



**FACULTAD DE INGENIERÍA UNAM
DIVISIÓN DE EDUCACIÓN CONTINUA**

CURSOS ABIERTOS

CA 353



**SOLDADURA CONFORME A LA
SECCION IX, DIV. 1 DEL CÓDIGO
ASME.**

APUNTES GENERALES

**INSTRUCTOR: ING. ORLANDO R. RIVERA MENDOZA
DURACIÓN: 20 HORAS
05 AL 09 DICIEMBRE DE 2005
PALACIO DE MINERÍA**

UNIVERSIDAD NACIONAL AUTONOMA DE MÉXICO
FACULTAD DE INGENIERIA
DIVISIÓN DE EDUCACIÓN CONTINUA

CURSO / MODULO
CALIFICACIONES
DE
SOLDADURA
CONFORME A SECCION IX DEL CODIGO ASME

Instructor : Ing. Orlando R. Rivera
Duración Total: 20 Horas
Lunes a Viernes de 17:00 a 21:00 Horas.

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CONFORME A SECCION IX DEL CODIGO ASME

Este curso / módulo está enfocado a la formación de profesionales que deseen desarrollarse en una de las actividades de mayor trascendencia en la industria metalmecánica. El programa incluye temas de actualidad dictados por el Código ASME para aquellos productos metálicos que requieren de una atención especial durante la operación de soldadura.

OBJETIVO GENERAL:

Proporcionar los conocimientos mínimos requeridos para seleccionar el proceso(s) de soldadura más adecuado a las condiciones existentes, los metales base y de aporte a utilizar, aplicación de especificaciones de procedimientos de soldadura calificados (WPS / PQR) y calificación de soldadores (WPQ / WOPQ) conforme a los lineamientos establecidos en la Sección IX del Código ASME.

DIRIGIDO A:

El curso / módulo esta dirigido a firmas de ingeniería, fabricantes, compañías de inspección, empresas de consultoría, y en general a todos los ingenieros, personal técnico y profesionistas que deseen especializarse o actualizar sus conocimientos en estos temas del Código ASME .

SECTION IX

WELDING QUALIFICATIONS

WELDING PROCESSES
(Specifically addressed
by Section IX)

OFW	PAW
SMAW	ESW
SAW	EGW
GMAW	EBW
FCAW	Stud welding
GTAW	

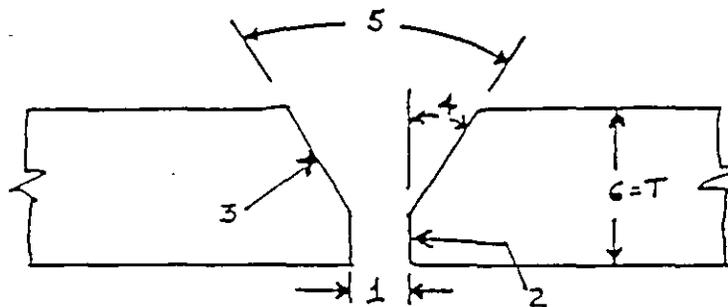
**SPECIAL WELDING
PROCESSES IN SECTION IX**

1. Corrosion-Resistant Weld Metal Overlay
 - a. SMAW
 - b. SAW
 - c. GMAW
 - d. GTAW
 - e. PAW

2. Hard-Facing Weld Metal Overlay (Wear Resistant)
 - a. SMAW
 - b. SAW
 - c. GMAW
 - d. OFW
 - e. PAW

SECTION IX ADDRESSES ONLY THREE TYPES OF WELDS

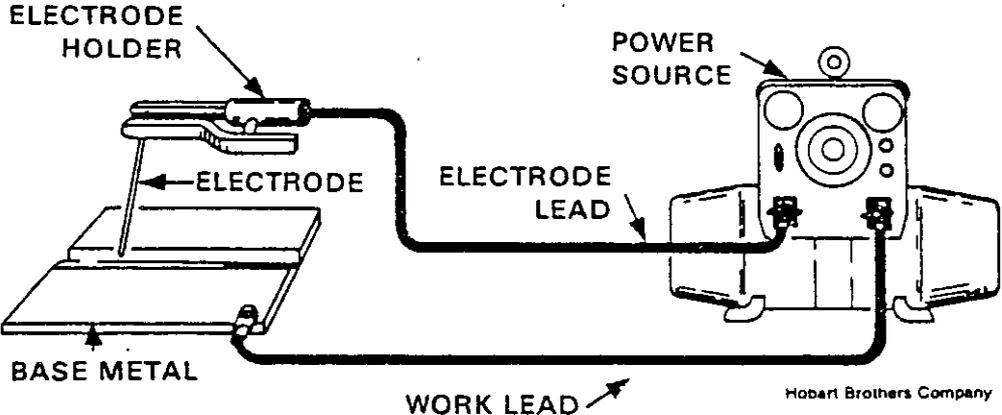
1. GROOVE WELDS
 - a. U GROOVE
 - b. J GROOVE
 - c. V GROOVE
 - d. PARTIAL PENETRATION
 - e. ETC.
2. FILLET WELDS
3. STUD WELDS

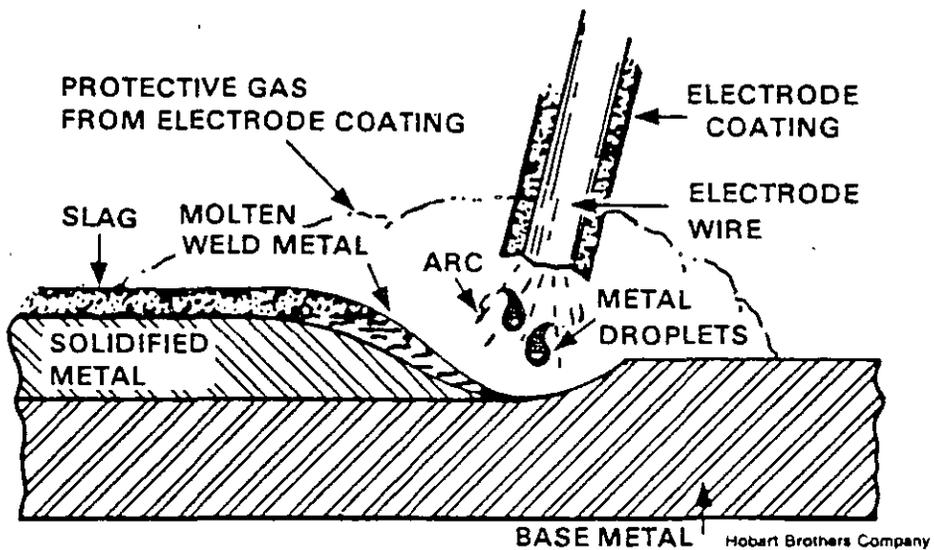


GROOVE WELD

- | | |
|----------------------------|-------------------------------------------------------------------------------------------------------------------|
| 1. ROOT OPENING:
or GAP | The separation between the member to be joined at root of the joint. |
| 2. ROOT FACE: | Groove face adjacent to the root of the joint. |
| 3. GROOVE FACE: | The surface of a member included in the groove. |
| 4. BEVEL ANGLE: | The angle formed between the prepared surface of a member and a plane perpendicular to the surface of the member. |
| 5. GROOVE ANGLE: | The total included angle of the groove between parts to be joined by a groove weld. |
| 6. PLATE THICKNESS: | Thickness welded of test plate or production weldment. Usually indicated by "T". |

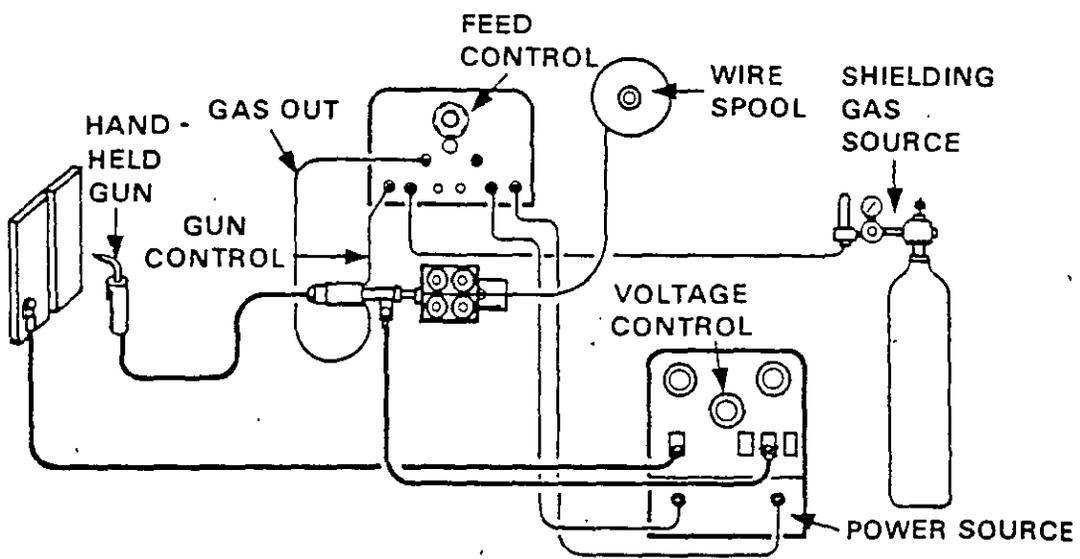
SHIELDED METAL ARC WELDING (SMAW)



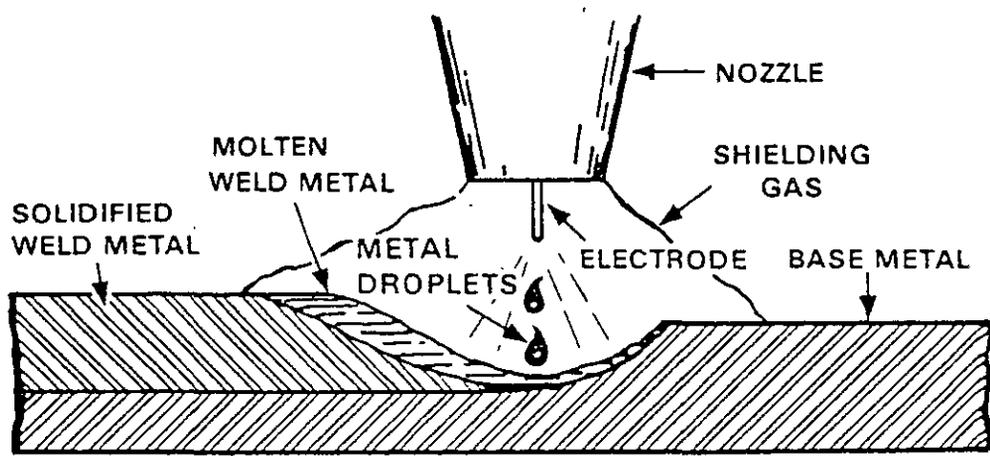


SHIELDED METAL ARC WELDING

GAS METAL ARC WELDING (GMAW)



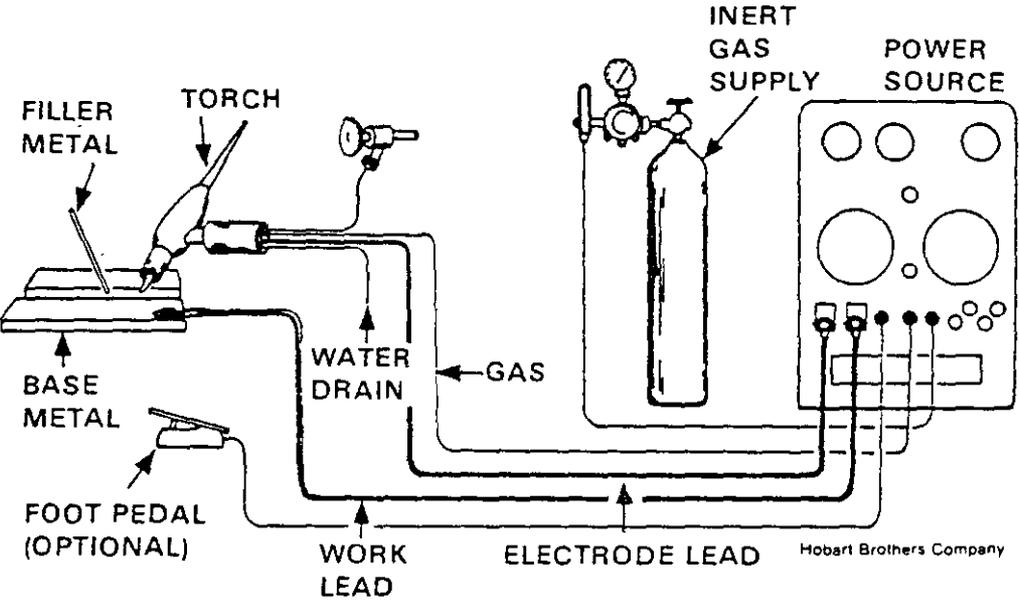
Hobart Brothers Company

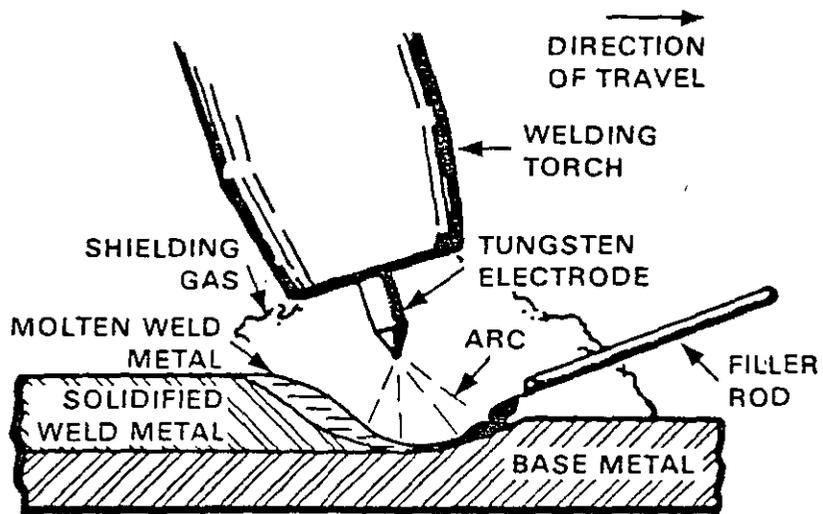


Hobart Brothers Company

GAS METAL ARC WELDING

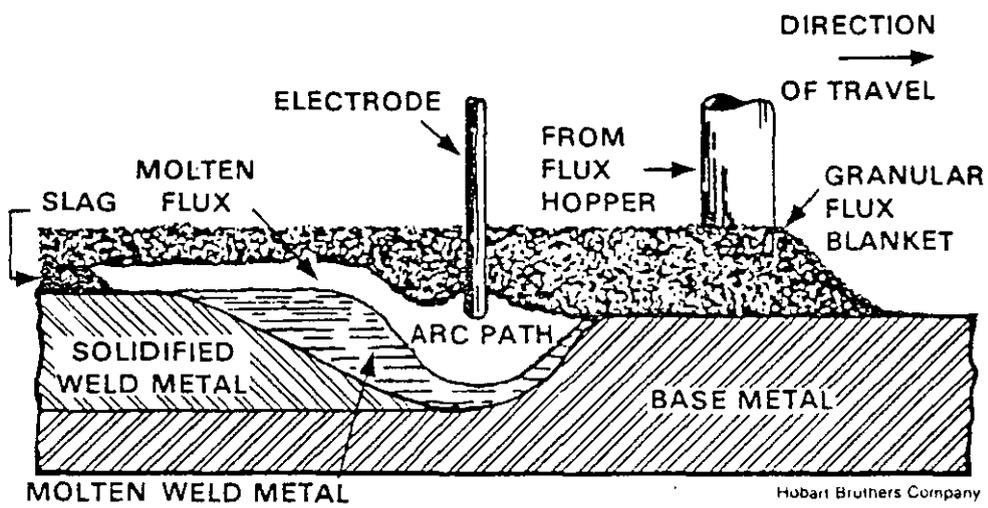
GAS TUNGSTEN ARC WELDING (GTAW)





