72 | SFA-5.21 | ERCFE-1A | W74031 |
| 72 | SFA-5.21 | ERCFE-2 | W74032 |
| 72 | SFA-5.21 | ERCFE-3 | W74033 |
| 72 | SFA-5.21 | ERCFE-5 | W74035 |

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F-NUMBERS (CONT'D)

Grouping of Electrodes and Welding Rods for Qualification

| F-No. | ASME Specification | AWS Classification | UNS No. |
|---|--------------------|--------------------|---------|
| Hard-Facing Weld Metal Overlay (CONT'D) | | | |
| 72 | SFA-5.21 | ERCFe-6 | W77530 |
| 72 | SFA-5.21 | ERCFe-8 | W77538 |
| 72 | SFA-5.21 | ERCFeCr-A | W74531 |
| 72 | SFA-5.21 | ERCFeCr-A1A | W74530 |
| 72 | SFA-5.21 | ERCFeCr-A3A | W74533 |
| 72 | SFA-5.21 | ERCFeCr-A4 | W74534 |
| 72 | SFA-5.21 | ERCFeCr-A5 | W74535 |
| 72 | SFA-5.21 | ERCFeCr-A9 | W74539 |
| 72 | SFA-5.21 | ERCFeCr-A10 | W74540 |
| 72 | SFA-5.21 | ERCFeMn-C | W79230 |
| 72 | SFA-5.21 | ERCFeMn-F | W79630 |
| 72 | SFA-5.21 | ERCFeMn-G | W79231 |
| 72 | SFA-5.21 | ERCFeMn-H | W79232 |
| 72 | SFA-5.21 | ERCFeMnCr | W79730 |
| 72 | SFA-5.21 | ERNiCr-A | W89634 |
| 72 | SFA-5.21 | ERNiCr-B | W89635 |
| 72 | SFA-5.21 | ERNiCr-C | W89636 |
| 72 | SFA-5.21 | ERNiCrFeCo | W83032 |
| 72 | SFA-5.21 | ERNiCrMo-5A | W80036 |
| 72 | SFA-5.21 | ERCoCr-A | R30006 |
| 72 | SFA-5.21 | ERCoCr-B | R30012 |
| 72 | SFA-5.21 | ERCoCr-C | R30001 |
| 72 | SFA-5.21 | ERCoCr-E | R30021 |
| 72 | SFA-5.21 | ERCoCr-F | R30002 |
| 72 | SFA-5.21 | ERCoCr-G | R30014 |
| 72 | SFA-5.21 | ERCuAl-A2 | C61800 |
| 72 | SFA-5.21 | ERCuAl-A3 | C62400 |
| 72 | SFA-5.21 | ERCuAl-C | C62580 |
| 72 | SFA-5.21 | ERCuAl-D | C62581 |
| 72 | SFA-5.21 | ERCuAl-E | C62582 |
| 72 | SFA-5.21 | ERCuSi-A | C65600 |
| 72 | SFA-5.21 | ERCuSn-A | C51800 |
| 72 | SFA-5.21 | ERCuSn-D | C52400 |
| 72 | SFA-5.21 | ERFe-1 | T74000 |
| 72 | SFA-5.21 | ERFe-1A | T74001 |
| 72 | SFA-5.21 | ERFe-2 | T74002 |
| 72 | SFA-5.21 | ERFe-3 | T74003 |
| 72 | SFA-5.21 | ERFe-5 | T74005 |
| 72 | SFA-5.21 | ERFe-6 | T74006 |
| 72 | SFA-5.21 | ERFe-8 | T74008 |
| 72 | SFA-5.21 | ERFeCr-A | ... |
| 72 | SFA-5.21 | ERFeCr-A1A | ... |
| 72 | SFA-5.21 | ERFeCr-A3A | ... |
| 72 | SFA-5.21 | ERFeCr-A4 | ... |
| 72 | SFA-5.21 | ERFeCr-A5 | ... |
| 72 | SFA-5.21 | ERFeCr-A9 | ... |
| 72 | SFA-5.21 | ERFeCr-A10 | ... |
| 72 | SFA-5.21 | ERFeMn-C | ... |
| 72 | SFA-5.21 | ERFeMn-F | ... |
| 72 | SFA-5.21 | ERFeMn-G | ... |
| 72 | SFA-5.21 | ERFeMn-H | ... |
| 72 | SFA-5.21 | ERFeMnCr | ... |
| 72 | SFA-5.21 | ERNiCr-A | N99644 |
| 72 | SFA-5.21 | ERNiCr-B | N99645 |
| 72 | SFA-5.21 | ERNiCr-C | N99646 |

