Welding Procedure Specification’s (WPS)

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What Is Welding?

AWS defines welding as:

" The art and science of joining metals by using the intrinsic adhesive and cohesive forces of attraction that exist within metals".

Welding, Brazing, Soldering

Does not include mechanical fastening such as bolts, rivets, screws, etc.

When Did Welding Begin?

Pressure Welding of Noble Metals

Over 2,000 years ago

Forge Welding

Blacksmiths

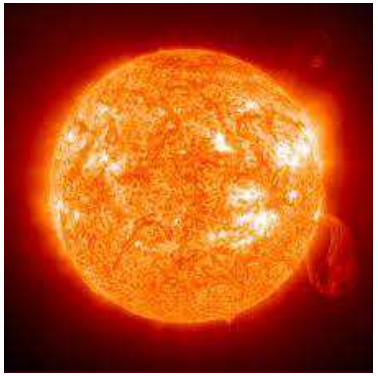
Over 1,000 years ago

Modern Welding

1880’s

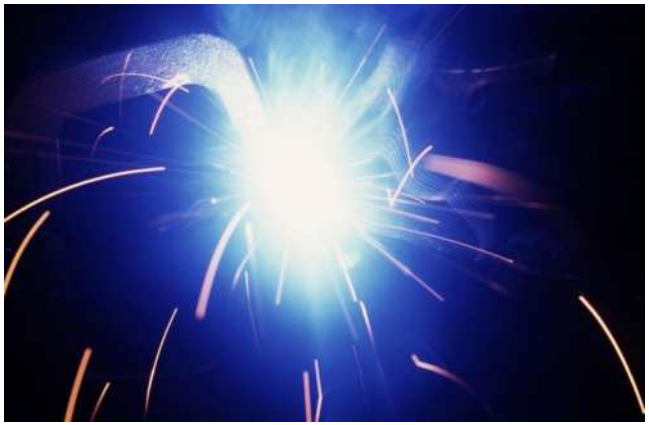
Interesting Fact

Temperature Of The Sun?



9,941°F

Temperature Of The Arc?



12,632°F

WELDING PROCEDURES

- What Is a Welding Procedure?
- Why Have Welding Procedures?
- Who Should Have Welding Procedures?
- What Information Should Procedures Contain?
- How do we know If Our Procedures Are Good?

What Is A Welding Procedure?

- A document that contains important variables on how to make the weld in question.

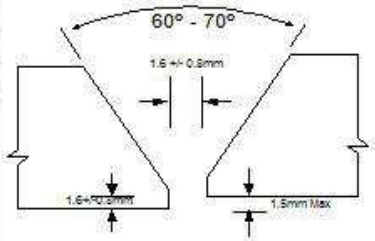
Welding Procedure Specification

Client:	Mobil	Project:	221010Goatee	REF No.	WPS 6 R1
Procedure Description:	12" Heavy Wall Offshore Tie-in				0290/1/WPS5
Material:	AS3679.1 Grade 250API 5L X65		Diameter: 168.3	Thickness:	18.3
Position:	6G		Clamp Type: Internal		
Preheat °C (Min):	100		Interpass °C (Max): 300		

	ROOT	HOT PASS	FILL & CAP
Welding Process	SMAW	SMAW	SMAW
Welding Direction	Vertical Down	Vertical Down	Vertical Down
Filler	Lincoln SA70+	Lincoln SA70+	Bohler BVD90M
Polarity	DC +ve	DC +ve	DC +ve
Shielding Gas	N/A	N/A	N/A
Purge Gas	N/A	N/A	N/A

Pass No	Filler Size (mm)	Amps	Volts	Speed (mm/sec)	Heat Input (kJ/mm)
1	3.2mm	70-130	18-33	3.3-6.6	0.4-0.8
2	4.0mm	110-210	18-35	2.9-6.8	0.6-1.3
FILL	4.0mm	145-260	16-27	1.6-7.0	0.6-2.2
CAP	4.0mm	130-230	16-26	1.8-5.3	0.6-1.7

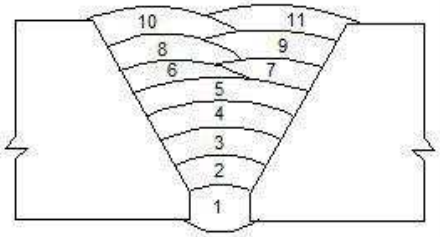
Weld Preparation



NOTES

1. API Std 1104BP3094-SP-PL-3010R1
2. Clamp removal stage : **100% completion of root (external clamp may be used in the event of a breakdown – removed after 50% minimum completion of the root.)**
3. Time lapse between root and second pass : **16 Minutes**
4. Time lapse between second pass and 1st fill : **12 Minutes**
5. Minimum number of passes before pipe movement : **2 passes**
6. Minimum number of passes before break in welding : **3 passes**
7. Minimum Number of welders- **Root & second pass: 2 , Fill & Cap : 1**
8. Method of cleaning : **Grinder / Wire brush**
9. Method of Preheat : **Gas Torch**
10. Qualification reference number : **48280/PP/WP6 R1**