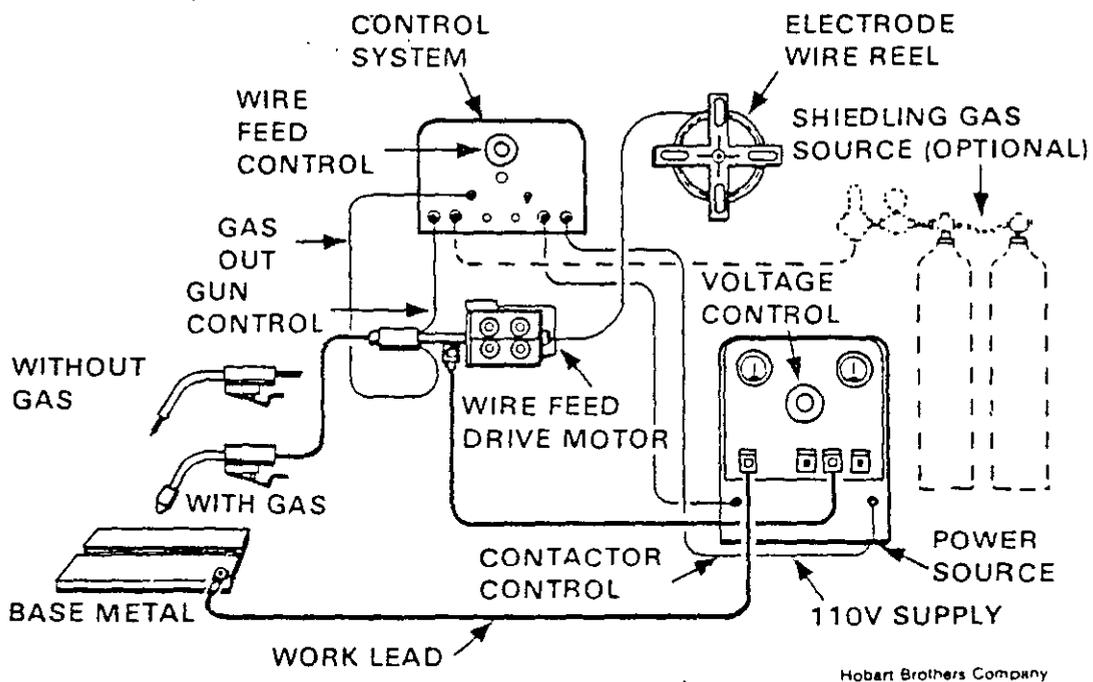
Hobart Brothers Company

GAS TUNGSTEN ARC WELDING

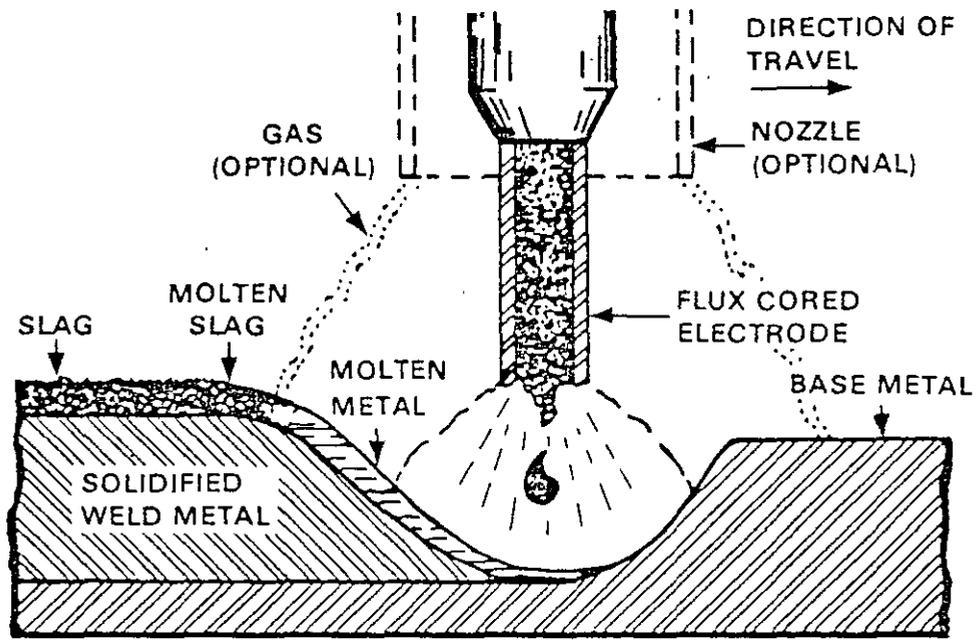


SUBMERGED ARC WELDING

FLUX CORED ARC WELDING (FCAW)

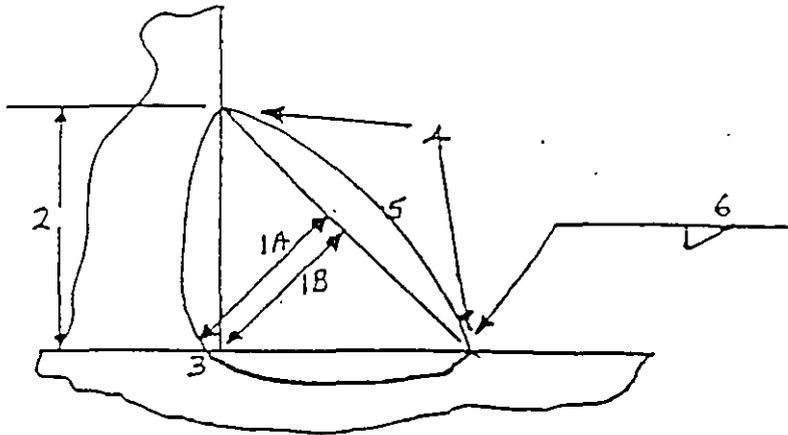


Hobart Brothers Company



Hobart Brothers Company

FLUX CORED ARC WELDING



FILLET WELD

- 1 A. THROAT OF A FILLET WELD: (by AWS) The shortest distance from the root of the fillet weld to its face. Design throat = $.707 \times \text{leg}$.
- 1 B. THEORETICAL THROAT: (by ASME) The shortest distance from the intersection of the two adjoining members to the fillet weld face.
- 2. LEG OF A FILLET WELD: The distance from the root of the joint to the toe of the fillet weld.
- 3. ROOT OF WELD: Deepest point of useful penetration in a fillet weld.
- 4. TOE OF A WELD: The junction between the face of a weld and the base metal. *Intersection*
Borda de soldadura
- 5. FACE OF WELD: The exposed surface of a weld on the side from which the welding was done.
- 6. SIZE OF WELD(S): Leg length of the fillet. Usually what is on drawings.

PROCEDURE QUALIFICATION RECORD (PQR)

Record of the actual values of the essential variables (and other variables if desired) used when welding a test coupon.

PQR CONTENTS

Verifies mechanical properties of the weld by destructive test

Is intended to provide proof of weldability

Lists actual variables used in making test sample

All essential variables for each process and test result must be listed.

SPECIFICATION
WELDING PROCEDURE ~~QUALIFICATION~~
~~RECORD~~ (WPS)

- Documents written (& qualified) to provide direction for making production welds to Code requirements (could be more than one piece of paper)
- Intended to provide direction to those individuals responsible for complying with the welding requirements.
- May be used to provide direction to the welder or welding operator.

WPS

Lists acceptable ranges (minimums or maximums) for all parameters

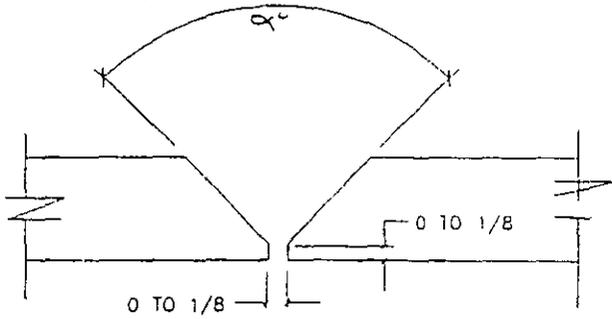
References supporting PQRs

Lists all essential and non-essential (supplementary essential variables if notch toughness applies)

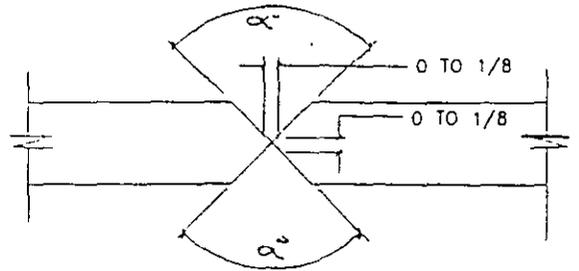
Provide much more detailed description as a true guide for the welder and as a good reference for the foreman and Inspector

JOINT PREPARATIONS

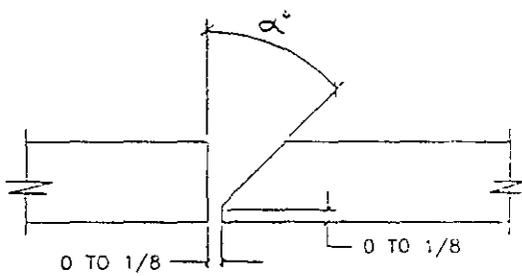
SINGLE VEE GROOVE



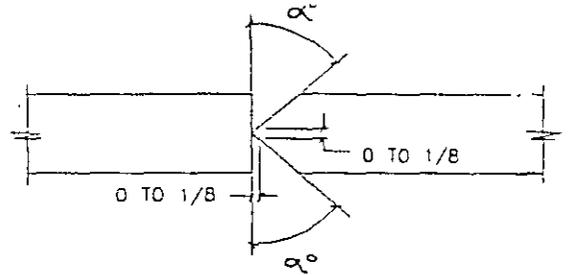
DOUBLE VEE GROOVE



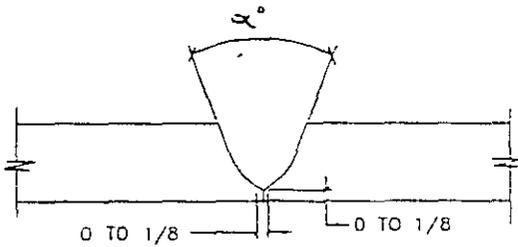
SINGLE BEVEL GROOVE



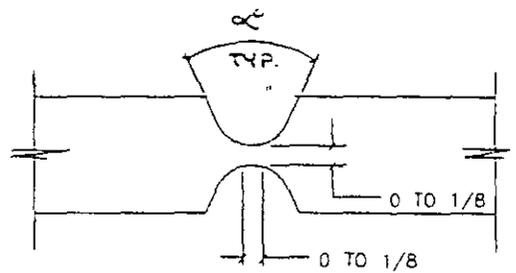
DOUBLE BEVEL GROOVE



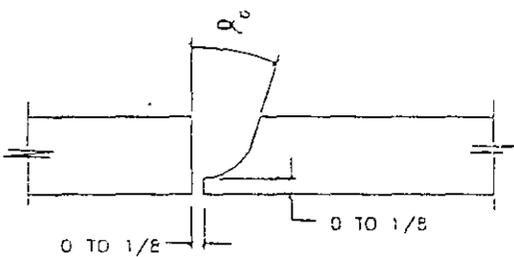
SINGLE U GROOVE



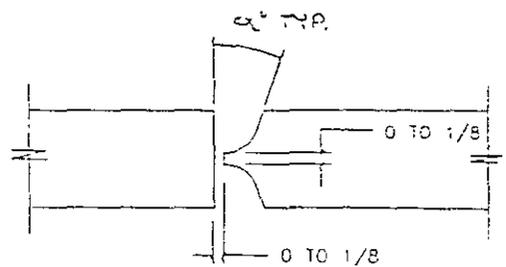
DOUBLE U GROOVE



SINGLE J GROOVE

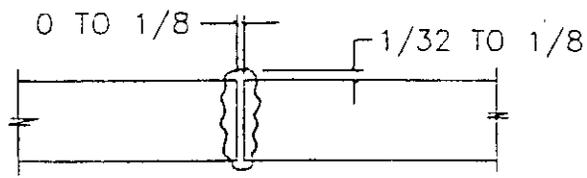


DOUBLE J GROOVE

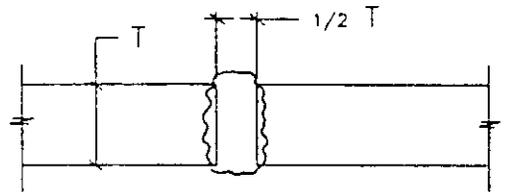


JOINT PREPARATIONS

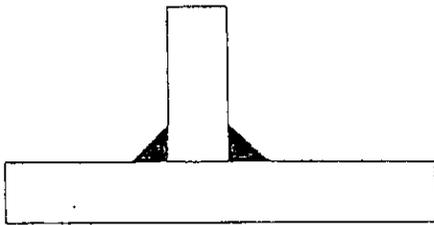
SQUARE GROOVE



SQUARE GROOVE



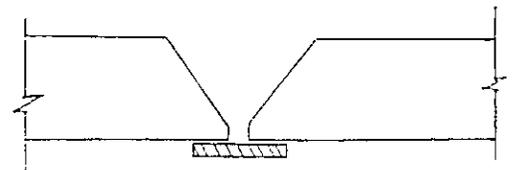
FILLET WELD



FILLET WELD



BACKING STRIP



STANDARD WELDING SYMBOLS*

The weld symbols presented here have been standardized and adopted by the American Welding Society. Like any systematic plan of symbols, they quickly describe to the designer, draftsman, production supervisor, and weldor the weld that will develop the required joint or connection strength and meet the prevailing in-service performance requirements.

A welding symbol consists of basic elements. These elements can be joined in various combinations to denote any type of weld needed for any type of joint. The condensed summary presented here identifies these elements and will serve as a ready reference for those associated with a welding program.

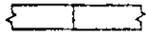
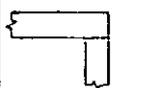
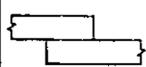
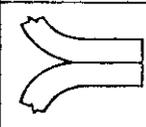
Since fillet welds and simple butt welds comprise 95 percent of most work, it is wise to initially limit the use of the symbols to just these types of welds. Later on, after the draftsmen and shop personnel learn to communicate with the symbols, additional, rarely used symbols can be introduced to

aid in detailing special welds.

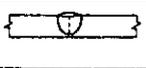
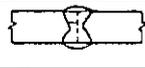
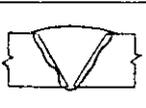
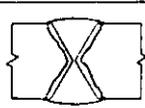
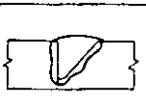
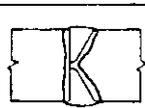
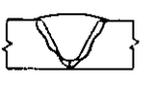
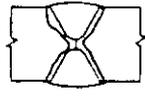
Adoption of this uniform system of symbols will assure that the correct welding instructions are being transmitted to all concerned with the work. This can help to cut drafting time and reduce shop costs arising from misinterpretation of instructions. In addition, since this system is in general use today, it simplifies the transmission of this type of information to outside suppliers.

In a joint, the adjoining members may contact each other in several ways, as illustrated by the butt, T, corner, lap, and edge joints. These general descriptions of the joint geometry, however, do not define the weld joint configuration, since it can be made in various ways. Thus, a welded butt joint can be made square, double-square, single-bevel, double-bevel, single-V, double-V, or by four other joint configurations. A T connection can be made with a double fillet, as shown: or it may be made with a single or double bevel or single or double J, V and U weld joints are feasible only for butt and corner welds because of the need for the preparation of both surfaces.

TYPES of JOINTS

Butt	 (B)
Tee	 (T)
Corner	 (C)
Lap	 (L)
Edge	 (E)

TYPES of WELDS

	Single	Double
Fillet		
Square		
Bevel Groove		
Vee Groove		
J Groove		
U Groove		

*From the American Welding Society "Standard Welding Symbols A2.0-68." For a complete copy, order from American Welding Society, 2501 N.W. 7th Street, Miami, Florida 33125.