WELDING DATA

QW-432

F-NUMBERS (CONT'D)

Grouping of Electrodes and Welding Rods for Qualification

| F-No. | ASME Specification | AWS Classification | UNS No. |
|---|--------------------|--------------------|---------|
| Hard-Facing Weld Metal Overlay (CONT'D) | | | |
| 72 | SFA-5.21 | ERNiCr-D | N99647 |
| 72 | SFA-5.21 | ERNiCr-E | N99648 |
| 72 | SFA-5.21 | ERNiCrFeCo | F46100 |
| 72 | SFA-5.21 | ERNiCrMo-5A | N10006 |
| 72 | SFA-5.21 | ERWCX-20/30 | ... |
| 72 | SFA-5.21 | ERWCX-30/40 | ... |
| 72 | SFA-5.21 | ERWCX-40 | ... |
| 72 | SFA-5.21 | ERWCX-40/120 | ... |
| 72 | SFA-5.21 | RWCX-20/30 | ... |
| 72 | SFA-5.21 | RWCX-30/40 | ... |
| 72 | SFA-5.21 | RWCX-40 | ... |
| 72 | SFA-5.21 | RWCX-40/120 | ... |

A-Numbers

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 | 0.20 | ... | ... | ... | 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 | 19.00-30.00 | 6.00 | 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.

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QW-450 SPECIMENS
QW-451 Procedure Qualification Thickness Limits and Test Specimens

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A05

QW-451.1
GROOVE-WELD TENSION TESTS AND TRANSVERSE-BEND TESTS

| Thickness T of Test Coupon, Welded, in. (mm) | Range of Thickness T of Base Metal, Qualified, in. (mm) | | Maximum Thickness t of Deposited Weld Metal, Qualified, in. (mm) | Type and Number of Tests Required (Tension and Guided-Bend Tests) [Note (2)] | | | | |
|--|---|--------------------|--|---|-------------------------|-------------------------|-------------------------|--|
| | [Notes (1) and (2)] | | | Tension, QW-150 | Side Bend, QW-160 | Face Bend, QW-160 | Root Bend, QW-160 | |
| | Min. | Max. | | | | | | |
| Less than $\frac{1}{16}$ (1.5) | T | $2T$ | $2t$ | 2 | ... | 2 | 2 | |
| $\frac{1}{16}$ to $\frac{3}{16}$ (1.5 to 10), incl. | $\frac{1}{16}$ (1.5) | $2T$ | $2t$ | 2 | Note (5) | 2 | 2 | |
| Over $\frac{3}{16}$ (10), but less than $\frac{3}{4}$ (19) | $\frac{3}{16}$ (5) | $2T$ | $2t$ | 2 | Note (5) | 2 | 2 | |
| $\frac{3}{4}$ (19) to less than $1\frac{1}{2}$ (38) | $\frac{3}{16}$ (5) | $2T$ | $2t$ when $t < \frac{3}{4}$ (19) | 2 [Note (4)] | 4 | ... | ... | |
| $\frac{3}{4}$ (19) to less than $1\frac{1}{2}$ (38) | $\frac{3}{16}$ (5) | $2T$ | $2T$ when $t \geq \frac{3}{4}$ (19) | 2 [Note (4)] | 4 | ... | ... | |
| $1\frac{1}{2}$ (38) and over | $\frac{3}{16}$ (5) | 8 (200) [Note (3)] | $2t$ when $t < \frac{3}{4}$ (19) | 2 [Note (4)] | 4 | ... | ... | |
| $1\frac{1}{2}$ (38) and over | $\frac{3}{16}$ (5) | 8 (200) [Note (3)] | 8 (200) [Note (3)] when $t \geq \frac{3}{4}$ (19) | 2 [Note (4)] | 4 | ... | ... | |

NOTES:

- (1) The following variables further restrict the limits shown in this table when they are referenced in QW-250 for the process under consideration: QW-403.9, QW-403.10, QW-404.32, and QW-407.4. Also, QW-202.2, QW-202.3, and QW-202.4 provide exemptions that supersede the limits of this table.
- (2) For combination of welding procedures, see QW-200.4.
- (3) For the welding processes of QW-403.7 only; otherwise per Note (1) or 2 T , or $2t$, whichever is applicable.
- (4) See QW-151.1, QW-151.2, and QW-151.3 for details on multiple specimens when coupon thicknesses are over 1 in. (25 mm).
- (5) Four side-bend tests may be substituted for the required face- and root-bend tests, when thickness T is $\frac{3}{8}$ in. (10 mm) and over.