Pass Location



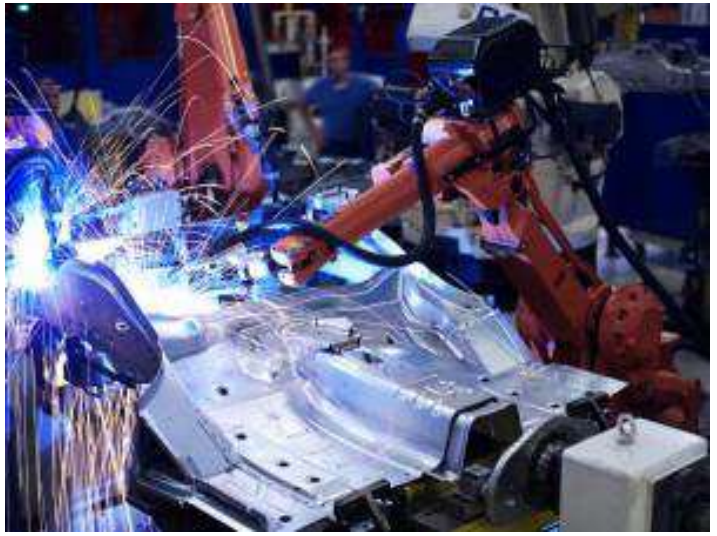
Company Welding Engineer Approved ..... **Approved for Client** .....

Why Have Welding Procedures?

- Required By Code
- Proves To Engineers & Regulators You Know What You Are Doing
- Helps To Produce Quality Welds

Who Should Have Welding Procedures?

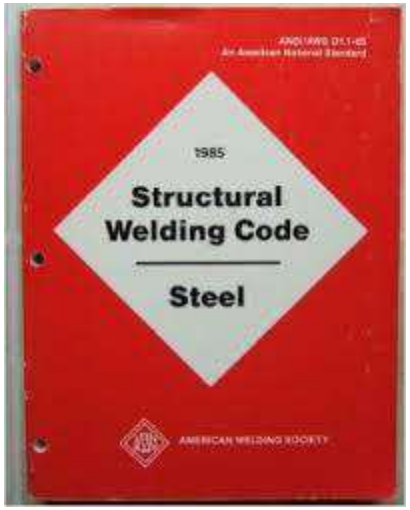
- Manufacturing
  - Automotive
  - Heavy Equipment
- Pipeline Industry
- Construction



What Information Should I Include?

Important Information

- Governing Code
  - API, AWS, ASME, ISO
  - Foreign Codes



Important Information

- Material Parameters
  - Spec & Grade
  - Wall Thickness
  - Size (Diameter)
  - Yield/Tensile Strength
  - Metallurgical Concerns

Important Information

- Welding Process
  - GMAW (MIG), GTAW (TIG), SMAW (STICK)
  - Automated Or Not?

Important Information

- Process Parameters
  - Volts, Amps, Travel Speed
  - Travel Direction
  - Polarity
  - Wire Welding Transfer Mode
    - Globular, Spray, Short Circuit, Plasma
    - Flux Core or Shielding Gas
  - Number of Passes
  - Number of Welders
  - Electrodes

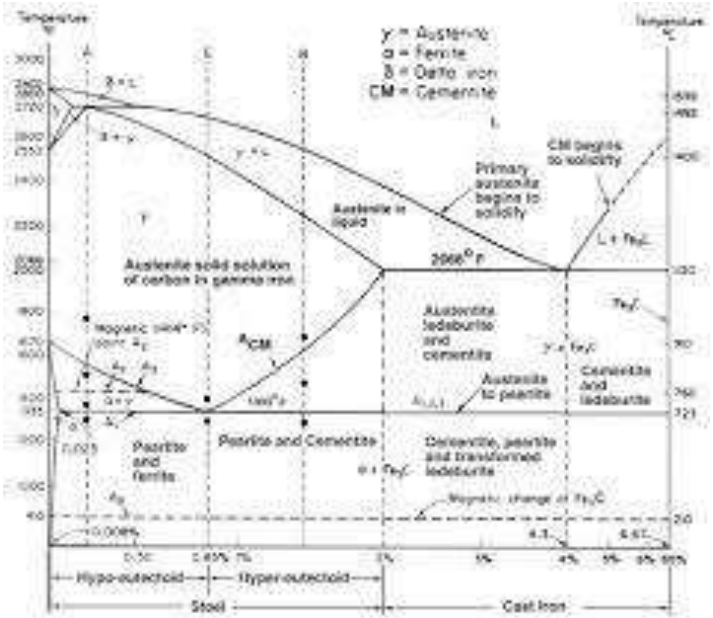
    Size

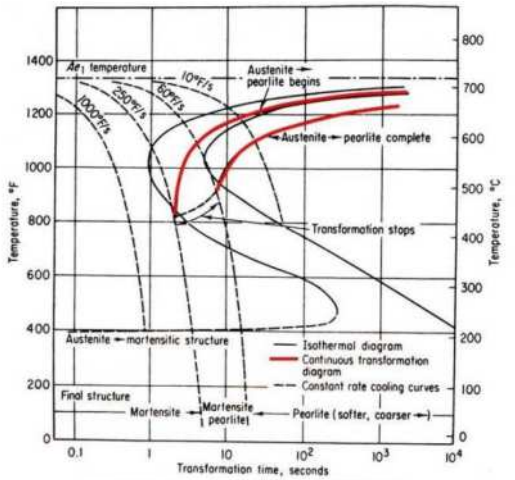
    Group Number = 1, 2, 3, etc.