AMERICAN WELDING SOCIETY



Location Significance	Fillet	Plug or Slot	Spot or Projection	Seam	Back or Backing	Surfacing	Scarf for Brazed Joint	Flange Edge
Arrow Side								
Other Side						Not used		
Both Sides		Not used	Not used	Not used	Not used	Not used		Not used
No Arrow Side or Other Side Significance	Not used	Not used			Not used	Not used	Not used	Not used

Supplementary Symbols Used with Welding Symbols

Convex Contour Symbol	Weld-All-Around Symbol
<p>Convex contour symbol indicates face of weld to be finished to convex contour</p> <p>Finish symbol (users standard) indicates method of obtaining specified contour but not degree of finish</p>	<p>Weld all around symbol indicates that weld extends completely around the joint</p>

Joint with Backing	Joint with Spacer	Melt-Thru Symbol
<p>With groove weld symbol</p> <p>Note: Material and dimensions of backing as specified</p>	<p>With modified groove weld symbol</p> <p>Note: Material and dimensions of spacer as specified</p>	<p>Any applicable weld symbol</p> <p>Melt thru symbol is not dimensioned (except height)</p>

Flush Contour Symbol	Multiple Reference Lines
<p>Flush contour symbol indicates face of weld to be made flush. When used without a finish symbol, indicates weld without subsequent finishing</p> <p>Finish symbol (users standard) indicates method of obtaining specified contour but not degree of finish</p>	<p>First operation shown on reference line nearest arrow</p> <p>Second operation or supplementary data</p> <p>Third operation, or test information</p>

Field Weld Symbol	Complete Penetration	Location of Elements of a Welding Symbol
<p>Field Weld symbol indicates that weld is to be made at a place other than that of initial construction</p>	<p>Indicates complete penetration regardless of type of weld or joint preparation</p>	<p>Location of Elements of a Welding Symbol</p> <p>Labels include: Finish symbol, Contour symbol, Groove angle, angle of countersink for plug welds, Length of weld, Pitch (center-to-center spacing) of welds, Field weld symbol, Arrow connecting reference line to arrow side member of joint, Weld all around symbol, Reference line, Elements in this area remain as shown when tail and arrow are reversed, Tail (Tail omitted when reference is not used), Basic weld symbol or detail reference, (BOTH SIDES), (ARROW SIDE), (OTHER SIDE), Groove angle, Effective throat, Root opening, depth of filling for plug and slot welds, Depth of preparation, size or strength for certain welds, Specification process, or other reference, T, S, (E), L, P, (N), Number of spot or projection welds.</p>

Supplementary Symbols						
Weld-All-Around	Field Weld	Melt-Thru	Backing, Spacer	Contour		
				Flush	Convex	Concave

Basic Joints—Identification of Arrow Side and Other Side of Joint

Butt Joint	Corner Joint	T-Joint
<p>Arrow of welding symbol</p> <p>Arrow side of joint</p> <p>Other side of joint</p>	<p>Arrow side of joint</p> <p>Arrow of welding symbol</p> <p>Other side of joint</p>	<p>Arrow of welding symbol</p> <p>Arrow side of joint</p> <p>Other side of joint</p>

A document prepared (*and qualified*) to provide direction for making production welds.

FIVE STEPS TO A QUALIFIED WPS

1. Write a sample WPS.
2. Weld a test coupon using the WPS.
3. Prepare test specimens.
4. Evaluate test results.
5. Document results on a PQR and certify.

THINGS FOR A MANUFACTURER TO CONSIDER PRIOR TO WELDING

1. Compatability of weld metal and base material.
2. Metallurgical properties.
3. PWHT or other heat treatment.
4. Design of joints and loadings.
5. Desired mechanical properties.
6. Service requirements.
7. Welder's ability.
8. Equipment available.
9. Location of welds.
10. Ecomony.

MANUFACTURER'S RESPONSIBILITIES FOR RECORDS

- Qualify WPS(s)
- Maintain WPS(s) and PQR(s)
- PQR includes welding data and test results
- All welding test coupons shall be by welders under direct control of manufacturer
- Certify PQR
- Certify that he has qualified each WPS

CONTENTS OF WPS

- Essential variables.
- Non-essential variables.
- Supplementary essential variables. (*When impacts are required*).
- Other information if desired.

PROCEDURE QUALIFICATION RECORD (PQR)

- Modifies or justifies the WPS.
- Support document that documents the results of welding and testing a coupon.

CONTENTS OF PQR

- Essential variables
- Supplementary essential variables. (*When impacts are required*).
- Other information if desired.

NOTE: Only actual information shall be documented. If it wasn't observed it should not be recorded. (i.e. — actual amps, volts, position, etc.)

FIRST: Unqualified WPS

SECOND: The PQR or PQRs

THIRD: The Qualified WPS

NOTE: A manufacturer must have a WPS. This document (or set of documents) shall describe the parameters to be used for welding. A WPS may reference production drawings to cover some variables. If all information required by the WPS is on production drawings, the production drawings may be called the "WPS."

A Code "WPS" may be many pieces of paper or documents. They must be controlled but if all variables are addressed... the Code requirements are met

YOU DON'T REQUALIFY A
PROCEDURE, YOU QUALIFY
A NEW PROCEDURE
QUALIFICATION RECORD.

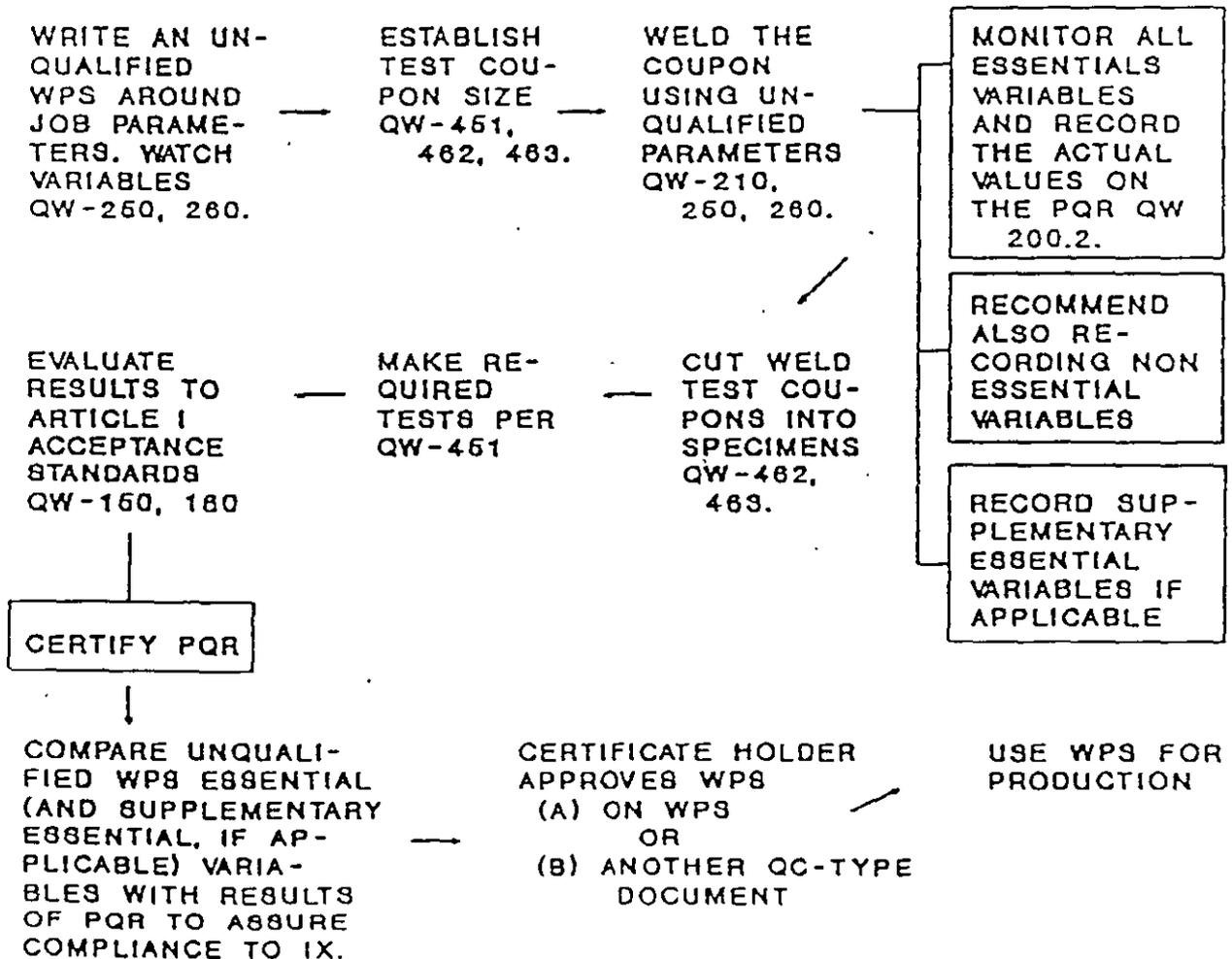
HOWEVER, A W.P.S. NEED ONLY
BE REQUALIFIED WHEN:

- AN ESSENTIAL VARIABLE CHANGES OR,
- THERE IS REASON TO QUESTION TO QUESTION
IT'S VALIDITY.

THE W.P.S DESCRIBES

1. THE ESSENTIAL VARIABLES.
2. THE NON-ESSENTIAL VARIABLES.
3. THE SUPPLEMENTARY ESSENTIAL VARIABLES.
4. ANYTHING ELSE USEFUL TO THE WELDER.
5. IT LISTS THE ACCEPTABLE RANGES TO BE FOLLOWED.

QUALIFYING A WPS



MECHANICAL TESTS FOR A W.P.S.

1. 2 TENSILE TESTS MINIMUM.
2. 4 BEND TESTS MINIMUM.
 - a. SIDE BENDS FOR $3/4"$ AND GREATER.
 - b. FACE & ROOT BENDS FOR LESS THAN $3/8"$.
 - c. YOUR OPTION FOR $3/8"$ TO LESS THAN $3/4"$.
3. THE MATERIALS TESTED MUST BE ONE OF THOSE LISTED ON THE W.P.S.

QW-450 SPECIMENS

QW-451 Groove-Weld Procedure Qualification Thickness Limits and Test Specimens

QW-451.1
TENSION TESTS AND TRANSVERSE-BEND TESTS

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

NOTES:

- (1) See QW-403 (2, 3, 6, 9, 10) and QW-407.4 for further limits on range of thicknesses qualified. Also see QW-202.2 for allowable exceptions
- (2) For the welding processes of QW-403.7 only, otherwise per Note (1) or $2T$, or $2t$, whichever is applicable.
- (3) Four side bend tests may be substituted for the required face- and root-bend tests, when thickness T is $\frac{3}{16}$ in. and over.

3.14

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TYPES OF TESTS ARE BASED ON COUPON THICKNESS

- If coupon is over 1" thick, multiple specimens may be cut (*mechanically*)
- Twice as many specimens are required
- Special exception for pipe 3" OD or less

TYPES OF TENSION TESTS

1. REDUCED SECTION --- PLATE
2. REDUCED SECTION --- PIPE
3. TURNED SPECIMEN
4. FULL SECTION --- PIPE

Discard		this piece
Reduced-section		tensile specimen
Root-bend		specimen
Face-bend		specimen
Root-bend		specimen
Face-bend		specimen
Reduced-section		tensile specimen
Discard		this piece



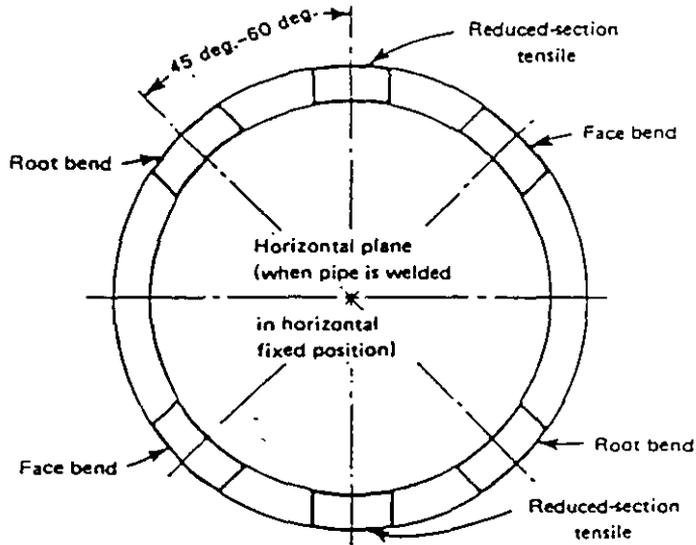
QW-463.1(a) PLATES — $\frac{1}{16}$ TO $\frac{3}{4}$ IN.
PROCEDURE QUALIFICATION

Discard		this piece
Side-bend		specimen
Reduced-section		tensile specimen
Side-bend		specimen
Side-bend		specimen
Reduced-section		tensile specimen
Side-bend		specimen
Discard		this piece



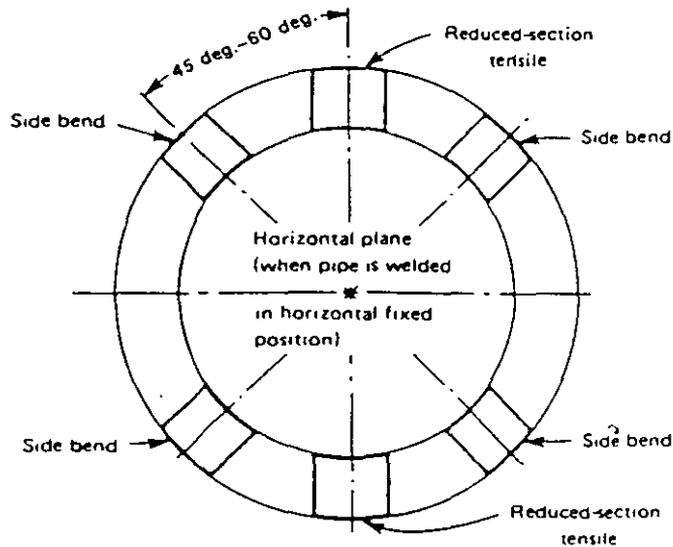
QW-463.1(b) PLATES — OVER $\frac{3}{4}$ AND
ALTERNATE $\frac{3}{8}$ TO $\frac{3}{4}$ IN.
PROCEDURE QUALIFICATION

QW-463 Order of Removal (Cont'd)



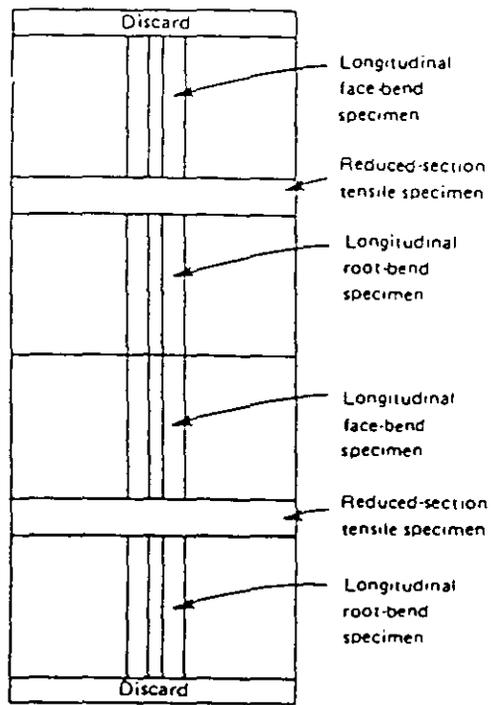
Pipes - 1/16 to 3/4 in. Thickness

QW-463.1(d) PROCEDURE QUALIFICATION



Pipes - Over 3/4 in. Thickness and Alternate From 3/8 in. but Less Than 3/4 in Thickness

