ARTICLE III
WELDING PERFORMANCE QUALIFICATIONS

QW-300 GENERAL

QW-300.1 This Article lists the welding processes separately, with the essential variables that 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.

A02 **QW-300.2**

(a) 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.

(b) 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.

(c) 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.

(d) The Code recognizes that manufacturers or contractors may maintain effective operational control of Welder/Welding Operator Performance Qualification (WPQ) records under different ownership than existed during the original welder or weld operator qualification. When a manufacturer or contractor or part of a manufacturer or contractor is acquired by a new owner(s), the WPQs may be used by the new owner(s) without requalification, provided all of the following are met:

(1) the new owner(s) takes responsibility for the WPQs;

(2) the WPQs reflect the name of the new owner(s);

(3) the Quality Control System/Quality Assurance Program reflects the source of the WPQs as being from the former manufacturer or contractor.

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 during welding of test coupons by an employee who is responsible for welder performance qualification. 01

The welding procedure specifications (WPS) that 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. Forms QW-484A/QW-484B (see Nonmandatory Appendix B) have been provided as a guide for the WPQ.

When a welder or welding operator changes employers between participating organizations, the employing 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 other participating organizations that the welder's or welding operator's qualification(s) has been revoked in accordance with QW-322.1(b). The remaining participating organizations 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 an employee who is responsible for welder performance qualification. 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. Suggested forms for these records are given in Forms QW-484A/QW-484B (see Nonmandatory Appendix B). 01

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(a) through QW-463.2(h). Fillet weld test specimens shall be removed in a manner similar to that shown in QW-462.4(a) through QW-462.4(d) 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. (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 $2^{7}/_{8}$ 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 $2^{7}/_{8}$ 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

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 minimum 6 in. (152 mm) length of the first production weld(s) made by a welder using the process(es) and/or mode of arc transfer specified in QW-304 may be examined by radiography. A02

(a) For pipe(s) welded in the 5G, 6G, or special positions, the entire production weld circumference made by the welder shall be radiographed.

(b) For small diameter pipe where the required minimum length of weld cannot be obtained from a single production pipe circumference, additional consecutive circumferences made by the welder shall be radiographed, except that the total number of circumferences need not exceed four.

(c) The radiographic technique and acceptance criteria for production welds shall be in accordance with QW-191.1 and QW-191.2.2.

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-No. 21 through P-No. 25, P-No. 51 through P-No. 53, and P-No. 61 through P-No. 62 metals. Welding operators 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 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.

A02 **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 minimum 3 ft (0.9 m) length of the first production weld(s) made entirely by the welding operator in accordance with a qualified WPS may be examined by radiography.

(a) For pipe(s) welded in the 5G, 6G, or special positions, the entire production weld circumference made by the welding operator shall be radiographed.

(b) For small diameter pipe where the required minimum length of weld cannot be obtained from a single production pipe circumference, additional consecutive circumferences made by the welding operator shall be radiographed except that the total number of circumferences need not exceed four.

(c) The radiographic technique and acceptance criteria for production welds shall be in accordance with QW-191.1 and QW-191.2.3.

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. (DN 150), 8 in. (DN 200), 10 in. (DN 250), or larger diameter pipe shall be employed to make up the test coupon as shown in QW-463.2(f) for 10 in. (DN 250) or larger pipe and in QW-463.2(g) for 6 in. (DN 150) or 8 in. (DN 200) 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. A02
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. (152 mm) plate coupons; for pipe, to examine two pipes for a total of 12 in. (305 mm) 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 may be retested by radiographing an additional twice the required length or number of pipe circumferences of the same or consecutively made production weld(s) specified in QW-304.1. 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 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 production weld alternative test may be retested by radiographing an additional twice the required length or number of pipe circumferences of the same or consecutively made production weld(s) specified in QW-305.1. 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 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 occurs:

(a) When he has not welded with a process during a period of 6 months or more, his qualifications for that process shall expire; unless, within the six month period, prior to his expiration of qualification,

(1) a welder has welded using a manual or semiautomatic welding process which will maintain his qualification for manual and semiautomatic welding with that process;

(2) a welding operator has welded with a machine or automatic welding process which will maintain his qualification for machine and automatic welding with that process.

(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 weld metal thickness for which he will be qualified are dependent upon the approximate thickness of the weld metal 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-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
	.31	ϕ *t* Weld deposit
QW-405 Positions	.1	+ Position
QW-408 Gas	.7	ϕ Type fuel gas

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-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-Corded 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
	.23	ϕ Solid or metal-cored to flux-cored
	.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
	.23	ϕ Solid or metal-cored to flux-cored
	.30	ϕ *t* Weld deposit
QW-405 Positions	.1	+ Position
	.3	ϕ ↑ ↓ Vertical welding
QW-408 Gas	.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

A welding operator shall be requalified whenever a change is made in one of the following essential variables. There may be exceptions or additional requirements for the processes of QW-362, QW-363, and the special processes of QW-380.

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 CO_2 to YAG).

(e) For friction welding, a change from continous 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

01 QW-381 Corrosion-Resistant Weld Metal Overlay

(a) The size of test coupons, limits of base metal thickness 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 there is no limit on the maximum thickness of corrosion-resistant overlay that may be applied in production. When specified as essential variables, the limitations of position and diameter qualified for groove welds shall apply to overlay welds except the limitations on diameter qualified shall apply only to welds deposited in the circumferential direction. A02

(d) A welder or welding operator who has qualified on composite welds in clad or lined material, as provided in QW-383.1(b) is also qualified to deposit corrosion-resistant weld metal overlay.

QW-382 Hard-Facing Weld Metal Overlay (Wear Resistant) 01

(a) The size of the test coupons, limits of base metal thickness 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 there is no limit on the maximum thickness of hard-facing overlay that may be applied in production. When specified as essential variables, the limitations of position and diameter qualified for groove welds shall apply to overlay welds except the limitations on diameter qualified shall apply only to welds deposited in the circumferential direction.

(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 Joining of Clad Materials and Applied Linings

QW-383.1 Clad Materials

(a) Welders and welding operators who will join the base material portion of clad materials shall be qualified for groove welding in accordance with QW-301. Weld-

ers and welding operators who will apply the cladding portion of a weld between clad materials shall be qualified in accordance with QW-381. Welders and welding operators need only be qualified for the portions of composite welds that they will make in production.

(b) As an alternative to QW-383.1(a), welders and welding operators may be qualified using composite test coupons. The test coupon shall be at least $^{3}/_{8}$ in. (10 mm) thick and of dimensions such that a groove weld can be made to join the base materials and the corrosion-resistant weld metal overlay can be applied to the completed groove 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

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.