    AWS Specification = A5.1, A5.5, etc.

Important Information

- Pre/Post Weld Heat Treatment
  - Temps
  - Time
  - Cooling Rates
  - Heat Input
  - Time Interval Between Passes

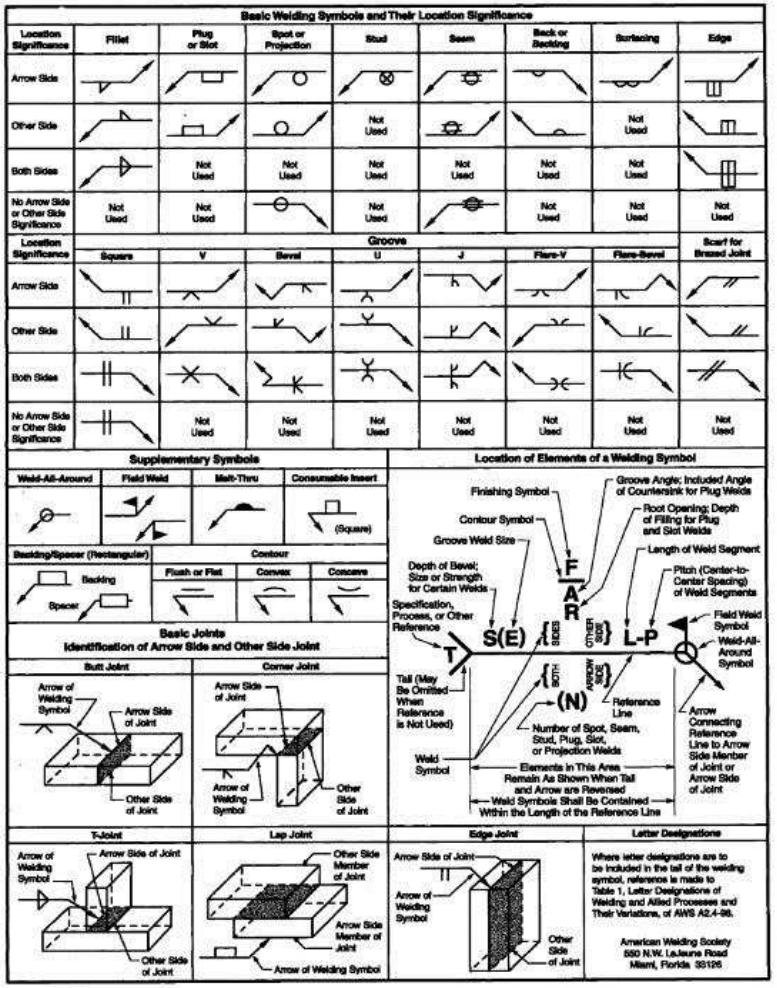




Continuous Cooling-Transformation (C-T) Diagram
(Derived from the isothermal-transformation diagram for a plain-carbon eutectoid steel)

Important Information

- Joint Design
  - Material Thickness
  - Joint Type
  - Bevel Angles
  - Root Opening Dimension
  - Backer Rods
  - Etc.



Important Information

- Filler Metals

E 6010

E = Electrode

60 = Tensile Strength (60,000psi)

1 = All Position

0 = Type Of Coating & Polarity

Cellulose, Low Hydrogen, Potassium, etc.

Important Information

- Cleanliness
  - Joint Cleaning
  - Coating Removal
  - How to Remove Coatings
- Joint Fit Up
  - Line Up Clamps
  - Internal or External

Procedure Qualification Record

- Lab Report
  - Parameters/Materials
  - Info Made for Each Pass
  - Ambient Conditions

SAMPLE PROCEDURE QUALIFICATION RECORD (PQR)
for SAW, SMAW, GMAW, GTAW, FCAW

Company _____ Approved by _____ (Signature Required)
PQR No. _____ Date _____
Welding Process(es) _____ Type(s) _____ (Manual, Semiautomatic, Automatic, Robotic, Mechanized)

Joints (see 4.14.1)

Joint Type _____
Backing _____
Backing Material (Type) _____
Groove Angle _____
Root Opening Radius: U ☐ J ☐
Root Face _____
Backgouging: Yes ☐ No ☐
Backgouging Method _____

Joint Details

Sketches, production drawings, welding symbols, or written description should show the general arrangement of the parts to be welded. Where applicable, the root details of the weld groove may be specified.

Base Metals (see 4.14.2)

M-No. _____ Group No. _____ or to M-No. _____ Group No. _____
Specification Type and Grade _____ to Specification Type and Grade _____
Thickness Range of Base Metal: Groove _____ Fillet _____
Pipe Diameter Range: Groove _____ Fillet _____
Other _____

Filler Metals (see 4.14.3)

Filler Metal F-No. _____ Other _____
AWS Classification _____ AWS Specification _____
Weld Metal Analysis A-No. _____ Other _____
Filler Metal Size _____ Electrode Flux (Class) _____
Weld Metal Thickness _____ Flux Trade Name _____
Consumable Insert _____ Other _____

Positions (see 4.14.4)

Position(s) of Groove _____
Position(s) of Fillet _____
Weld Progression _____

Preheat (see 4.14.5)

Preheat Temperature (Min.) _____
Temperature (Max.) _____

PWHT (see 4.14.6)