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

| Thickness T of Test Coupon Welded, in. (mm) | Range of Thickness T of Base Metal Qualified, in. (mm) [Notes (1) and (2)] | | Thickness t of Deposited Weld Metal Qualified, in. (mm) [Notes (1) and (2)] | | 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 $\frac{1}{16}$ (1.5) | T | $2T$ | | $2t$ | 2 | 2 | 2 |
| $\frac{1}{16}$ to $\frac{3}{8}$ (1.5 to 10), incl. | $\frac{1}{16}$ (1.5) | $2T$ | | $2t$ | 2 | 2 | 2 |
| Over $\frac{3}{8}$ (10) | $\frac{3}{16}$ (5) | $2T$ | | $2t$ | 2 | 2 | 2 |

NOTES:

- (1) The following variables further restrict the limits shown in this table when they are referenced in QW-250 for the process under consideration: QW-403.9, QW-403.10, QW-404.32, and QW-407.4. Also, QW-202.2, QW-202.3, and QW-202.4 provide exemptions that supersede the limits of this table.
- (2) For combination of welding procedures, see QW-200.4.

WELDING DATA

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**QW-451.3
FILLET-WELD TESTS**

| 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 |

GENERAL NOTE: 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-452 Performance Qualification Thickness Limits and Test Specimens

QW-452.1 Groove-Weld Test. The following tables identify the required type and number of tests and the thickness of weld metal qualified.

**QW-452.1(a)
TEST SPECIMENS**

| Thickness of Weld Metal, in. (mm) | Type and Number of Examinations and Test Specimens Required | | | |
|--|---|-------------------------------|---|---|
| | Visual Examination per QW-302.4 | Side Bend QW-462.2 [Note (1)] | Face Bend QW-462.3(a) or QW-462.3(b) [Notes (1), (2)] | Root Bend QW-462.3(a) or QW-462.3(b) [Notes (1), (2)] |
| Less than $\frac{3}{8}$ (10) | X | ... | 1 | 1 |
| $\frac{3}{8}$ (10) to less than $\frac{3}{4}$ (19) | X | 2 [Note (3)] | Note (3) | Note (3) |
| $\frac{3}{4}$ (19) and over | X | 2 | ... | ... |

GENERAL NOTE: The "Thickness of Weld Metal" is the total weld metal thickness deposited by all welders and all processes in the test coupon exclusive of the weld reinforcement.

NOTES:

- (1) To qualify using positions 5G or 6G, a total of four bend specimens are required. To qualify using a combination of 2G and 5G in a single test coupon, a total of six bend specimens are required. See QW-302.3. The type of bend test shall be based on weld metal thickness.
- (2) Coupons tested by face and root bends shall be limited to weld deposit made by one welder with one or two processes or two welders with one process each. Weld deposit by each welder and each process shall be present on the convex surface of the appropriate bent specimen.
- (3) One face and root bend may be substituted for the two side bends.

**QW-452.1(b)
THICKNESS OF WELD METAL QUALIFIED**

| Thickness, t , of Weld Metal in the Coupon, in. (mm) [Notes (1) and (2)] | Thickness of Weld Metal Qualified [Note (3)] |
|--|--|
| All | $2t$ |
| $\frac{1}{2}$ (13) and over with a minimum of three layers | Maximum to be welded |

NOTES:

- (1) When more than one welder and/or more than one process and more than one filler metal F-Number is used to deposit weld metal in a coupon, the thickness, t , of the weld metal in the coupon deposited by each welder with each process and each filler metal F-Number in accordance with the applicable variables under QW-404 shall be determined and used individually in the "Thickness, t , of Weld Metal in the Coupon" column to determine the "Thickness of Weld Metal Qualified."
- (2) Two or more pipe test coupons with different weld metal thickness may be used to determine the 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 $\frac{3}{4}$ in. (19 mm) or over shall be used for qualifying a combination of three or more welders each of whom may use the same or a different welding process.