QW-463.1(e) PROCEDURE QUALIFICATION



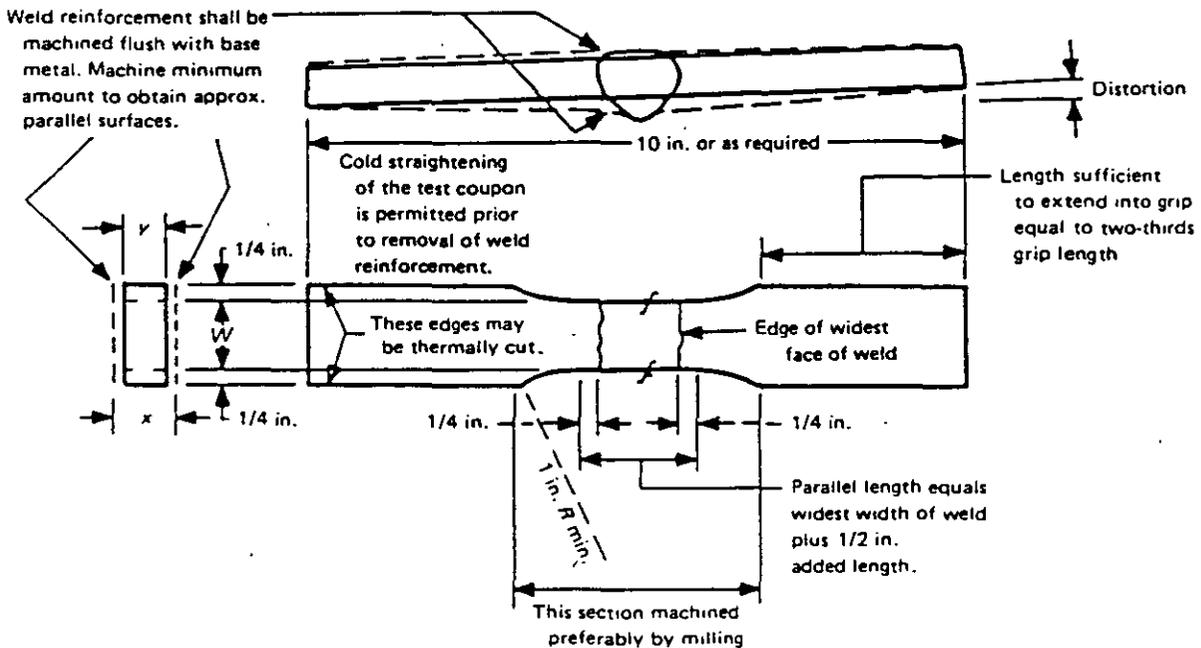
QW-463.1(c) PLATES — LONGITUDINAL
PROCEDURE QUALIFICATION

QW-462 Test Specimens

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

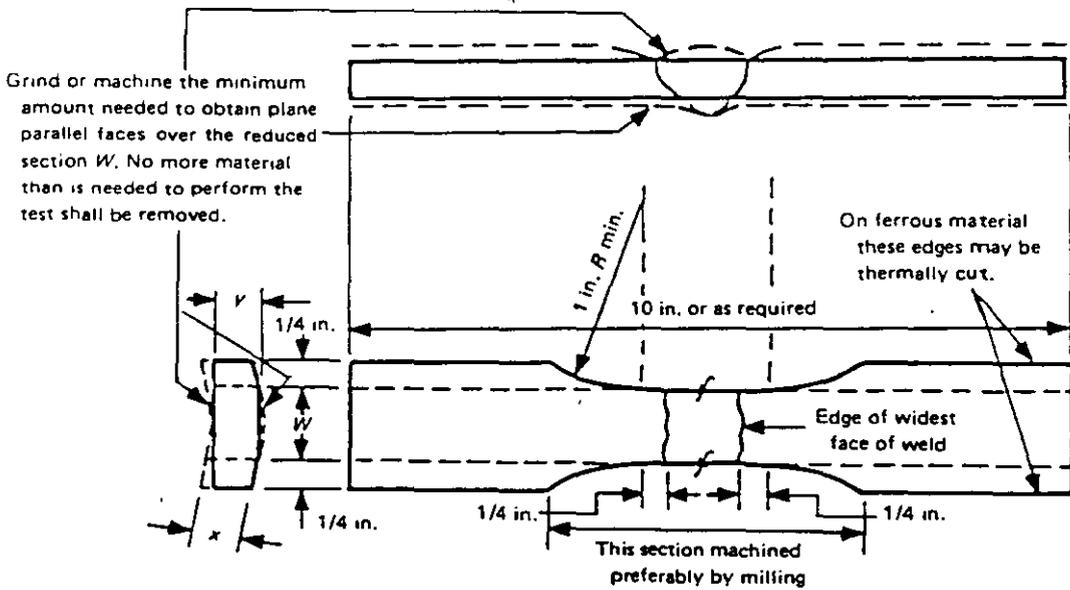
are to be considered approximate. All welding processes and filler material to be qualified must be included in the test specimen.

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

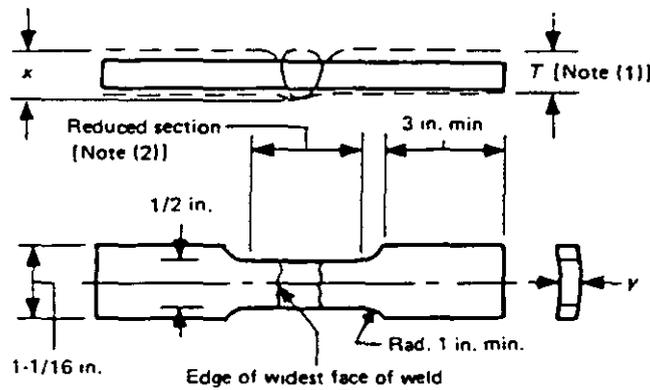


QW-462.1(a) TENSION — REDUCED SECTION — PLATE

QW-462 Test Specimens (Cont'd)



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



NOTES:

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

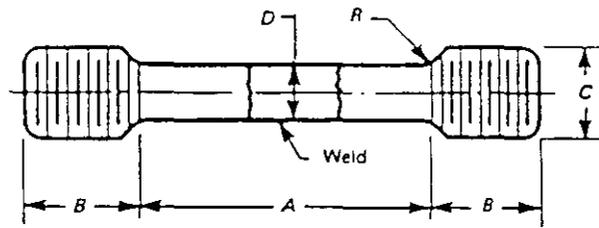
QW-462.1(c) TENSION — REDUCED SECTION
ALTERNATE FOR PIPE

V-16

TENSION TEST ACCEPTANCE CRITERIA

1. MINIMUM STRENGTH OF THE BASE MATERIAL.
2. MINIMUM STRENGTH OF THE WEAKER MATERIAL IF DIFFERENT MATERIALS ARE USED.
3. MINIMUM STRENGTH OF THE WELD METAL IF THE BASE MATERIAL AND THE FILLER MATERIAL HAVE DIFFERENT STRENGTHS AT DESIGN TEMPERATURE.
4. IF THE BREAK OCCURS IN THE BASE MATERIAL, AWAY FROM THE HEAT AFFECTED ZONE, THE CRITERIA MAY BE 5% BELOW THE MINIMUM STRENGTH OF THE BASE MATERIAL.

QW-462 Test Specimens (Cont'd)



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

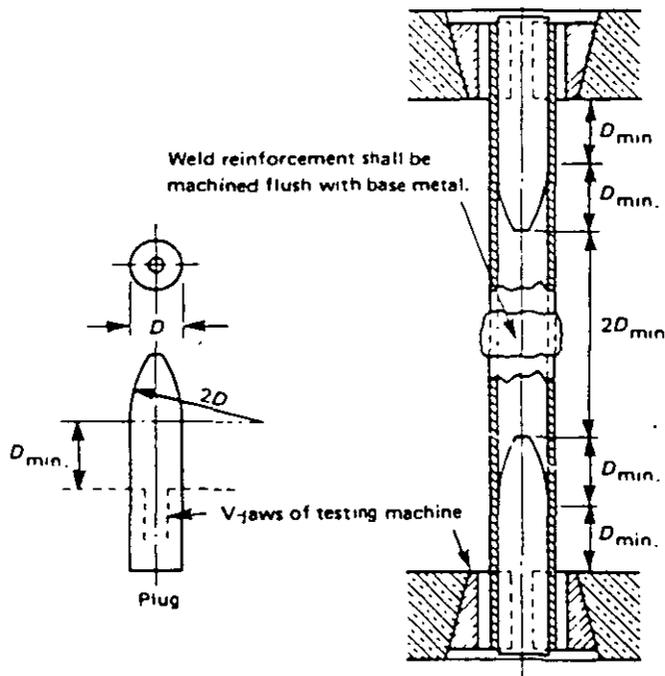
GENERAL NOTES:

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

NOTE:

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

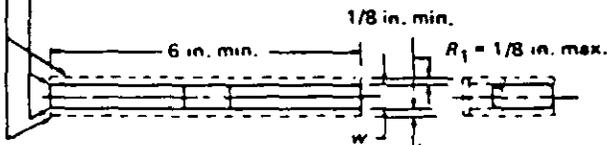
QW-462.1(d) TENSION — REDUCED SECTION — TURNED SPECIMENS



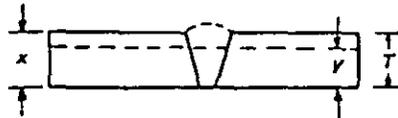
QW-462.1(e) TENSION — FULL SECTION — SMALL DIAMETER PIPE

QW-462 Test Specimens (Cont'd)

- (1a) For procedure qualification of materials other than P-No. 1 in QW-422, if the surfaces of the side bend test specimens are gas cut, removal by machining or grinding of not less than 1/8 in. from the surface shall be required.
- (1b) Such removal is not required for P-No. 1 materials, but any resulting roughness shall be dressed by machining or grinding.
- (2) For performance qualification of all materials in QW-422, if the surfaces of side bend tests are gas cut, any resulting roughness shall be dressed by machining or grinding.



T , in.	y , in.	w (in.)	
		P-No. 23, F-No. 23, or P-No. 35	All other metals
3/8 to 1-1/2, incl.	T	1/8	3/8
> 1-1/2	[Note (1)]	1/8	3/8



GENERAL NOTE:

Weld reinforcement and backing strip or backing ring, if any, may be removed flush with the surface of the specimen. Thermal cutting, machining, or grinding may be employed. Cold straightening is permitted prior to removal of the reinforcement.

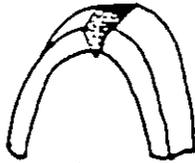
NOTE:

- (1) When specimen thickness T exceeds 1-1/2 in., use one of the following.
 - (a) Cut specimen into multiple test specimens y of approximately equal dimensions (3/4 in. to 1-1/2 in.).
 y = tested specimen thickness when multiple specimens are taken from one coupon
 - (b) The specimen may be bent at full width. See requirements on jig width in QW-466.1.

QW-462.2 SIDE BEND

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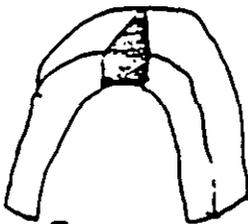
BEND TESTS



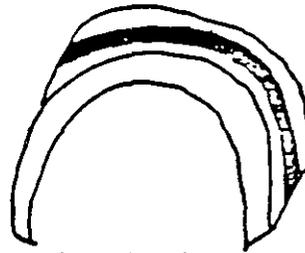
Face
Bend



Root
Bend



Transverse
Side Bend

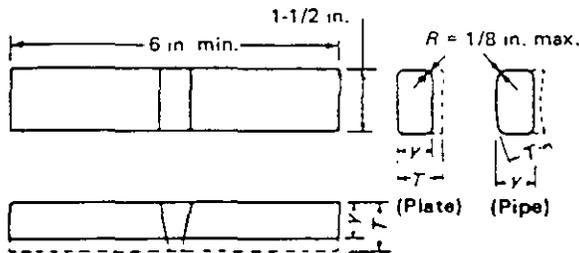


Longitudinal
Face Bend

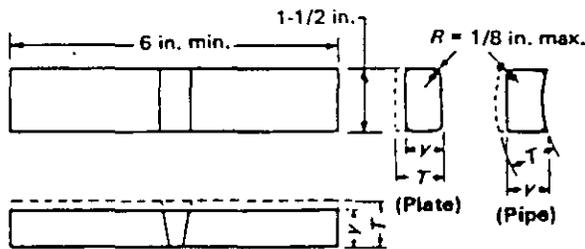
GUIDED BEND ACCEPTANCE CRITERIA

- No open defects in weld or Heat Affected Zone greater than 1/8"
- Cracks at corners may be ignored unless resulting from slag or internal defects

QW-462 Test Specimens (Cont'd)



Face-bend specimen — Plate and Pipe



Root-bend specimens — Plate and pipe

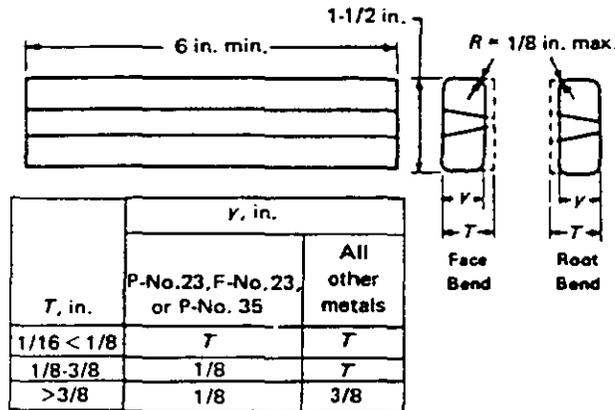
T, in.	y, in.	
	P-No.23,F-No.23, or P-No. 35	All other metals
1/16 < 1/8	T	T
1/8-3/8	1/8	T
>3/8	1/8	3/8

NOTES:

- (1) Weld reinforcement and backing strip or backing ring, if any, shall be removed flush with the surface of the specimen. If a recessed ring is used, this surface of the specimen may be machined to a depth not exceeding the depth of the recess to remove the ring, except that in such cases the thickness of the finished specimen shall be that specified above. Do not flame-cut nonferrous material.
- (2) If the pipe being tested is 4 in. nominal diameter or less, the width of the bend specimen may be 3/4 in. for pipe diameters 2 in. to and including 4 in. The bend specimen width may be 3/8 in. for pipe diameters less than 2 in. down to and including 3/8 in. and as an alternative, if the pipe being tested is equal to or less than 1 in. nominal pipe size (1.315 in. O. D.), the width of the bend specimens may be that obtained by cutting the pipe into quarter sections, less an allowance for saw cuts or machine cutting. These specimens cut into quarter sections are not required to have one surface machined flat as shown in QW-462.3(a). Bend specimens taken from tubing of comparable sizes may be handled in a similar manner.

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QW-462.3(a) FACE AND ROOT BENDS — TRANSVERSE^{1,2}



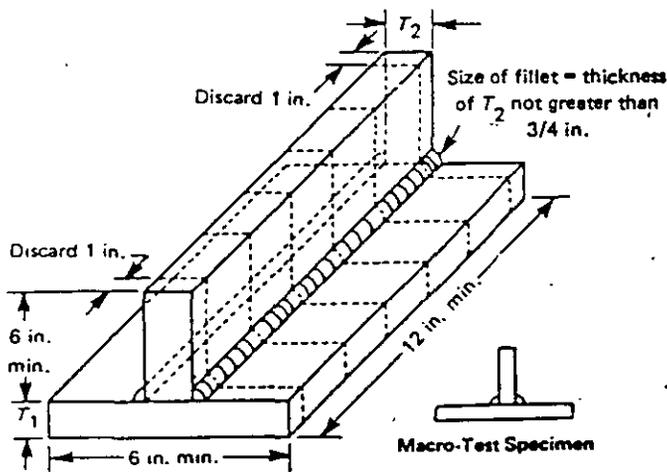
NOTE:

- (1) Weld reinforcements and backing strip or backing ring, if any, shall be removed essentially flush with the undisturbed surface of the base material. If a recessed strip is used, this surface of the specimen may be machined to a depth not exceeding the depth of the recess to remove the strip, except that in such cases the thickness of the finished specimen shall be that specified above.