Temperature _____ Time _____

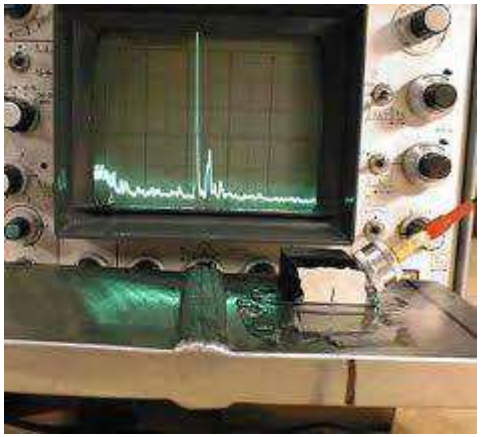
Shielding (see 4.14.7)

	Torch Shielding	Root Shielding	Trailing	Environmental Shielding
Gas(es)				
Composition				
Flow Rate				

Figure F.3—Example of a Procedure Qualification Record

Procedure Qualification Record

Testing Reports



AWS B2.1/B2.1M:2009

Electrical Characteristics and Welding Parameters (see 4.13.8)

Current Type/Polarity _____
Pulsing: Yes ☐ No ☐
Current (Range) _____
Voltage (Range) _____
Wire Feed Speed (Range) _____
Travel Speed (Range) _____
Tungsten Electrode Size/Type _____
Transfer Mode _____
Pulsing Parameters _____
Heat Input _____
Other _____

Other Variables (see 4.14.9)

Cup or Nozzle Size _____
Collet Body ☐ or Glass Lens ☐
Cleaning Method _____
Technique: Stringer ☐ or Weave Bead ☐
Number of Electrodes _____
Number of Passes per Side _____
Other _____

Test Results

Visual Test Results _____

Tensile Results

Specimen No.	Width	Thickness	Area	Results				Failure Type and Location
				Yield Load	Yield Strength	Tensile Load	Tensile Strength	

Guided Bend Tests	Qualification Results for Toughness Application
Type and Figure Number	Type and Figure Number
Results	Results

Fillet Weld Tests	Other Tests
Type and Figure Number	Type and Figure Number
Results	Results

We, the undersigned, certify that the statements in this record are correct and the test welds were prepared, welded, and tested in accordance with the requirements of AWS B2.1/B2.1M, (_____), *Specification for Welding Procedure and Performance Qualification.*
(year)

Manufacturer or Contractor _____

Date _____ By _____ _____
Please Print Signature Required

Figure F.3 (Continued)—Example of a Procedure Qualification Record

Welder Qualification

- Three Welder Testing Procedures

  API 1104

  Field Welding

  ASME Section 9

  Fab Shop Welding

  Part 192-Appendix C

  Low Stress

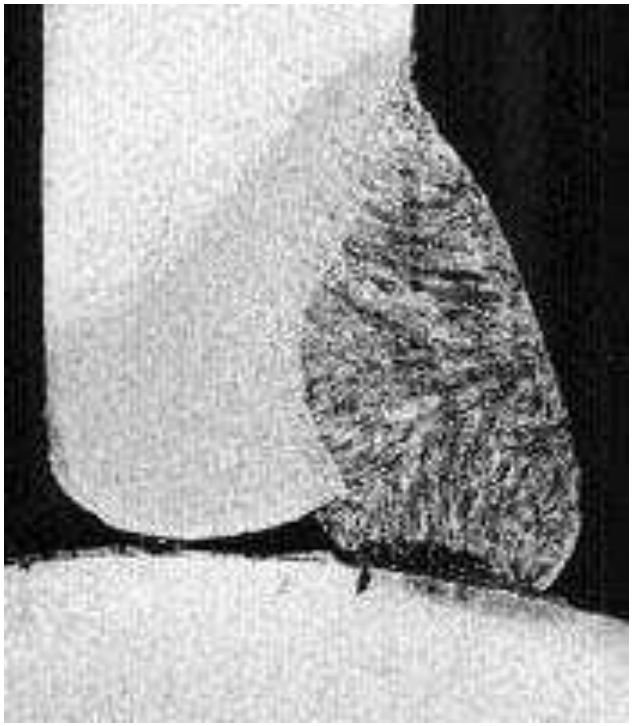
  12 Inch And Less Pipe

Welder Qualification

- Initial Test
  - Initial Test = Destructive
- 6 Month Retest
  - Non Destructive
  - Compressor Station & Components
    - » Part 192.229
    - » Destructive Only
- If a Welder Performs a Procedure Qualification, Is The Welder Also Qualilfied?