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QW-452.3
GROOVE-WELD DIAMETER LIMITS

| Outside Diameter of Test Coupon, in. (mm) | Outside Diameter Qualified, in. (mm) | |
|--|---|-----------|
| | Min. | Max. |
| Less than 1 (25) | Size welded | Unlimited |
| 1 (25) to $2\frac{7}{8}$ (73) | 1 (25) | Unlimited |
| Over $2\frac{7}{8}$ (73) | $2\frac{7}{8}$ (73) | Unlimited |

GENERAL NOTES:

- (a) Type and number of tests required shall be in accordance with QW-452.1.
(b) $2\frac{7}{8}$ in. (73 mm) O.D. is the equivalent of NPS $2\frac{1}{2}$ (DN 65).

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QW-452.4
SMALL DIAMETER FILLET-WELD TEST

| Outside Diameter of Test Coupon, in. (mm) | Minimum Outside Diameter, Qualified, in. (mm) | Qualified Thickness |
|--|---|------------------------|
| Less than 1 (25) | Size welded | All |
| 1 (25) to $2\frac{7}{8}$ (73) | 1 (25) | All |
| Over $2\frac{7}{8}$ (73) | $2\frac{7}{8}$ (73) | All |

GENERAL NOTES:

- (a) Type and number of tests required shall be in accordance with QW-452.5.
(b) $2\frac{7}{8}$ in. (73 mm) O.D. is considered the equivalent of NPS $2\frac{1}{2}$ (DN 65).

WELDING DATA

QW-452.5 FILLET-WELD TEST

| Type of Joint | Thickness of Test Coupon as Welded, in. (mm) | Qualified Range | Type and Number of Tests Required [QW-462.4(b) or QW-462.4(c)] | |
|---------------|--|--|--|----------|
| | | | Macro | Fracture |
| Tee fillet | $\frac{3}{16}$ – $\frac{3}{8}$ (5–10) | All base material thicknesses, fillet sizes, and diameters $2\frac{7}{8}$ (73) O.D. and over [Note (1)] | 1 | 1 |
| | Less than $\frac{3}{16}$ (5) | T to $2T$ base material thickness, T maximum fillet size, and all diameters $2\frac{7}{8}$ (73) O.D. and over [Note (1)] | 1 | 1 |

GENERAL NOTE: 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.

NOTE:

(1) $2\frac{7}{8}$ in. (73 mm) O.D. is considered the equivalent of NPS $2\frac{1}{2}$ (DN 65). For smaller diameter qualifications, refer to QW-452.4 or QW-452.6.

QW-452.6 FILLET QUALIFICATION BY GROOVE-WELD TESTS

| Type of Joint | Thickness of Test Coupon as Welded, in. (mm) | Qualified Range | 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 |

2004 SECTION IX

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 | | Hard-facing Overlay (Wear-Resistant) [Note (2)] | |
|--|---|--------------------------------------|--|--------------------------------------|
| | Nominal Base Metal Thickness Qualified (T) | Type and Number of Tests Required | Nominal Base Metal Thickness Qualified (T) | Type and Number of Tests Required |
| Procedure Qualification Testing | | | | |
| Less than 1 in. (25 mm) T | T qualified to unlimited | Notes (4), (5), and (9) | T qualified up to 1 in. (25 mm) | Notes (3), (7), (8), and (9) |
| 1 in. (25 mm) and over T | 1 in. (25 mm) to unlimited | | 1 in. (25 mm) to unlimited | |
| Performance Qualification Testing | | | | |
| Less than 1 in. (25 mm) T | T qualified to unlimited | Note (6) | T qualified to unlimited | Notes (8) and (10) |
| 1 in. (25 mm) and over T | 1 in. (25 mm) to unlimited | | 1 in. (25 mm) to unlimited | |