QW-462.3(b) FACE AND ROOT BENDS — LONGITUDINAL¹

V-24

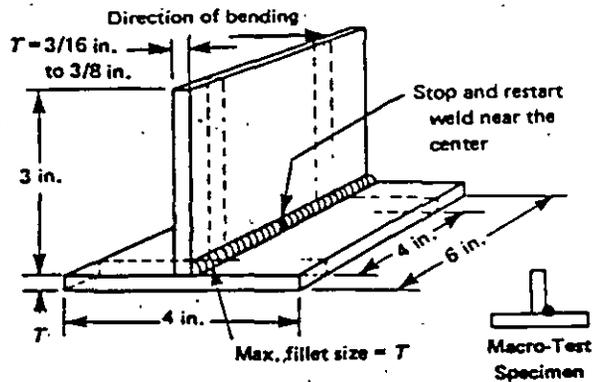
QW-462 Test Specimens (Cont'd)



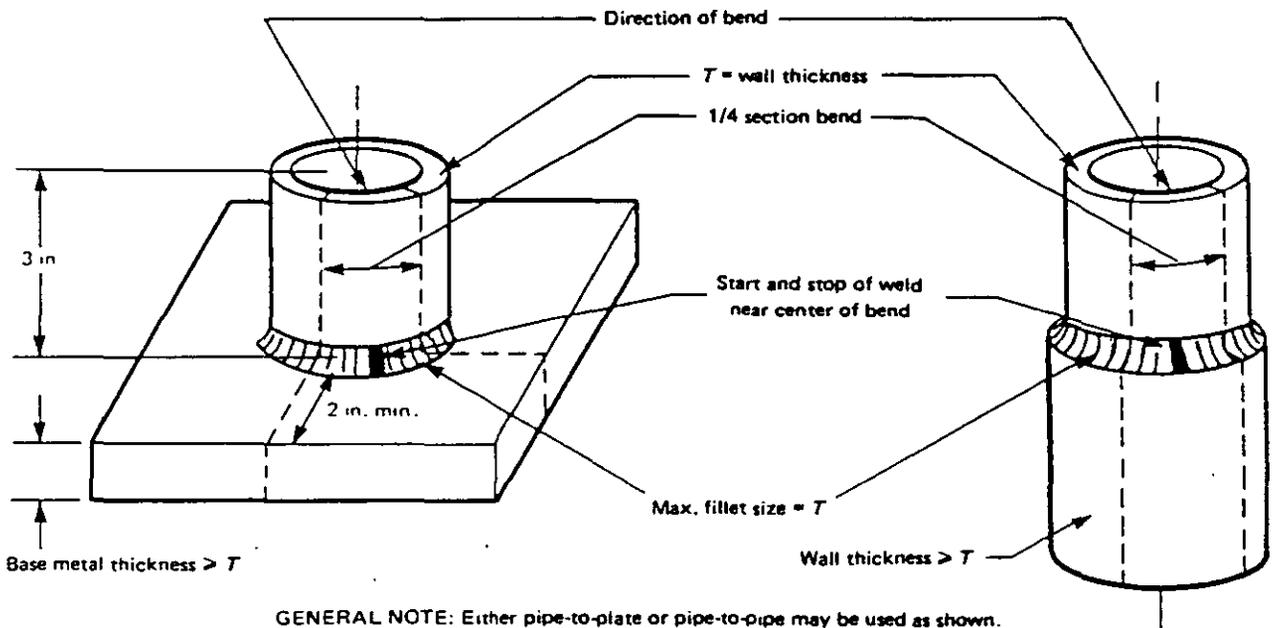
GENERAL NOTE:
 Macro test — The fillet shall show fusion at the root of the weld but not necessarily beyond the root. The weld metal and heat affected zone shall be free of cracks.

QW-462.4(a) FILLET WELDS — PROCEDURE

T_1	T_2
1/8 in. and less	T_1 Equal to or less than T_1 but not less than 1/8 in.
Over 1/8 in.	



QW-462.4(b) FILLET WELDS — PERFORMANCE



GENERAL NOTE: Either pipe-to-plate or pipe-to-pipe may be used as shown.

QW-462.4(c) FILLET WELDS IN PIPE — PERFORMANCE

GROOVE WELD TEST COUPON QUALIFIES FOR

All fillet weld

- (a) Thicknesses
- (b) Sizes
- (c) Diameters of pipe
- (d) Within essential variables

(Note: Exception is P-11A groups 3, 4, 5 and P-11B which requires special qualifications.)

FILLET WELD QUALIFICATIONS (QW-451.3)

- 1 Tee Fillet Test
- 4-5 Macro Etch Tests

FILLET PROCEDURES

Plate — 5 macro etches

Pipe — 4 macro etches

Acceptance: No visible cracks in weld metal or HAZ, full fusion at the root and leg lengths shall differ by less than 1/8".

NEVER USE ARTICLE II
WHEN QUALIFYING WELDERS
OR WELDING OPERATORS

ONLY ARTICLE III APPLIES

WHO IS A WELDER?

One who performs a manual or semi-automatic welding operation.

PURPOSE OF QUALIFYING A WELDER

To determine the welder's ability to deposit sound weld metal.

WHO IS A WELDING OPERATOR?

One who operates machine or automatic welding equipment.

PURPOSE OF QUALIFYING A WELDING OPERATOR

To determine the operator's mechanical ability to operate the welding equipment.

RESPONSIBILITIES OF MFG. (FOR WELDERS)

- Conduct tests to qualify the welders to use one or more of mfg. welding procedures that will be used on Code work.
- Test weld made under supv. and control of Mfg.

THE WELDER'S QUALIFICATION IS LIMITED BY
THE ESSENTIAL VARIABLES OF QW-350.

THE ESSENTIAL VARIABLES OF QW-350 DO NOT
APPLY TO WELDING OPERATORS.

WELDER RECORDS

- WPQ
- Continuity Log
- I.D. Log

WELDER'S PERFORMANCE QUALIFICATION RECORD

A W.P.Q. IS A DOCUMENT FOR RECORDING
THE QUALIFICATIONS OF A WELDER OR
WELDING OPERATOR.

CONTENTS OF THE WPQ

- (a) All applicable variables used by the welder to make a test coupon
- (b) Results of the tests
- (c) The ranges (*when applicable*) — some variables only have min. or max. values) qualified.

CERTIFICATION OF WELDERS

- (a) Not specifically required in IX.
- (b) However, recertification and QA/QC program requirements strongly suggest this must be done.

Continued CERTIFICATION OF WELDERS

- Must weld at least every 3 months.
- Must use each process at least every 6 months.
- Need not be on Code work.

Continued CERTIFICATION — EXAMPLE 1

- A welder is qualified on June 15, 1983 to use the SMAW process.
- The welder is qualified on July 30, 1983 to use the GTAW process.

If no welding is performed after July 30, when does this welder's SMAW qualification expire? GTAW?

Continued CERTIFICATION — EXAMPLE 2

SMAW process — June 15, 1983
GTAW process — July 30, 1983
SMAW process — October 15, 1983
SMAW process — November 15, 1983

When does this welder's SMAW qualification expire? GTAW?

WELDER'S LOG

WELDER A							
SMAW	1/3/85	4/1/85	7/1/85	12/1/85			
GTAW	1/6/85	8/5/85	10/5/85				
SAW	5/8/85	12/1/85	1/1/86				
WELDER B							
GTAW	1/3/85	4/1/85	12/1/85				
GMAW	6/1/85	9/1/85	12/1/85				
WELDER C							
GMAW	6/8/85	12/1/85					
SMAW	9/1/85						

4.5

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PREPARATION OF TEST COUPONS

- Must use a WPS (*qualified or unqualified*)
- Preheat not required
- PWHT not required
- Welders who qualify a WPS may use that WPS in production (*fillet welds are an exception*)
- P-11B WPS groove may not be used to make a P-11B fillet weld but welder may be qualified.
- May be terminated if test appears to be unsatisfactory.

TYPES OF TESTS

1. Mechanical
 - a. Bends
 - b. Macro/fracture
2. Radiography
 - a. Only permitted by QW-304 or QW-305
 - b. 6" radiograph on plate or entire circumference of pipe

MECHANICAL TESTS FOR WELDERS

- Plate groove test:
2 bend tests
- Pipe groove test:
1G or 2G — 2 bend tests
5G or 6G — 4 bend tests
- Plate fillet test:
2 — macro, 1 — fracture
- Pipe fillet test:
2 — macro, 1 — fracture

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WHAT WOULD BE REQUIRED IF A WELDER'S QUALIFICATIONS EXPIRE?

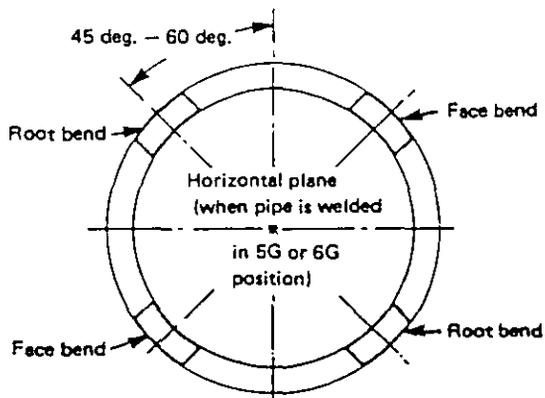
REQUALIFICATION OF WELDERS

- When time limit expires
- When reason to doubt ability
- When outside limits of qualified ranges

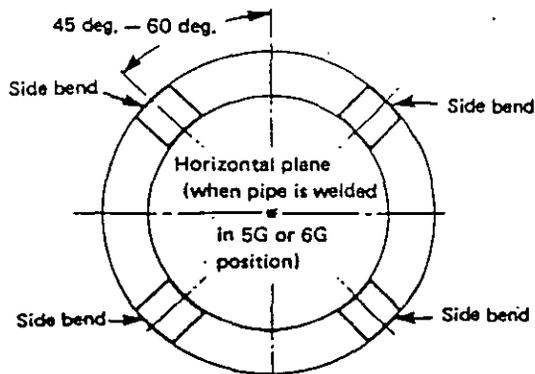
RECERTIFICATION

1. THE WELDER MUST WELD EVERY THREE MONTHS.
2. THE WELDER MUST USE EVERY PROCESS AT LEAST EVERY SIX MONTHS.
3. REQUALIFICATION IS BASED ON ONE COUPON. IF SUCESSFUL, THIS COUPON WILL RE-ESTABLISH THE WELDER'S QUALIFICATIONS FOR ALL THICKNESSES, DIAMETERS ETC. FOR EACH PROCESS.

QW-463 Order of Removal (Cont'd)



Pipes — 1/16 Up to 3/4 in. Thickness

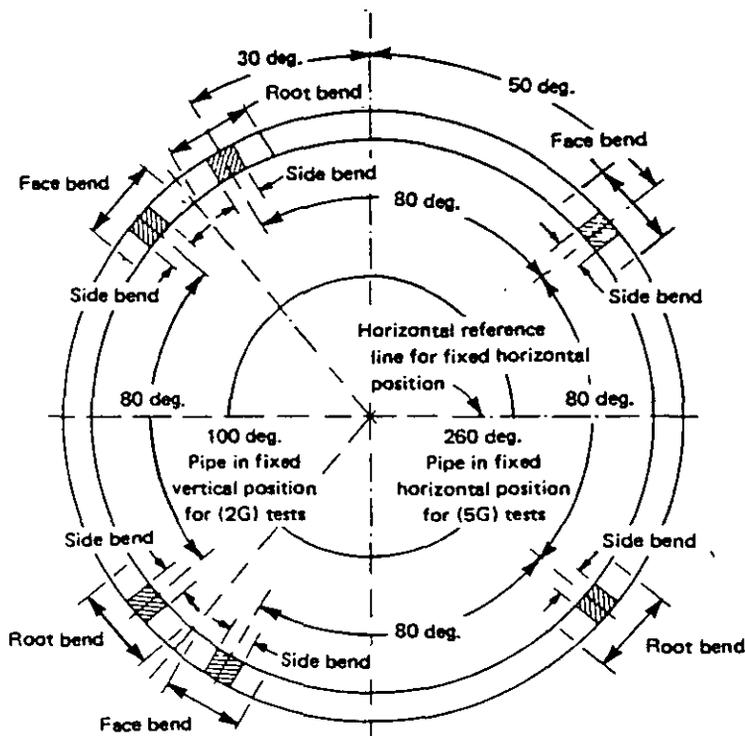


Pipes — 3/4 in. and Over Thickness and Alternate From 3/8 in. but Less Than 3/4 in. Thickness

QW-463.2(d) PERFORMANCE QUALIFICATION

QW-463.2(e) PERFORMANCE QUALIFICATION

A87



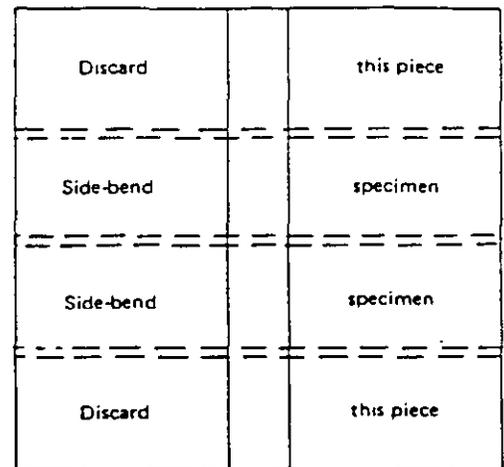
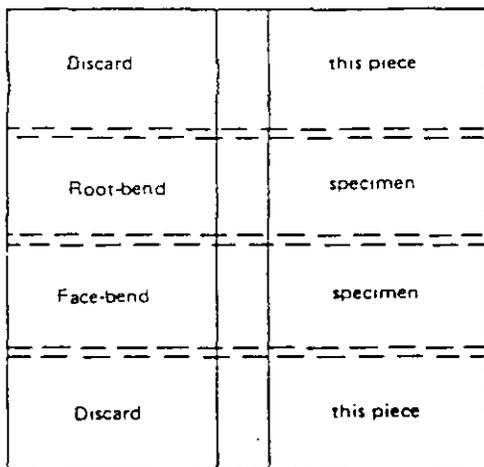
GENERAL NOTE:

When side-bend tests are made in accordance with QW-452.1 and QW-452.3, they shall be removed as shown in QW-463.2(f) in place of the face and root bends.

QW-463.2(f) PIPE — 10 IN. ASSEMBLY PERFORMANCE QUALIFICATION

U-37

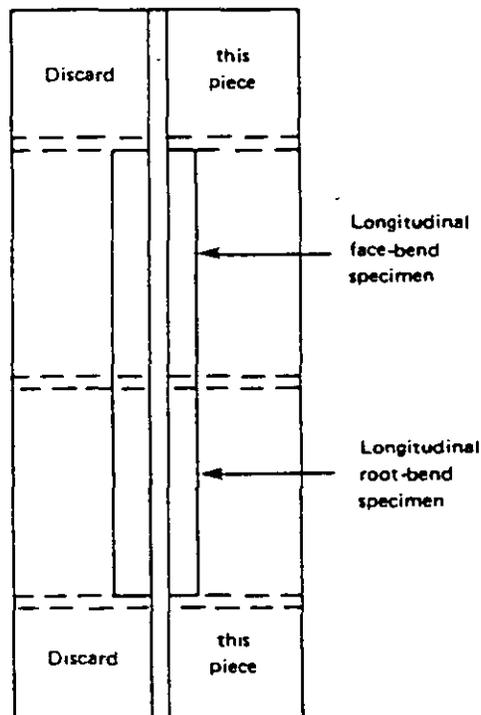
QW-463 Order of Removal (Cont'd)



QW-463.2(a) PLATES — $\frac{1}{16}$ TO $\frac{3}{4}$ IN.
PERFORMANCE QUALIFICATION



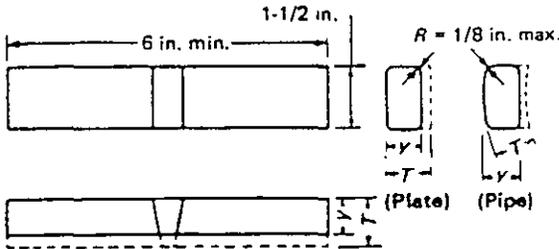
QW-463.2(b) PLATES — OVER $\frac{3}{4}$ AND
ALTERNATE $\frac{3}{8}$ TO $\frac{3}{4}$ IN.
PERFORMANCE QUALIFICATION



QW-463.2(c) PLATES — LONGITUDINAL PERFORMANCE QUALIFICATION

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QW-462 Test Specimens (Cont'd)

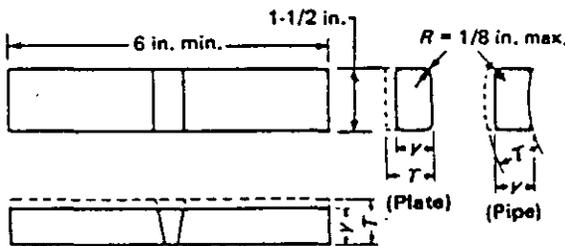


Face-bend specimen — Plate and Pipe

T, in.	y, in.	
	P-No. 23, F-No. 23, or P-No. 35	All other metals
1/16 < 1/8	T	T
1/8-3/8	1/8	T
>3/8	1/8	3/8

NOTES:

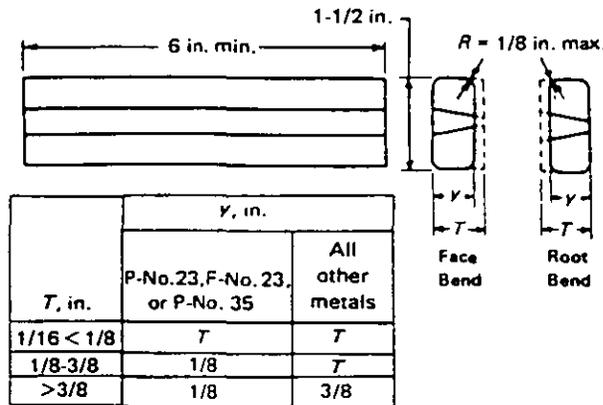
- (1) Weld reinforcement and backing strip or backing ring, if any, shall be removed flush with the surface of the specimen. If a recessed ring is used, this surface of the specimen may be machined to a depth not exceeding the depth of the recess to remove the ring, except that in such cases the thickness of the finished specimen shall be that specified above. Do not flame-cut nonferrous material.
- (2) If the pipe being tested is 4 in. nominal diameter or less, the width of the bend specimen may be 3/4 in. for pipe diameters 2 in. to and including 4 in. The bend specimen width may be 3/8 in. for pipe diameters less than 2 in. down to and including 3/8 in. and as an alternative, if the pipe being tested is equal to or less than 1 in. nominal pipe size (1.315 in. O. D.), the width of the bend specimens may be that obtained by cutting the pipe into quarter sections, less an allowance for saw cuts or machine cutting. These specimens cut into quarter sections are not required to have one surface machined flat as shown in QW-462.3(a). Bend specimens taken from tubing of comparable sizes may be handled in a similar manner.