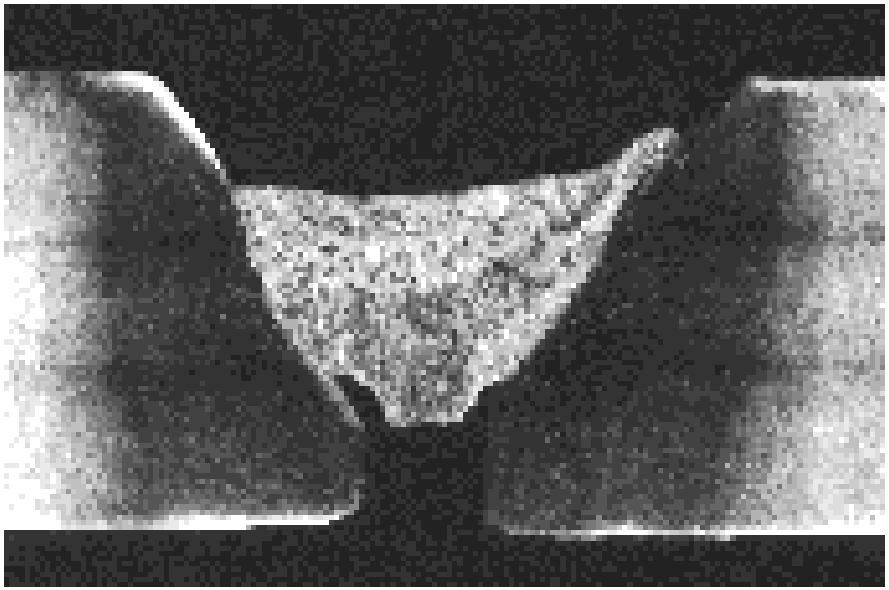
Weld Quality

- Lack of Fusion



Weld Quality

- Lack of Penetration

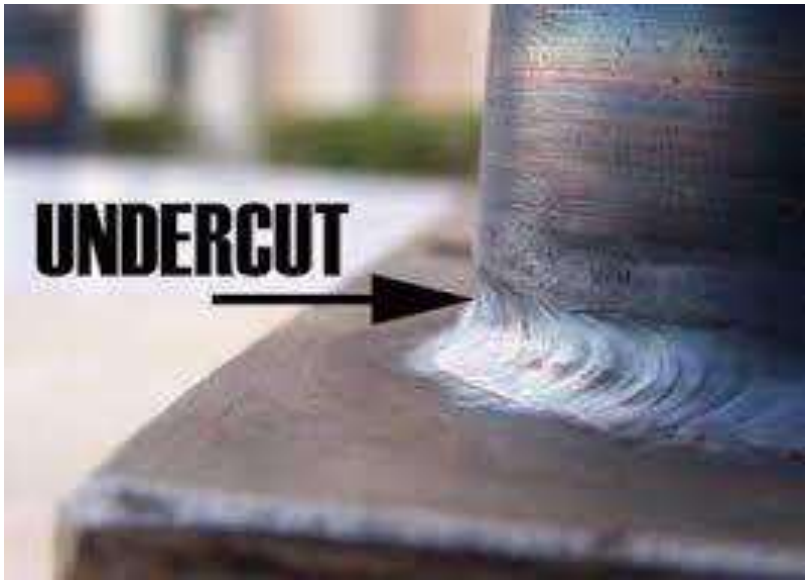


Weld Quality

- Porosity

Weld Quality

- Under Cut



American Welding Society Nashville Section

Welding Procedure Development

AWS & ASME Welding Procedures

Welding Procedure Specification (WPS)

- Written document that provides direction to the welder for making production welds in accordance with Code requirements
- Rules for qualification of procedures vary by referencing Code
  - Qualified by testing (ASME, AWS)
  - Pre-qualified (AWS)
  - Standard Welding Procedure Specification (AWS)

AWS Standard Welding Procedure Specification (SWPS)

- Procedures that have been qualified by the Welding Research Council accepted and published by AWS for use as a qualified welding procedure
- ASME and NBIC accepted procedures are listed in the appendix of the applicable Code

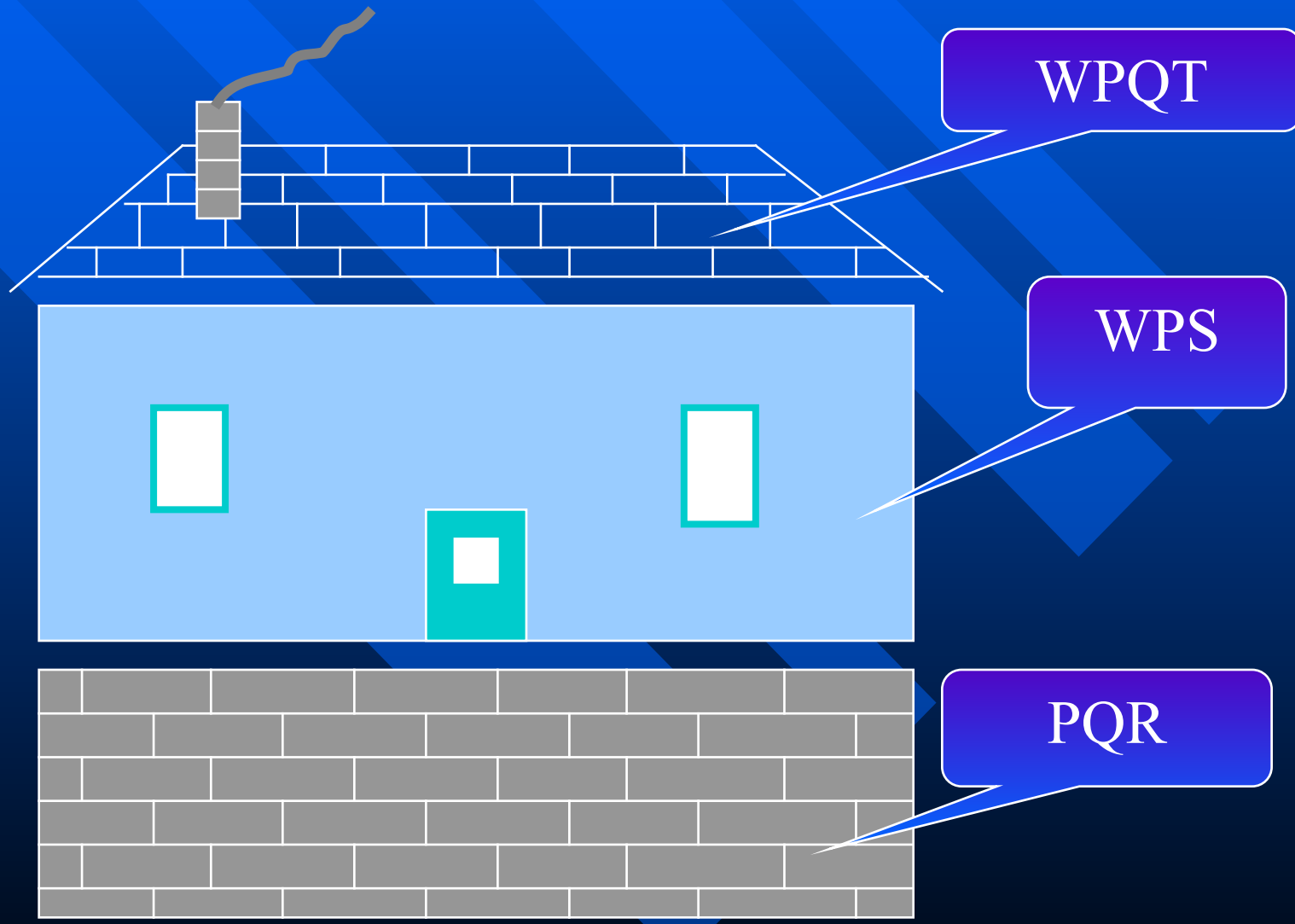
Welding Procedure Qualification (PQR)