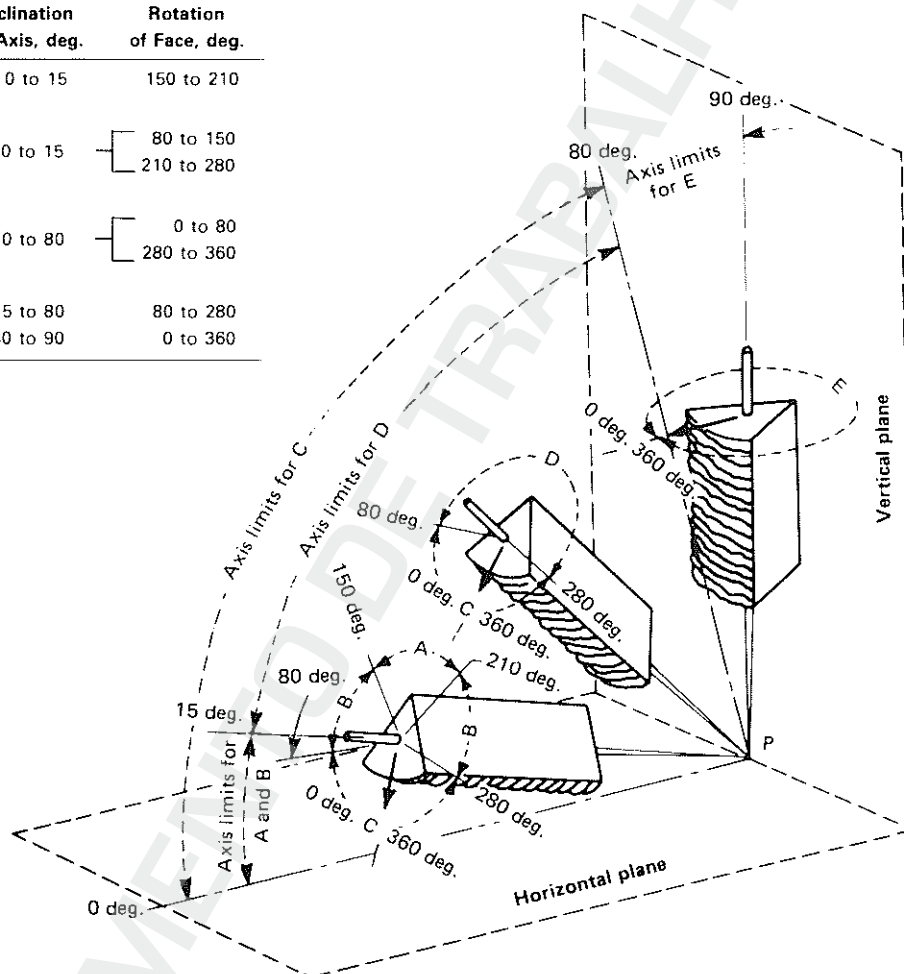
NOTES:

- (1) The qualification test coupon shall consist of base metal not less than 6 in. (150 mm) × 6 in. (150 mm). The weld overlay cladding shall be a minimum of 1½ in. (38 mm) wide by approximately 6 in. (150 mm) long. For qualification on pipe, the pipe length shall be a minimum of 6 in. (150 mm), 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. (13 mm) 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. (150 mm) wide × approximately 6 in. (150 mm) long with a hard-faced layer a minimum of 1½ in. (38 mm) wide × 6 in. (150 mm) 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 that represents the size of the production part. For qualification on pipe, the pipe length shall be 6 in. (150 mm) 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 in QW-195.2 or 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 that are less than ⅜ in. (10 mm) 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(b) or QW-462.5(e). All readings shall meet the requirements of the WPS.
- (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 ×5 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. See QW-462.5(b) for pipe and QW-462.5(e) for plate.
- (9) When a chemical composition is specified in the WPS, 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) and shall be within the range specified in the WPS. This chemical analysis is not required when a chemical composition is not specified on the WPS.
- (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 in QW-195.2 or as specified in the WPS. Surface conditioning prior to liquid penetrant examination is permitted.

QW-460 GRAPHICS

QW-461 Positions

| Tabulation of Positions of Welds | | | |
|----------------------------------|-------------------|---------------------------|------------------------|
| Position | Diagram Reference | Inclination of Axis, deg. | Rotation of Face, deg. |
| Flat | A | 0 to 15 | 150 to 210 |
| Horizontal | B | 0 to 15 | 80 to 150 |
| | | | 210 to 280 |
| Overhead | C | 0 to 80 | 0 to 80 |
| | | | 280 to 360 |
| Vertical | D | 15 to 80 | 80 to 280 |
| | E | 80 to 90 | 0 to 360 |



GENERAL NOTE:

The horizontal reference plane is taken to lie always below the weld under consideration.

Inclination of axis is measured from the horizontal reference plane toward the vertical.