Root-bend specimens — Plate and pipe

A87

QW-462.3(a) FACE AND ROOT BENDS — TRANSVERSE^{1,2}



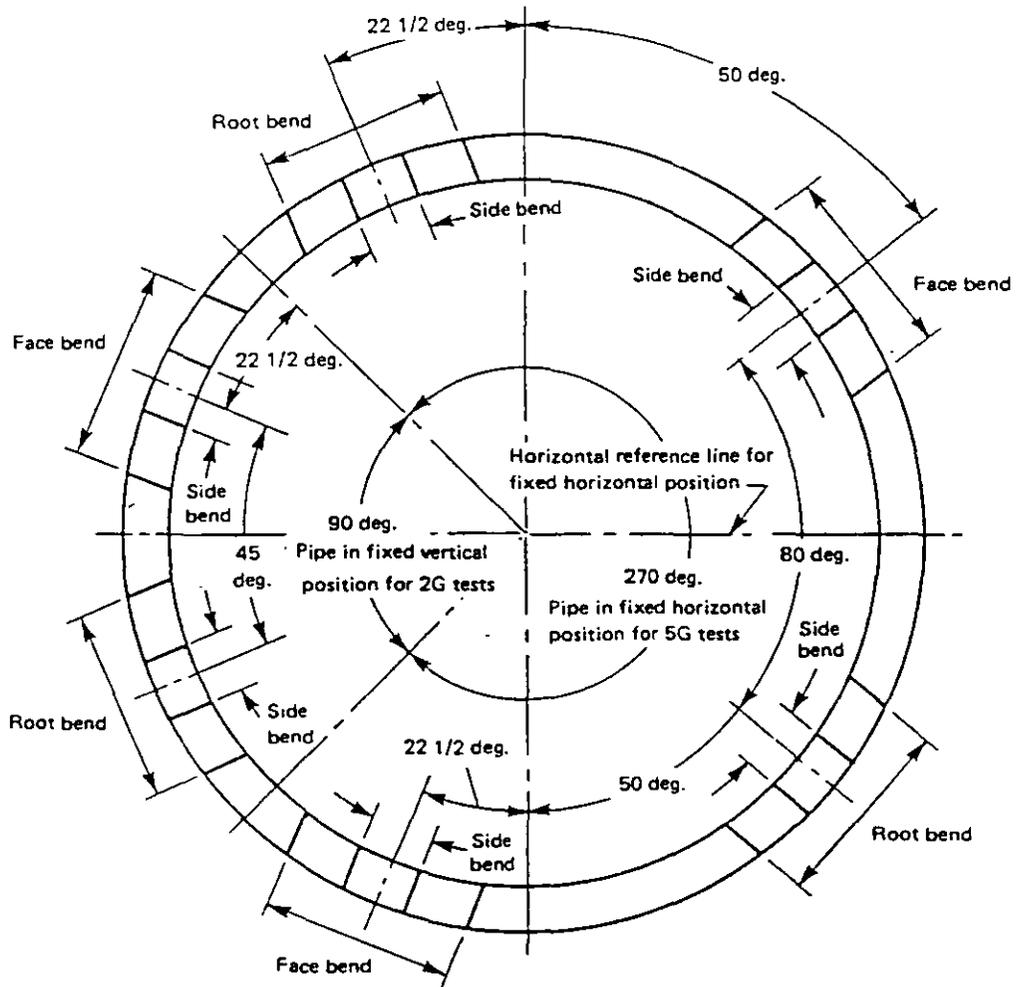
NOTE:

- (1) Weld reinforcements and backing strip or backing ring, if any, shall be removed essentially flush with the undisturbed surface of the base material. If a recessed strip is used, this surface of the specimen may be machined to a depth not exceeding the depth of the recess to remove the strip, except that in such cases the thickness of the finished specimen shall be that specified above.

QW-462.3(b) FACE AND ROOT BENDS — LONGITUDINAL¹

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QW-463 Order of Removal (Cont'd)



GENERAL NOTE:

When side bend tests are made in accordance with QW-452.1 and QW-452.3, they shall be removed as shown in QW-463.2(g) in place of the face and root bends

QW-463.2(g) 6 IN. OR 8 IN. ASSEMBLY PERFORMANCE QUALIFICATION

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MECHANICAL TESTING ACCEPTANCE CRITERIA

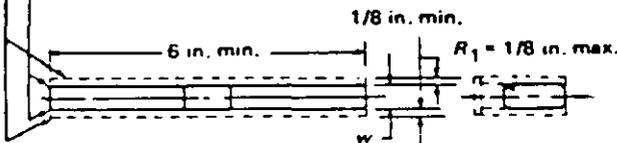
- Bends — no defect exceeding 1/8" measured on convex surface of the weld after bending.
- Fillet Macro — visually no cracks or lack of fusion. Linear indications @ root less than 1/32" are acceptable.
- Fillet Fracture
 - a. no breaks
 - b. fracture indicates no incomplete root fusion, no inclusions and porosity greater than 3/8" for plate, or greater than 10% of quarter section thickness on pipe.

MACRO-ETCHING

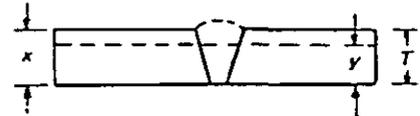
- Ferrous and nonferrous etching solutions of QW-470
- Written procedure not required
- Personnel need not have any specified qualifications for performing the tests.

QW-462 Test Specimens (Cont'd)

- (1a) For procedure qualification of materials other than P-No. 1 in QW-422, if the surfaces of the side bend test specimens are gas cut, removal by machining or grinding of not less than 1/8 in. from the surface shall be required.
- (1b) Such removal is not required for P-No. 1 materials, but any resulting roughness shall be dressed by machining or grinding.
- (2) For performance qualification of all materials in QW-422, if the surfaces of side bend tests are gas cut, any resulting roughness shall be dressed by machining or grinding.



T, in.	y, in.	w (in.)	
		P-No. 23, F-No. 23, or P-No. 35	All other metals
3/8 to 1-1/2, incl.	T	1/8	3/8
> 1-1/2	{Note (1)}	1/8	3/8



GENERAL NOTE:

Weld reinforcement and backing strip or backing ring, if any, may be removed flush with the surface of the specimen. Thermal cutting, machining, or grinding may be employed. Cold straightening is permitted prior to removal of the reinforcement.

NOTE:

- (1) When specimen thickness T exceeds 1-1/2 in., use one of the following.
 - (a) Cut specimen into multiple test specimens y of approximately equal dimensions (3/4 in. to 1-1/2 in.).
 y = tested specimen thickness when multiple specimens are taken from one coupon
 - (b) The specimen may be bent at full width. See requirements on jig width in QW-466.1.

QW-462.2 SIDE BEND

CHOICES FOR TEST COUPON

- Position
- Backing
- Pipe or plate

COMBINATION PROCESSES

- More than one F-number
- More than one process
- More than one welder

RADIOGRAPHIC TESTING FOR WELDERS

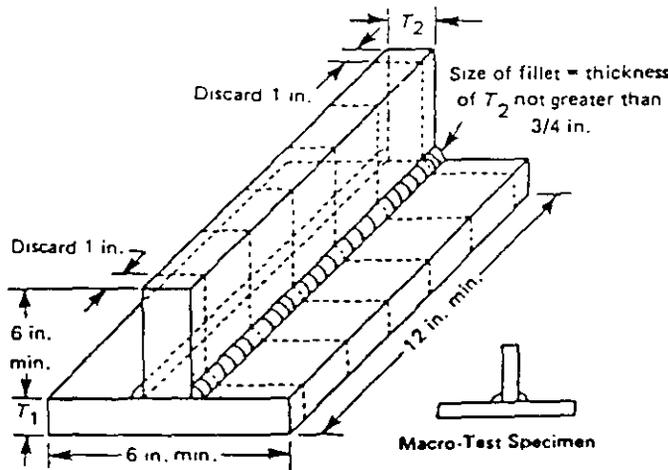
- SMAW, SAW, GTAW, PAW, FCAW, and GMAW (not GMAW-S)
- P-1 thru 11, P-3X and P-4X base materials
- GTAW also includes P-2X and P-5X base materials

RADIOGRAPHY FOR WELDS BY A WELDER

- Test Coupon — 6" long RT
- Production Weld — 6" long RT

(Qualification on pipe requires RT of entire circumference of the pipe.
Maximum of 4 pipe to accumulate 6" of total weld.)

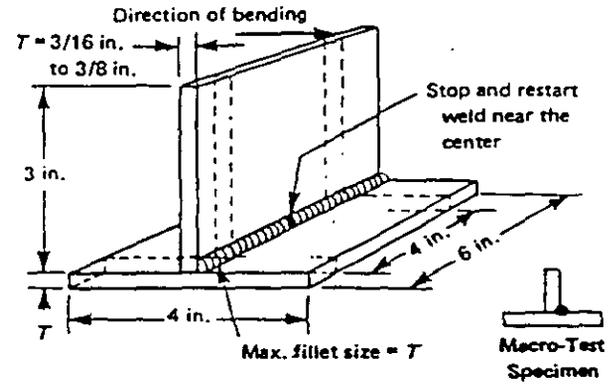
QW-462 Test Specimens (Cont'd)



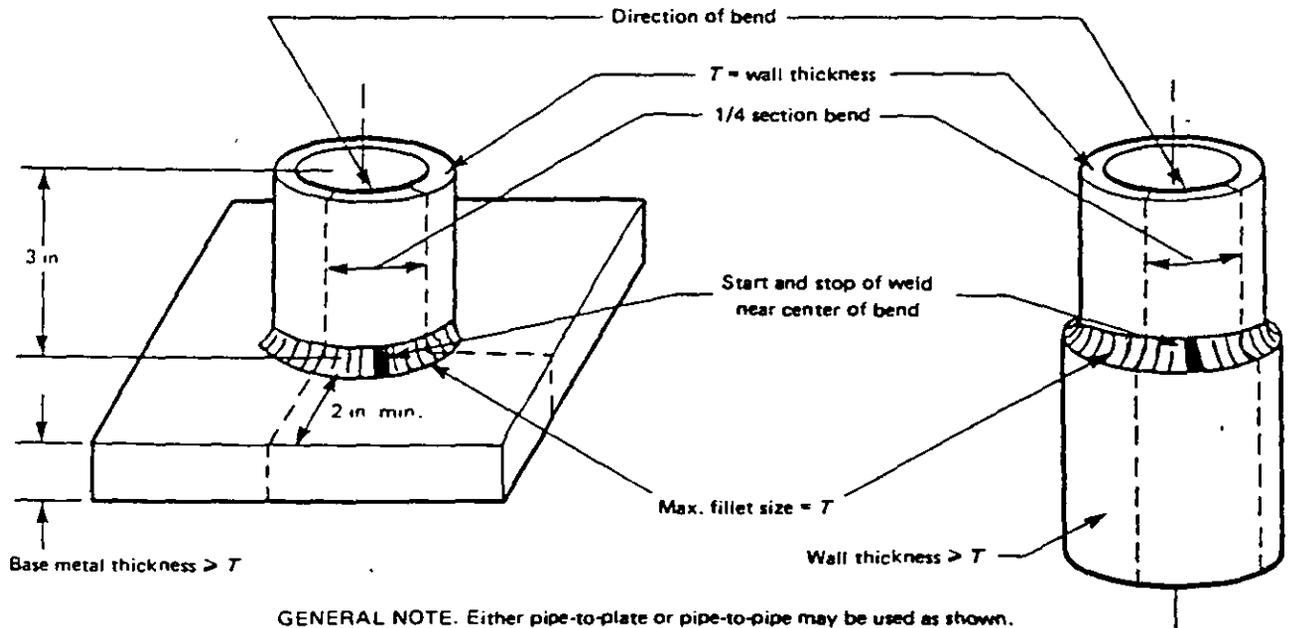
GENERAL NOTE:
 Macro test — The fillet shall show fusion at the root of the weld but not necessarily beyond the root. The weld metal and heat affected zone shall be free of cracks.

QW-462.4(a) FILLET WELDS — PROCEDURE

T_1	T_2
1/8 in. and less	T_1
Over 1/8 in.	Equal to or less than T_1 but not less than 1/8 in.



QW-462.4(b) FILLET WELDS — PERFORMANCE



GENERAL NOTE. Either pipe-to-plate or pipe-to-pipe may be used as shown.

QW-462.4(c) FILLET WELDS IN PIPE — PERFORMANCE

WELDER RADIOGRAPH ACCEPTANCE CRITERIA COMPARISON

Section IX (QW-191.2)	Section VIII Div. 1 (Full RT-UW-51)
<p>(a) Linear indications:</p> <ol style="list-style-type: none"> (1) Any crack or zone of incomplete Fusion or Penetration (2) Any elongated Slag inclusion greater than: <ul style="list-style-type: none"> • 1/8" for $t \leq 3/8"$ • $1/3 t$ for $t > 3/8"$ to $2\frac{1}{4}"$ incl. • 3/4" for t greater than $2\frac{1}{4}"$ (3) Any group of slag inclusions in-line greater than t in a $12t$ length (except when distance between inclusions is greater than $6L$). 	<p>(a) Linear indications:</p> <ol style="list-style-type: none"> (1) Any crack or zone of incomplete Fusion or Penetration (2) Any elongated Slag inclusion greater than: <ul style="list-style-type: none"> • 1/4" for t less than $3/4"$ • $1/3 t$ for $t = 3/4"$ to $2\frac{1}{4}"$ incl. • 3/4" for t greater than $2\frac{1}{4}"$ (3) Any group of slag inclusions in line greater than t in $12t$ length (except when distance between inclusions is greater than $6L$).
<p>(b) Rounded indications:</p> <ol style="list-style-type: none"> (1) Max. dimension 20% t or 1/8", whichever is smaller. (2) When T is less than 1/8" max. number of indications is 12 in 6" length. (3) When T is equal to or greater than 1/8" use charts in Appendix I. When max. dia. is less than 1/32" it is irrelevant. 	<p>(b) Rounded indications:</p> <ol style="list-style-type: none"> (1) Max. dimension 25% t or 5/32" whichever is smaller. (Some exceptions) (2) See Appendix 4. When T is less than 1/8" max. number of indications is 12 in 6" length. (3) See Appendix 4. (Some ranges more restrictive, some less restrictive than Section IX.)

t = thickness of deposited weld metal.

T = thickness of base material.

L = length of longest imperfection in a group.

RADIOGRAPHIC TESTING FOR WELDING OPERATORS

THE REQUIREMENTS FOR RADIOGRAPHING WELDING OPERATORS IS FOUND IN Q.W.- 305. THE REQUIREMENTS ARE THE SAME AS FOR WELDERS. THIS IS A FAIRLY NEW REQUIREMENT AND G.M.A.W. SHORT ARC MUST ALWAYS BE QUALIFIED MECHANICALLY.