- A test that is performed to demonstrate that the contractor can make satisfactory welds as specified in the Welding Procedure Specification
- Mechanical testing is required and NDE may be required, depending on the Code being qualified to
- Impact testing may be required by the referencing Code (i.e., ASME Sect VIII)

Welder Performance Qualification Test (WPQT)

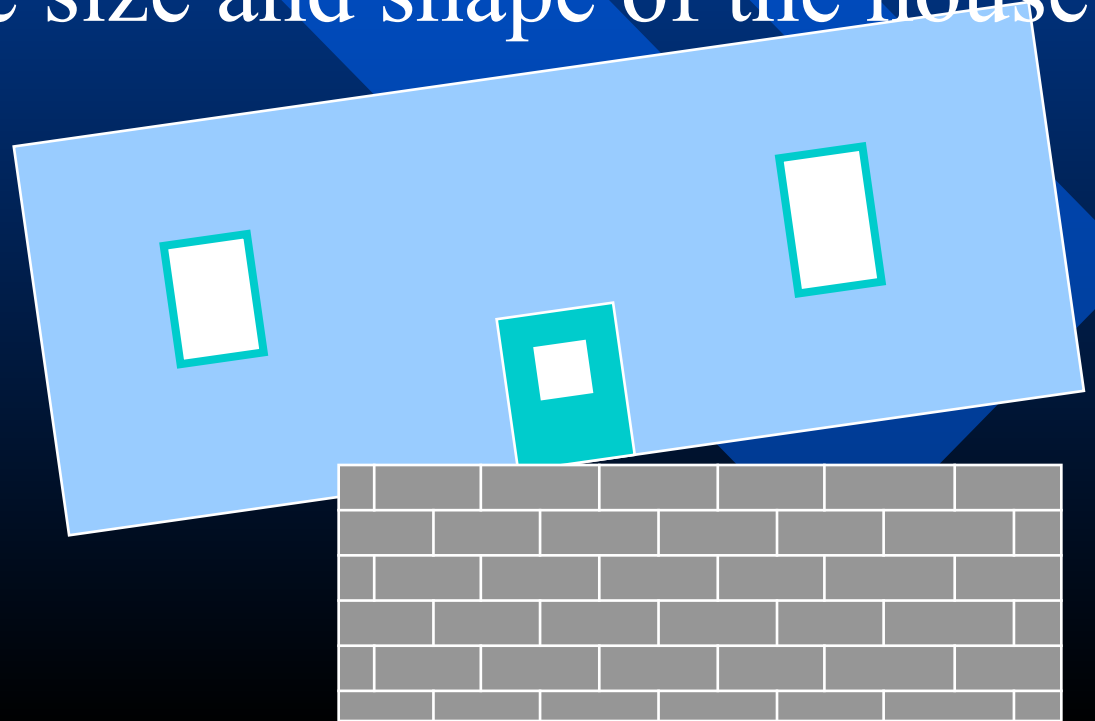
- Performance test which determines the welders ability to make acceptable production welds under a given set of conditions (essential variables)
  - Process
  - Joint type
  - Base metal
  - Filler metal
  - Position
  - Gas
  - Electrical characteristics