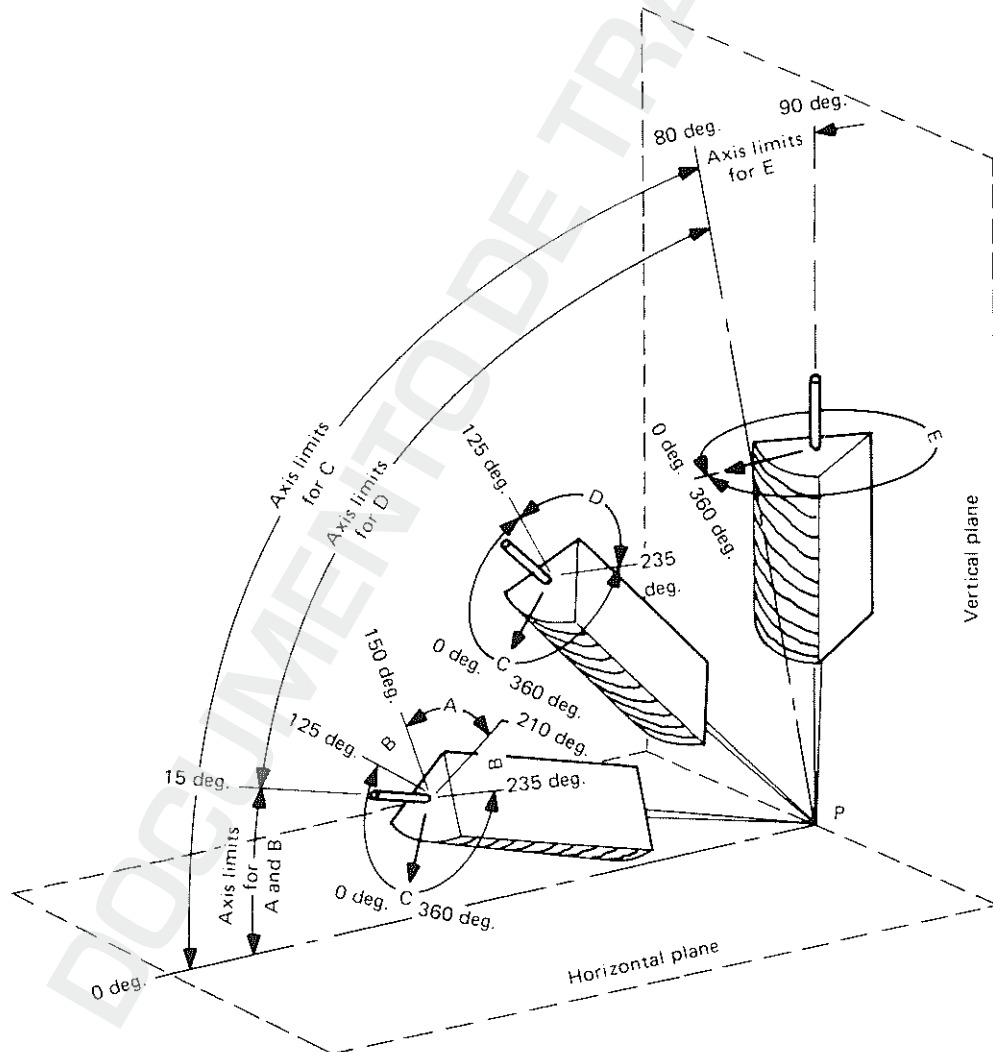
Angle of rotation of face is measured from a line perpendicular to the axis of the weld and lying in a vertical plane containing this axis. The reference position (0 deg.) of rotation of the face invariably points in the direction opposite to that in which the axis angle increases. The angle of rotation of the face of weld is measured in a clockwise direction from this reference position (0 deg.) when looking at point P.

QW-461.1 POSITIONS OF WELDS — GROOVE WELDS

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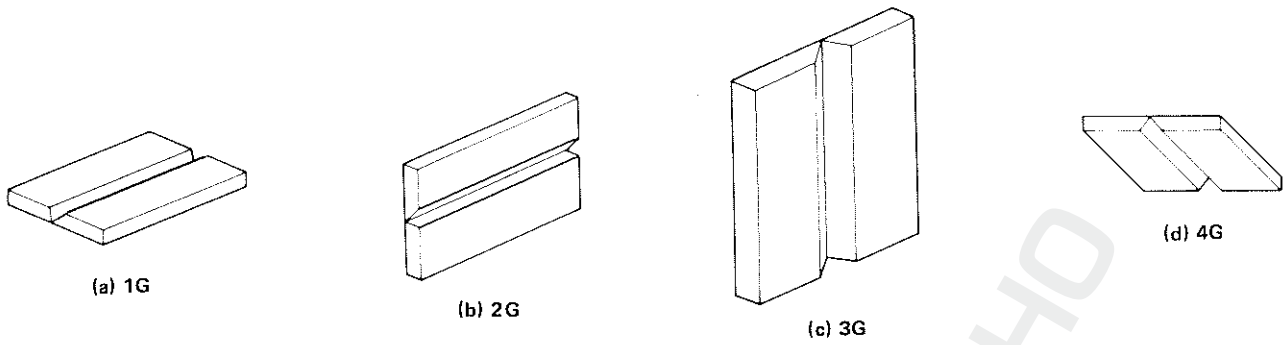
Tabulation of Positions of Fillet Welds