RADIOGRAPHY FOR WELDING OPERATORS

- Test Coupon — 6" long RT
- Production Weld — 3' long RT

(Qualification on pipe requires RT of entire circumference of the pipe.
Maximum of 4 pipe to accumulate 6" of total weld)

WELDERS DO NOT HAVE NON-ESSENTIAL
NOR SUPPLEMENTARY ESSENTIAL VARIABLES

WELDERS DO NOT NECESSARILY HAVE TO
FOLLOW A WPS WHEN QUALIFYING

- May omit PWHT and preheat
- Base material substitution
- Possible filler metal substitution
- Must, as minimum, follow or record essential variables.

FAILURE OF TEST COUPONS FOR WELDING OPERATORS

- Same as welders except for production RT.
- Production RT for immediate retest is 6' long.

FAILURE OF TEST COUPONS FOR WELDERS

- Immediate RETEST:

Mechanical — 2 consecutive test coupons

RT test coupon — 2 consecutive test coupons (not 12" in one test coupon)

RT production — additional 12" radiograph

- Same method that failed must be used for immediate retests.
- With additional training just start over, no specifics in IX.

WELDING VARIABLES FOR WELDERS

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	.11		F-No. 4X limits
	.15	φ	F-Number limits
	.30	φ	t Weld deposit
QW-405 Positions	.1	+	Position
	.3	φ	r | Vertical welding

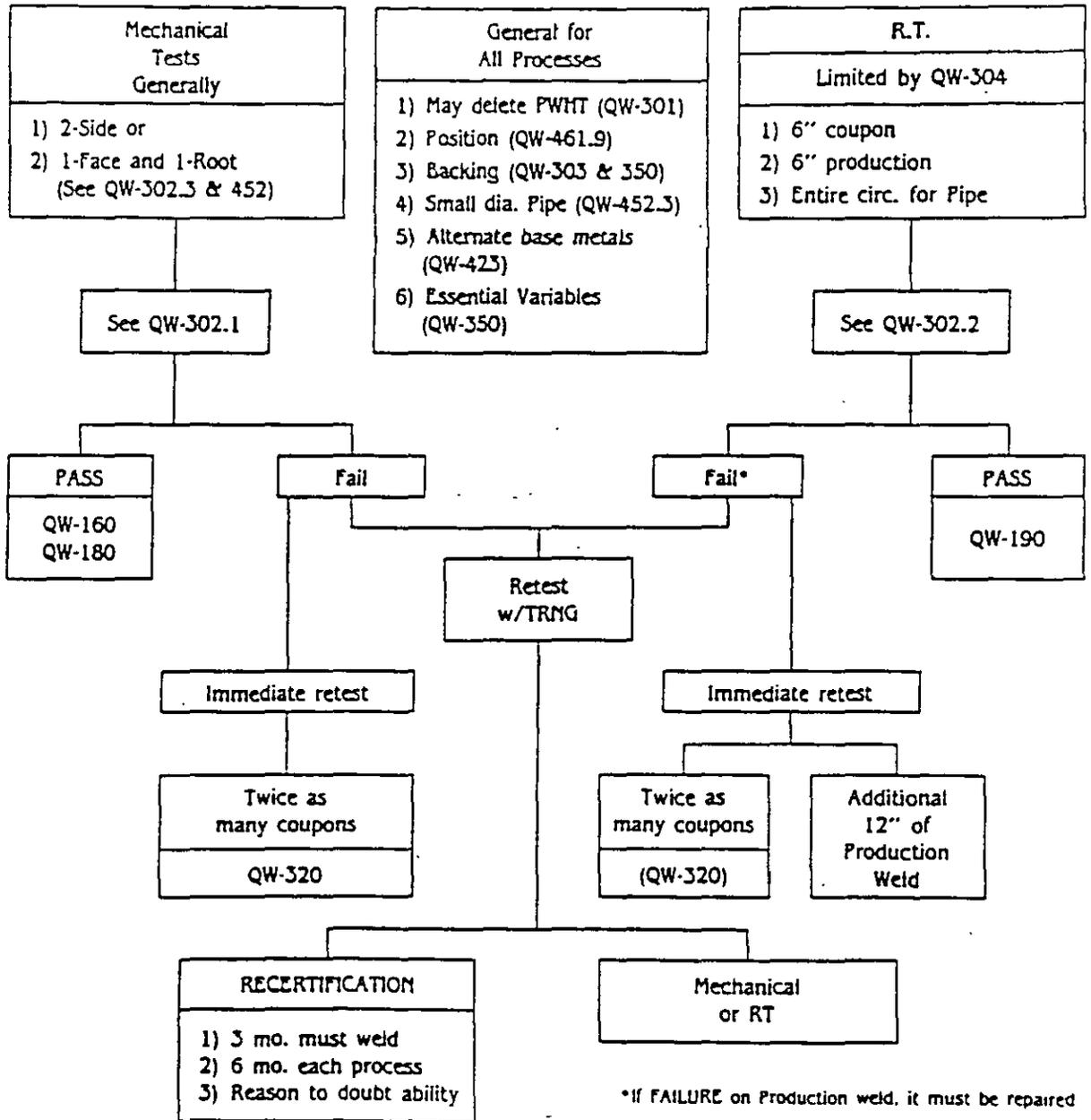
QW-354 SEMIAUTOMATIC SUBMERGED-ARC WELDING (SAW) Essential Variables

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

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

Paragraph		Brief of Variables	
QW-402 Joints	.4	-	Backing
QW-403 Base Metals	.16	φ	Pipe diameter
	.18	φ	P-Number
QW-404 Filler Metals	.11		F-No. 4X limits
	.16		F-No. 2X limits
	.28	φ	F-Number
	.30	φ	t Weld metal
	.32		t Limit (S. Cir. Arc.)
QW-405 Positions	.1	+	Position
	.3	φ	r | Vertical welding
QW-408 Gas	.8	-	Gas backing
QW-409 Electrical	.2	φ	Transfer mode

WELDER QUALIFICATION USING A WPS

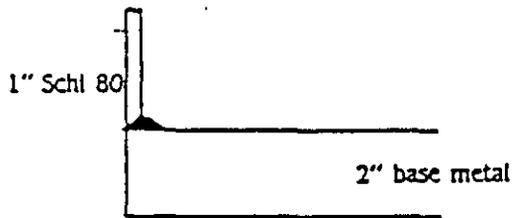


QW-452.3
GROOVE-WELD DIAMETER LIMITS^{1,2}

Outside Diameter of Test Coupon, in.	Minimum Outside Diameter Qualified, in.
Less than 1	Size welded
1 to 2 $\frac{3}{8}$	1
2 $\frac{3}{8}$ and over	2 $\frac{3}{8}$

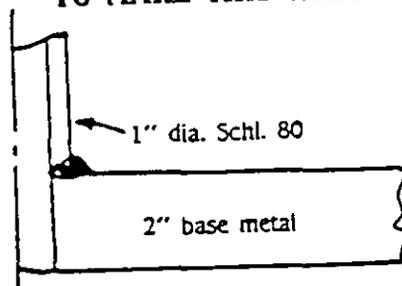
NOTES:

- (1) Type and number of tests required shall be in accordance with QW-452.1.
- (2) 2 $\frac{3}{8}$ in. O.D. is considered the equivalent of NPS 2 $\frac{1}{2}$.



Which of the above is small diameter pipe welding under Section IX?

**WHAT IS THE LARGEST DIAMETER
OF PIPE THE WELDER MAY BE QUALIFIED ON
TO MAKE THIS WELD?**



V-51

QW-452 Performance Qualification Thickness Limits and Test Specimens

QW-452.1
TRANSVERSE-BEND TESTS

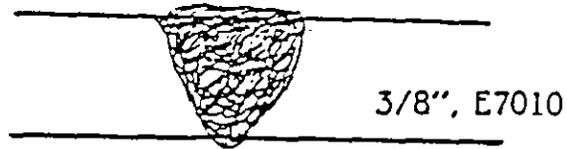
Type of Joint	Thickness of Test Coupon Welded, in. [Note (1)]	Thickness <i>t</i> of Deposited Weld Metal Qualified, in. [Note (2)] (See QW-310.1)	Type and Number of Tests Required (Guided-Bend Tests) [Notes (3),(4)]		
		Max.	Side Bend QW-462.2(a)	Face Bend [Note (5)] QW-462.3(a)	Root Bend [Note (5)]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

NOTES:

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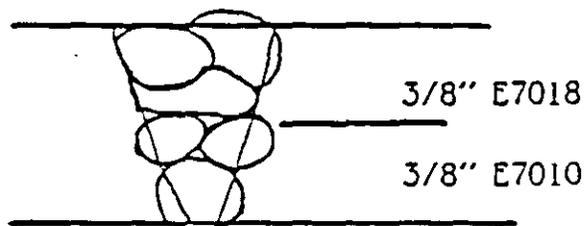
- (1) When using one, two, or more welders, the thickness *t* of the deposited weld metal for each welder with each process shall be determined and used individually in the Thickness column.
- (2) Two or more pipe test coupons of different thicknesses may be used to determine the deposited weld metal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

EXAMPLE 1



1. What is welder qualified thickness?
2. What is welder qualified F-Number(s)?
3. How many and what type bends are required?

EXAMPLE 2



1. What is welder qualified thickness?
2. What is welder qualified F-Number(s)?
3. How many and what type bends are required?

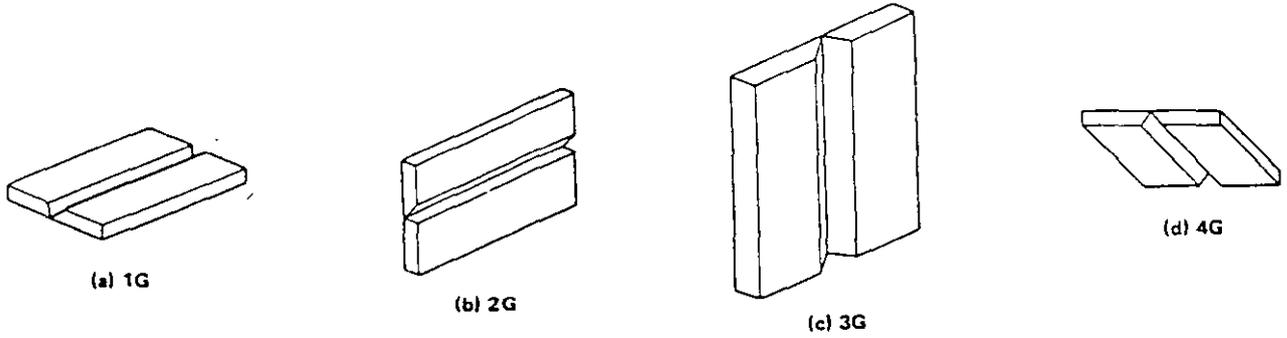
QW-423 Alternate Base Materials for Welder Qualification

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

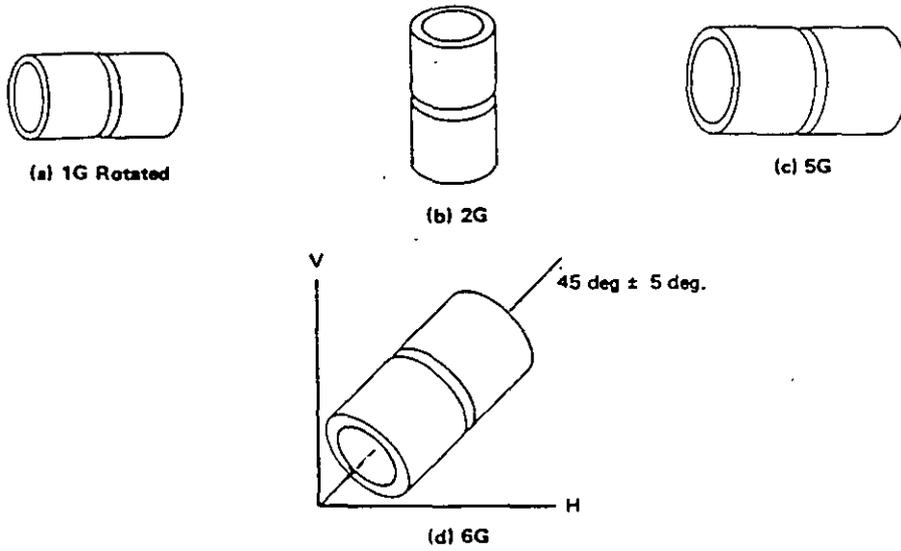
Base Metal(s) for Welder Qualification	Qualified Production Base Metal(s)
P-No. 1 through P-No. 11 and P-No. 4X	P-No. 1 through P-No. 11 and P-No. 4X
P-No. 21 through P-No. 25	P-No. 21 through P-No. 25
P-No. 52	P-No. 51 and P-No. 52
P-No. 62	P-No. 61 and P-No. 62

V.52

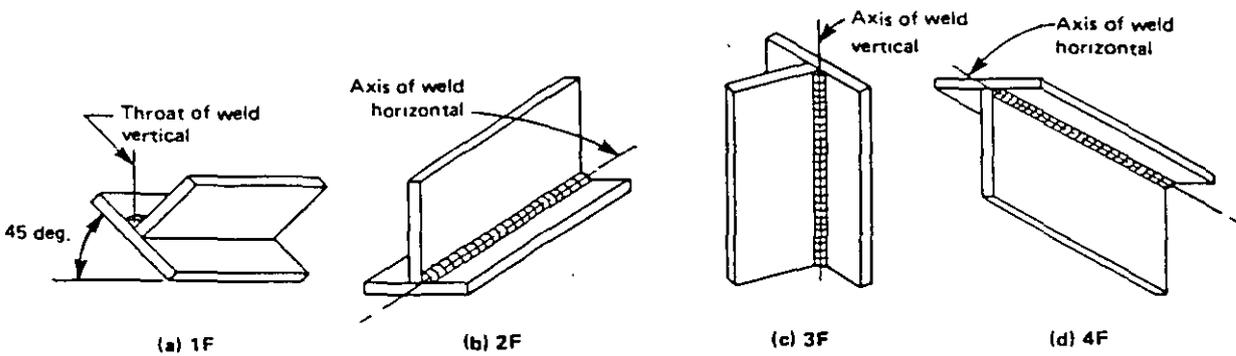
QW-461 Positions (Cont'd)