Which Comes First



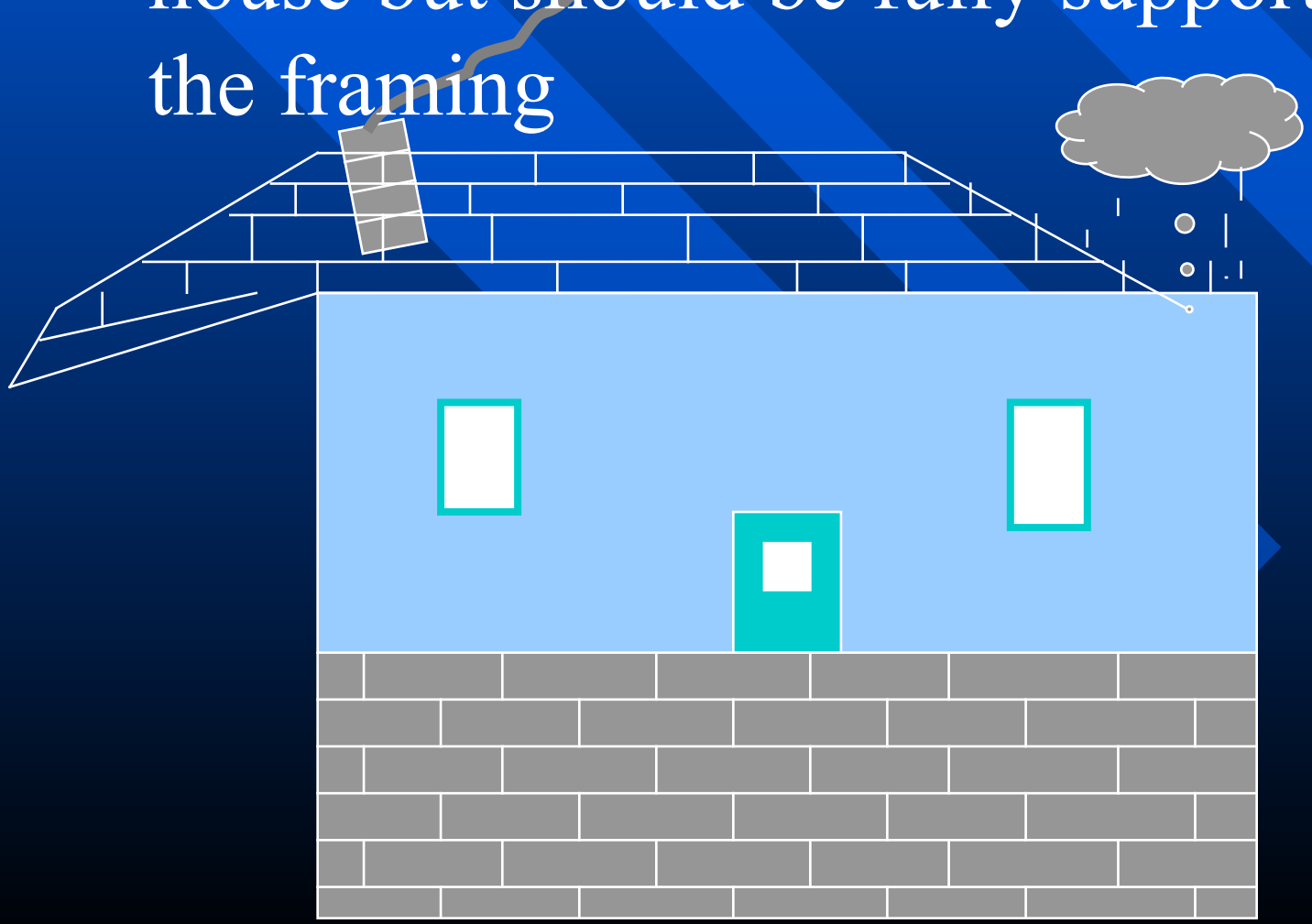
Which Comes First

- To frame a house you need to know the size of the foundation
- To build a foundation you need to know the size and shape of the house



Which Comes First

- The roof does not have to cover the house but should be fully supported by the framing



The Welding House

- The WPS and the PQR are developed concurrently
  - Rough draft the WPS to determine how to do the PQR(s)
  - More than one PQR may be required to fully support the WPS (e.g., thickness range)
  - Welder qualification tests should be designed to not exceed the limits of the WPS but do not need to meet all of the limits of the WPS

AWS B2.1

- Specification for Welding Procedure and Performance Qualification
  - Base metals categorized in M number format Similar to ASME P numbers
  - Similar to ASME Section IX

ASME B&PV Code

- ASME B&PV Code Section IX contains the guidelines for welding procedure and welder qualification
  - Requires procedure qualification for all welding procedures except when the contractor has adopted one of the AWS Standard Welding Procedure Specifications

AWS Codes

- Many AWS Codes allow the use of Pre-qualified Welding Procedures
  - Pre-qualified procedures are written documents that define welding parameters for the welder and are within defined limits set by the referencing Code (e.g., AWS D1.1)
  - Welding procedures that exceed the limits for pre-qualification must be qualified by testing

Develop the WPS

- Process(es)
- Material(s)
- Material thickness
- Joint design
- Filler metal
- Weld deposit thickness
- Positions
- Pre-heat
- Post heat
- Shielding gas
- Electrical characteristics
- Technique

Qualify or Not to Qualify

- Does the Code allow use of a pre-qualified procedure?
- Does the planned WPS stay within the limits of a pre-qualified procedure?
  - Process, joint type, material, filler metal, position, deposit thickness