| Position | Diagram Reference | Inclination of Axis, deg. | Rotation of Face, deg. |
|------------|-------------------|---------------------------|--------------------------|
| Flat | A | 0 to 15 | 150 to 210 |
| Horizontal | B | 0 to 15 | 125 to 150 210 to 235 |
| Overhead | C | 0 to 80 | 0 to 125 235 to 360 |
| Vertical | D | 15 to 80 | 125 to 235 |
| | E | 80 to 90 | 0 to 360 |

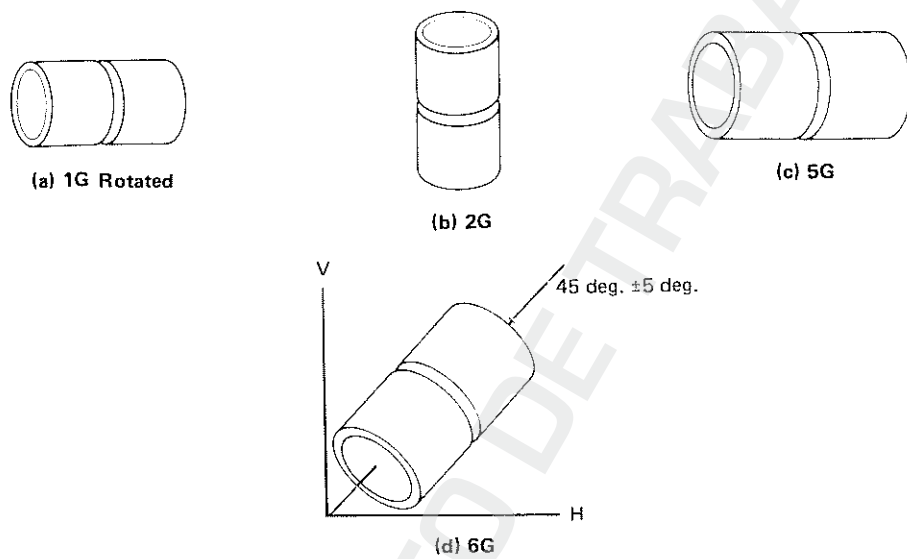