QW-461.3 GROOVE WELDS IN PLATE — TEST POSITIONS



QW-461.4 GROOVE WELDS IN PIPE — TEST POSITIONS

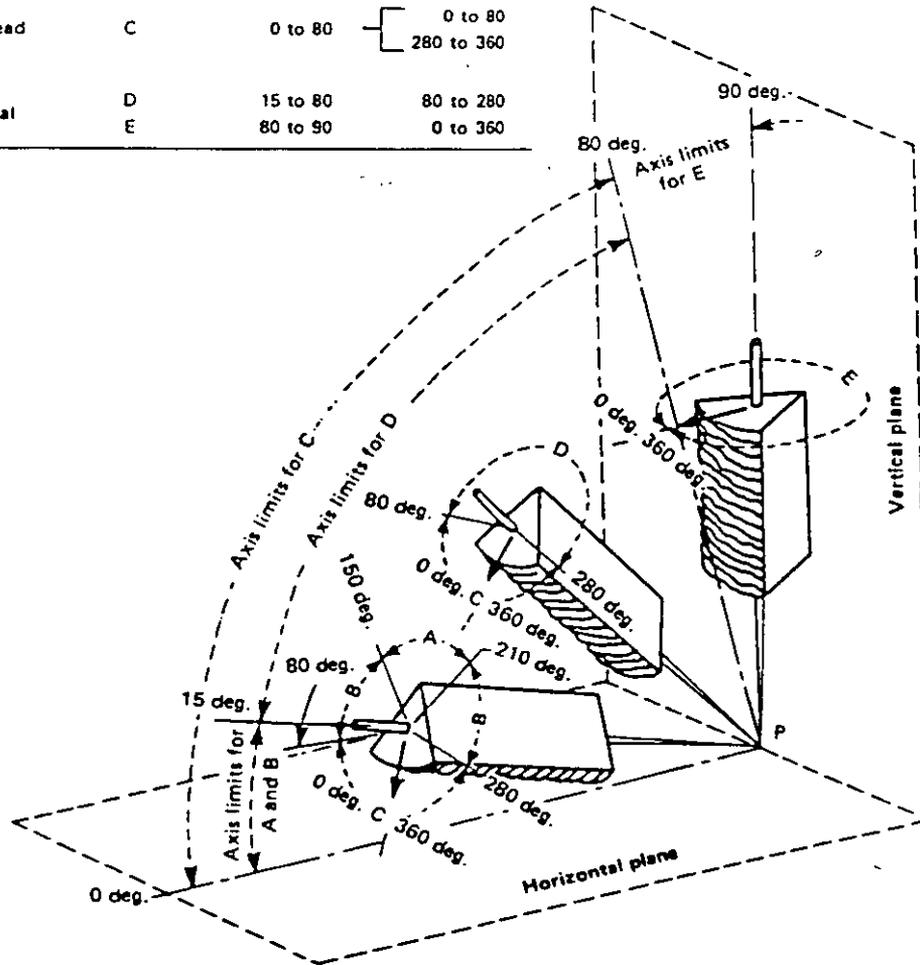


QW-461.5 FILLET WELDS IN PLATE — TEST POSITIONS

QW-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

REMEMBER

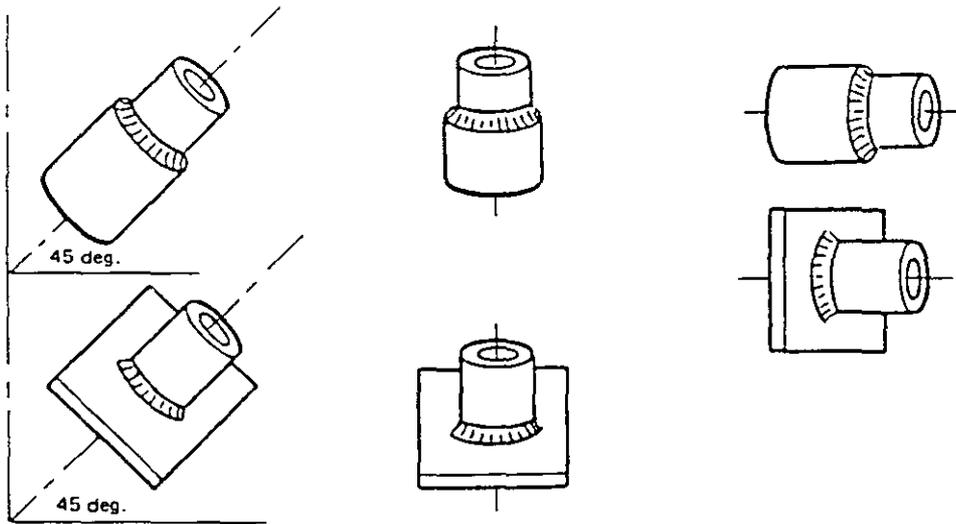
Even though the welder's range may include many F-Nos., and large thickness ranges, he is limited by the qualified procedures.

Without a qualified WPS the welder maybe qualified to ranges (including min. or max.) that may not be acceptable for Code welding.

LIMITS OF POSITIONS

- Qualification on groove welds qualifies for fillet welds.
- See QW-461.9
- Special orientations not required but permitted (plus or minus 15°)

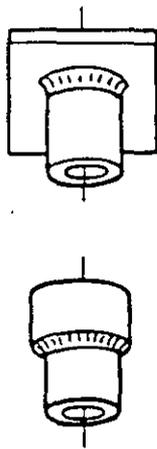
QW-461 Positions (Cont'd)



(a) 1F (Rotated)

(b) 2F

(c) 2FR (Rotated)



(d) 4F

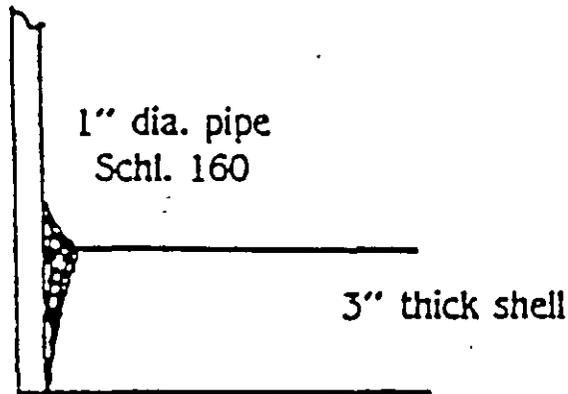
(e) 5F

QW-461.6 FILLET WELDS IN PIPE — TEST POSITIONS

V-56

A welder is qualified on the following test coupons. What are his position limits?

1. 6" dia. pipe groove in 6G?
2. Plate groove in 4G position?



May a welder qualified on a plate-groove in the 1G position make this groove weld and fillet weld cap?

QW-461 Positions (Cont'd)

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

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

NOTES:

(1) Positions of welding as shown in QW-461.1 and QW-461.2.

F = Flat
 H = Horizontal
 V = Vertical
 O = Overhead

(2) Pipe 2 $\frac{7}{8}$ in. O.D. and over.

(3) See diameter restrictions in QW-452.3, QW-452.4, and QW-452.6.

W.P.S./P.Q.R./W.P.Q. FORMS

1. Q.W.-482 AND 483 AND Q.W-484
2. RECOMMENDED FORMS
3. LOCATED IN A NON-MANDATORY APPENDIX
4. SAMPLE IS PRINTED ON THE EXAMPLE
IN THE CODE.

MULTIPLE PQR(S) SUPPORTING ONE WPS

- More than one PQR may support a single WPS
- Example: PQR 1 w/PWHT and PQR 2 w/o PWHT support a WPS w/and w/o PWHT

NOTE: Although it may be confusing, it is possible to have only 1 WPS to cover all possible welding circumstances.

ONE PQR MAY SUPPORT SEVERAL WPSs

- For control and clarity to production people manufacturers may limit particular WPS usage.
- Example: A PQR covers all diameter of electrodes for welding.
WPS 1 covers only 1/16" to 1/8" electrodes.
WPS 2 covers only 1/8" to 1/4" electrodes.

COMBINATION WELDING PROCESSES AND PROCEDURES

- A change in welding process requiring requalification.
- Several processes may be included in one WPS (they may be qualified separately or in combination).
- Using more than one WPS to complete a weld.
- For WPSs with more than one process, a weld may be made using the same WPS and deleting one or more of the processes within the essential variables.

QW-482 SUGGESTED FORMAT FOR WELDING PROCEDURE SPECIFICATION (WPS)
 (See QW-201.1, Section IX, ASME Boiler and Pressure Vessel Code)

Company Name _____ By: _____
 Welding Procedure Specification No. _____ Date _____ Supporting PQR No.(s) _____
 Revision No. _____ Date _____ Edition/Addenda _____
 Welding Process(es) _____ Type(s) _____
(Automatic, Manual, Machine, or Semi-Auto.)

JOINTS (QW-402)

Details

Joint Design _____

Becking (Yes) _____ (No) _____

Becking Material (Type) _____

- base metal nontusing metal
 nonmetallic weld metal other

Sketches, Production Drawings, Weld Symbols or Written Description should show the general arrangement of the parts to be welded. Where applicable, the root spacing and the details of weld groove may be specified.

(At the option of the Mfg., sketches may be attached to illustrate joint design, weld layers and bead sequence, e.g. for notch toughness procedures, for multiple process procedures, etc.)

***BASE METALS (QW-403)**

P-No. _____ Group No. _____ to P-No. _____ Group No. _____

OR

Specification type and grade _____

to Specification type and grade _____

OR

Chem. Analysis and Mech. Prop. _____

to Chem. Analysis and Mech. Prop. _____

Thickness Range:

Base Metal: "T" Groove _____ Fillet _____

 Groove _____ Fillet _____

Pipe Dia. Range: Groove _____ Fillet _____

Other _____

***FILLER METALS (QW-404)**

F-No. _____

A-No. _____

Spec. No. (SFAI) _____

AWS No. (Class) _____

Size of filler metals _____

Deposited weld metal "t" _____

 thickness range _____

 groove _____

 fillet _____

Electrode-Flux (Class) _____

Flux Trade Name _____

Consumable Insert _____

* Each base metal filler metal combination should be recorded individually

POSITIONS (QW-405) Position(s) of Groove _____ Welding Progression: Up _____ Down _____ Position(s) of Fillet _____	POSTWELD HEAT TREATMENT (QW-407) Temperature Range _____ Time Range _____
PREHEAT (QW-406) Preheat Temp. Min. _____ Interpass Temp. Max. _____ Heat Maintenance _____ (Continuous or special heating where applicable should be recorded)	GAS (QW-408) Shielding Gas(es) _____ Percent Composition (mixtures) _____ _____ Flow Rate _____ Gas Backing _____ Trailing Shielding Gas Composition _____

ELECTRICAL CHARACTERISTICS (QW-409)

Current AC or DC _____ Polarity _____
 Amperes (Range) _____ Volts (Range) _____

(Amperes and volts range should be recorded for each electrode size, position, and thickness, etc. This information may be listed in a tabular form similar to that shown below.)

Tungsten Electrode Size and Type _____
 (Pure Tungsten, 2% Thoriated, etc.)

Mode of Metal Transfer for GMAW _____
 (Spray arc, short circuiting arc, etc.)

Electrode Wire feed speed range _____

TECHNIQUE (QW-410)

String or Weave Bead _____
 Orifice or Gas Cup Size _____
 Initial and Interpass Cleaning (Brushing, Grinding, etc.) _____

Method of Back Gauging _____
 Oscillation _____
 Contact Tube to Work Distance _____
 Multiple or Single Pass (per side) _____
 Multiple or Single Electrodes _____
 Travel Speed (Range) _____
 Peening _____
 Other _____

Weld Layer(s)	Process	Filler Metal		Current		Volt Range	Travel Speed Range	Other
		Class	Dis.	Type Polar.	Amper. Range			

QW-483 SUGGESTED FORMAT FOR PROCEDURE QUALIFICATION RECORD (PQR)
 (See QW-201.2, Section IX, ASME Boiler and Pressure Vessel Code)
 Record Actual Conditions Used to Weld Test Coupon.

Company Name _____
 Procedure Qualification Record No. _____ Date _____
 WPS No. _____
 Welding Process(es) _____
 Types (Manual, Automatic, Semi-Auto.) _____

JOINTS (QW-402)

Groove Design of Test Coupon

(For combination qualifications, the deposited weld metal thickness shall be recorded for each filler metal or process weld.)

<p>BASE METALS (QW-403) Material Spec. _____ Type or Grade _____ P.No. _____ to P.No. _____ Thickness of Test Coupon _____ Diameter of Test Coupon _____ Other _____ _____ _____</p>	<p>POSTWELD HEAT TREATMENT (QW-407) Temperature _____ Time _____ Other _____ _____ _____</p>
<p>FILLER METALS (QW-404) Weld Metal Analysis A-No. _____ Size of Filler Metal _____ Filler Metal F-No. _____ SFA Specification _____ AWS Classification _____ Other _____ _____ _____</p>	<p>GAS (QW-408) Type of Gas or Gases _____ Composition of Gas Mixture _____ Other _____ _____ _____</p>
<p>POSITION (QW-405) Position of Groove _____ Weld Progression (Uphill, Downhill) _____ Other _____ _____</p>	<p>ELECTRICAL CHARACTERISTICS (QW-409) Current _____ Polarity _____ Amps. _____ Volts _____ Tungsten Electrode Size _____ Other _____ _____</p>
<p>PREHEAT (QW-406) Preheat Temp. _____ Interpass Temp. _____ Other _____ _____</p>	<p>TECHNIQUE (QW-410) Travel Speed _____ String or Weave Bead _____ Oscillation _____ Multipass or Single Pass (per side) _____ Single or Multiple Electrodes _____ Other _____ _____</p>

PQR No. _____

Tensile Test (QW-150)

Specimen No.	Width	Thickness	Area	Ultimate Total Load lb.	Ultimate Unit Stress psi	Type of Failure & Location

Guided Bend Tests (QW-160)

Type and Figure No.	Result

Toughness Tests (QW-170)

Specimen No.	Notch Location	Notch Type	Test Temp.	Impact Values	Lateral Exp.		Drop Weight	
					% Shear	Mils	Break	No Break

Fillet Weld Test (QW-180)

Result — Satisfactory. Yes _____ No _____ Penetration into Parent Metal: Yes _____ No _____
 Macro—Results _____

Other Tests

Type of Test _____
 Deposit Analysis _____
 Other _____

Welder's Name _____ Clock No. _____ Stamp No. _____

Tests conducted by: _____ Laboratory Test No. _____

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of Section IX of the ASME Code.

Manufacturer _____

Date _____ By _____

(Detail of record of tests are illustrative only and may be modified to conform to the type and number of tests required by the Code.)

QUALIFICATION TESTS

(See QW-301, Section IX, ASME Boiler and Pressure Vessel Code)

Welder Name _____ Check No. _____ Stamp No. _____

Using WPS No. _____ Rev. _____

the above welder is qualified for the following ranges.

Variable	Record Actual Values Used in Qualification	Qualification Range
Process	_____	_____
Process Type	_____	_____
Backing [metal, weld metal, flux, etc. (QW-402)]	_____	_____
Material Spec. (QW-403)	_____ to _____	_____ to _____
Thickness	_____	_____
Groove	_____	_____
Fillet	_____	_____
Diameter	_____	_____
Groove	_____	_____
Fillet	_____	_____
Filler Metal (QW-404)	_____	_____
Spec. No.	_____	_____
Class	_____	_____
F-No.	_____	_____
Position (QW-405)	_____	_____
Weld Progression (QW-410)	_____	_____
Gas Type (QW-408)	_____	_____
Electrical Characteristics (QW-409)	_____	_____
Current	_____	_____
Polarity	_____	_____

Guided Bend Test Results QW-462.2(a), QW-462.3(a), QW-462.3(b)

Type and Fig. No.

Result

Type and Fig. No.	Result

Radiographic Test Results (QW-304 & QW-305)

For alternative qualification of groove welds by radiography

Radiographic Results: _____

Fillet Weld Test Results [See QW-462.4(a), QW-462.4(b)]

Fracture Test (Describe the location, nature and size of any crack or tearing of the specimen) _____

Length and Per Cent of Defects _____ inches _____ %

Macro Test—Fusion _____

Appearance—Fillet Size (leg) _____ in. X _____ in. Convexity _____ in. or Concavity _____ in.

Test Conducted by _____ Laboratory—Test No. _____

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of Sections IX, of the ASME Code.

Organization _____

Date _____

By _____

(Detail of record of tests are illustrative only and may be modified to conform to the type and number of tests required by the Code.)

NOTE: Any essential variables in addition to those above shall be recorded.

UNIVERSIDAD NACIONAL AUTONOMA DE MÉXICO
FACULTAD DE INGENIERIA
DIVISIÓN DE EDUCACIÓN CONTINUA

DATOS DEL INSTRUCTOR

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Es Ingeniero Mecánico Titulado egresado de la Escuela Superior de Ingeniería Mecánica y Eléctrica del Instituto Politécnico Nacional. Cuenta con una experiencia profesional de más de 20 años en diseño, fabricación, inspección, prueba, certificación, montaje y reparación de calderas, recipientes a presión, sistemas de tubería y componentes nucleares. Ha calificado ante el Gobierno de Texas, Ohio, Pennsylvania y The National Board of Boiler and Pressure Vessel Inspectors de Norte America como Inspector Autorizado, Supervisor de Inspectores Autorizados e Inspector Nuclear Autorizado de ASME. Ha sido asesor de más de 40 empresas en México, Colombia, Venezuela, Brasil y Argentina en Sistemas y Certificaciones de ASME y National Board. Ha impartido el Diplomado de Ingeniería de Calderas y Recipientes a Presión en la División de Educación Continua de la Facultad de Ingeniería de la Universidad Nacional Autónoma de México, y ha presentado ponencias en Talleres Internacionales de Capacitación en Calderas, Recipientes a Presión y Temas Afines de la Asociación Mexicana de Ingenieros Mecánicos y Electricistas, A.C. (AMIME). Actualmente es Presidente del Comité de Calderas y Recipientes a Presión de AMIME y Consultor de varias compañías nacionales e internacionales.

2004.