QW-461.2 POSITIONS OF WELDS — FILLET WELDS

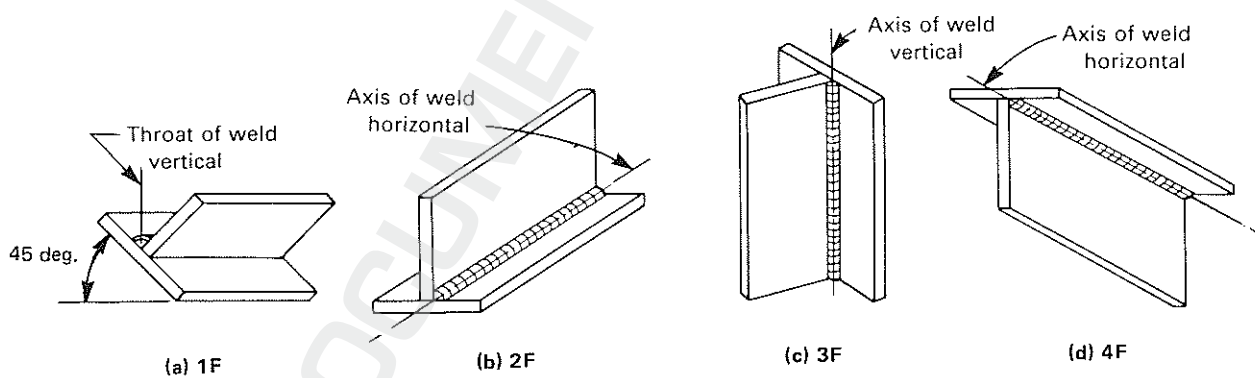
WELDING DATA



QW-461.3 GROOVE WELDS IN PIPE — TEST POSITIONS

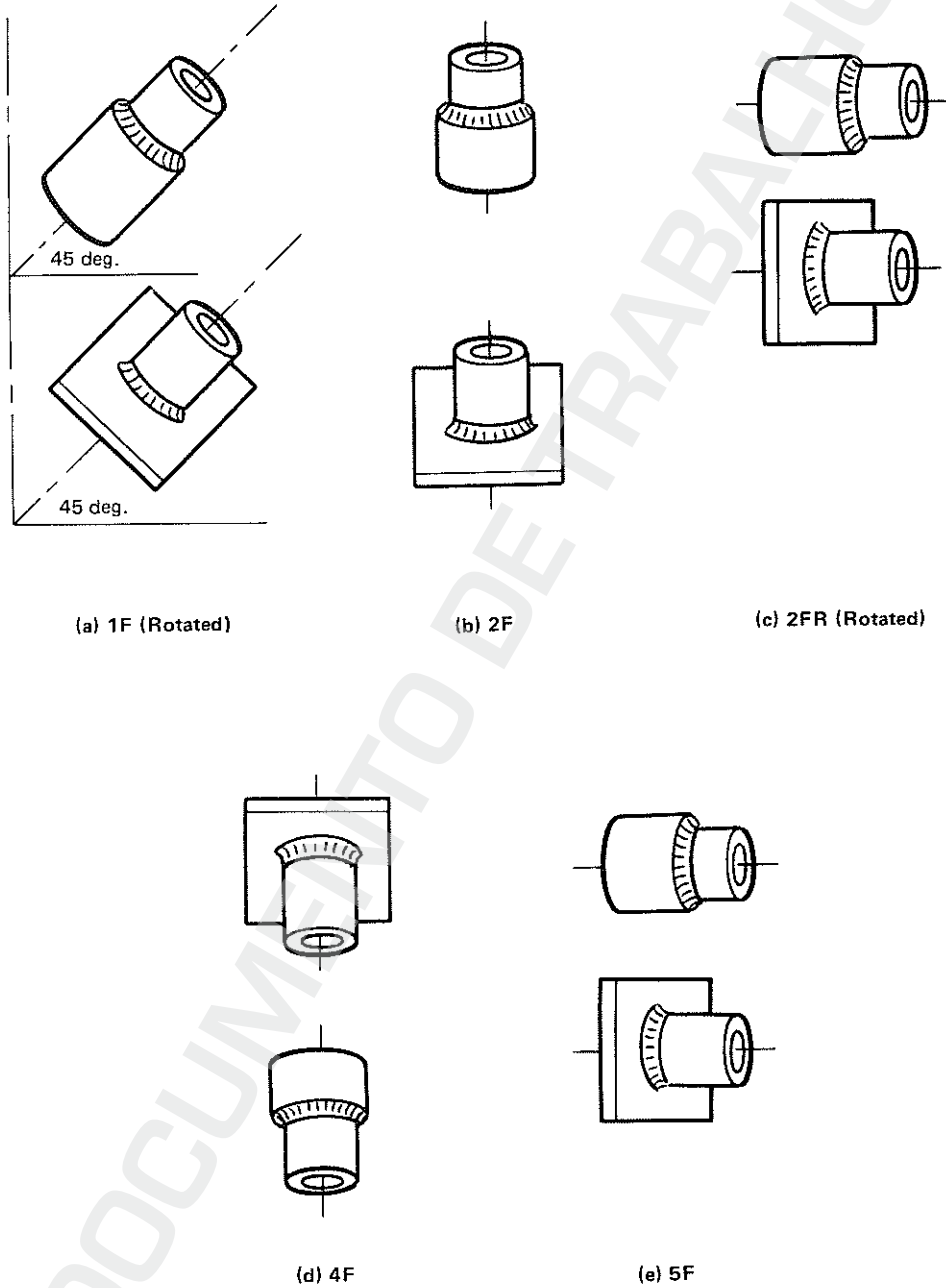


QW-461.4 GROOVE WELDS IN PIPE — TEST POSITIONS



QW-461.5 FILLET WELDS IN PLATE — TEST POSITIONS

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QW-461.6 FILLET WELDS IN PIPE — TEST POSITIONS