What is in the WPS

- The WPS should describe all essential, non-essential and when required by the referencing Code supplementary essential variables for each welding process

Essential Variables

- Essential variables are those variables in which a change, as described in the specific variables, is considered to affect the mechanical properties of the weldment
- If there is a change in the essential variable the procedure must be re-qualified

Supplementary Essential Variables

- Supplementary essential variables are required for metals for which other Sections or Codes specify notch-toughness testing and are in addition to essential variables for each process
  - This means that when ASME Section VIII (which requires qualification to Section IX) also requires notch toughness testing on a material, the supplementary essential variables become essential variables for that WPS
  - A change in either essential or supplementary essential variables requires re-qualification of the procedure

Nonessential Variables

- Nonessential variables are those in which a change, as described in the specific variables, may be made in the WPS without re-qualification

Qualifying a procedure

- Determine what the required essential and if applicable supplementary essential variables are for:
  - Process
  - Joints
  - Base metals
  - Filler metals
  - Positions
  - Pre & post weld heat treatment
  - Gas
  - Electrical Characteristics
  - Technique

SMAW Variables (ASME Sect IX)

PROCEDURE QUALIFICATIONS

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

Paragraph			Brief of Variables	Essential	Supplementary Essential	Nonessential
QW-402 Joints	.1	ϕ	Groove design			×
	.4	–	Backing			×
	.10	ϕ	Root spacing			×
	.11	±	Retainers			×
QW-403 Base Metals	.5	ϕ	Group Number		×	
	.6		*T* Limits impact		×	
	.7		*T*/*t* Limits > 8 in.	×		
	.8	ϕ	*T* Qualified	×		
	.9		*t* Pass > ½ in.	×		
	.11	ϕ	P-No. qualified	×		
	.13	ϕ	P-No. 5/9/10	×		
QW-404 Filler Metals	.4	ϕ	F-Number	×		
	.5	ϕ	A-Number	×		
	.6	ϕ	Diameter			×
	.7	ϕ	Diam. > ¼ in.		×	
	.12	ϕ	AWS class.		×	
	.30	ϕ	*t*	×		
	.33	ϕ	AWS class.			×
QW-405 Positions	.1	+	Position			×
	.2	ϕ	Position		×	
	.3	ϕ	↑↓ Vertical welding			×
QW-406 Preheat	.1		Decrease > 100°F	×		
	.2	ϕ	Preheat maint.			×
	.3		Increase > 100°F (IP)		×	
QW-407 PWHT	.1	ϕ	PWHT	×		
	.2	ϕ	PWHT (T & T range)		×	
	.4		*T* Limits	×		
QW-409 Electrical Characteristics	.1	>	Heat input		×	
	.4	ϕ	Current or polarity		×	×
	.8	ϕ	I & E range			×
QW-410 Technique	.1	ϕ	String/weave			×
	.5	ϕ	Method cleaning			×
	.6	ϕ	Method back gouge			×
	.25	ϕ	Manual or automatic			×
	.26	±	Peening			×

Legend:
+ Addition
– Deletion
> Increase/greater than
< Decrease/less than
↑ Uphill
↓ Downhill
← Forehand
→ Backhand
ϕ Change

Welding Data (ASME Sect IX)

- The welding variables table refers to the paragraph in the welding data section of the Code
  - These paragraphs give rules for specific applications (specific variables)

Welding Data (ASME Sect IX)

QW-403.7 For the multipass processes of shielded metal-arc, submerged-arc, gas tungsten-arc, and gas metal-arc, the maximum thickness qualified for 1½ in. (38 mm) and over thickness *T* of the test coupon of QW-451.1 shall be 8 in. (203 mm) for the conditions shown in QW-451.1. For thicknesses greater than 8 in. (203 mm), the maximum thicknesses of base metal and deposited weld metal qualified is 1.33*T* or 1.33*t*, as applicable.

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

QW-403.9 For single-pass or multipass welding in which any pass is greater than ½ in. (13 mm) thick, an increase in base metal thickness beyond 1.1 times that of the qualification test coupon.

Planning the PQR

- Plan your PQR to give you the greatest possibility of success!
  - Base metal and filler metal grouping
  - Thickness limitations
  - Multiple processes require addressing essential variables for both processes
  - Note that position is not an essential variable unless notch toughness testing has been required, take advantage of that

Base Metal

- Assigned P numbers (M or S) so that similar base metals may be qualified by testing one base metal in the same P number (essential variable)
- Group numbers may be assigned within a P number to further differentiate (supplementary essential variable)
  - SA-106 Grade B > P-No.1, Group-No.1
    - » 60 KSI min specified tensile
  - SA-106 Grade C > P-No.1, Group-No.2
    - » 70 KSI min specified tensile

Filler Metals

- F number
  - Electrodes and weld rods are grouped to reduce the number of welding procedure and performance qualifications where it can be logically done
- A number
  - Classification of ferrous weld metal analysis
- Product Form
  - Flux cored
  - Bare (solid) or metal cored
  - powder

Preheat

- Decrease > 100°F
  - Essential variable
- Increase > 100 °F
  - Supplementary essential variable

Post Weld Heat Treatment

- PWHT
  - Essential variable
- PWHT (Time & Temp range)
  - Supplementary essential variable
- Base metal thickness (T) limits
  - Essential variable

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

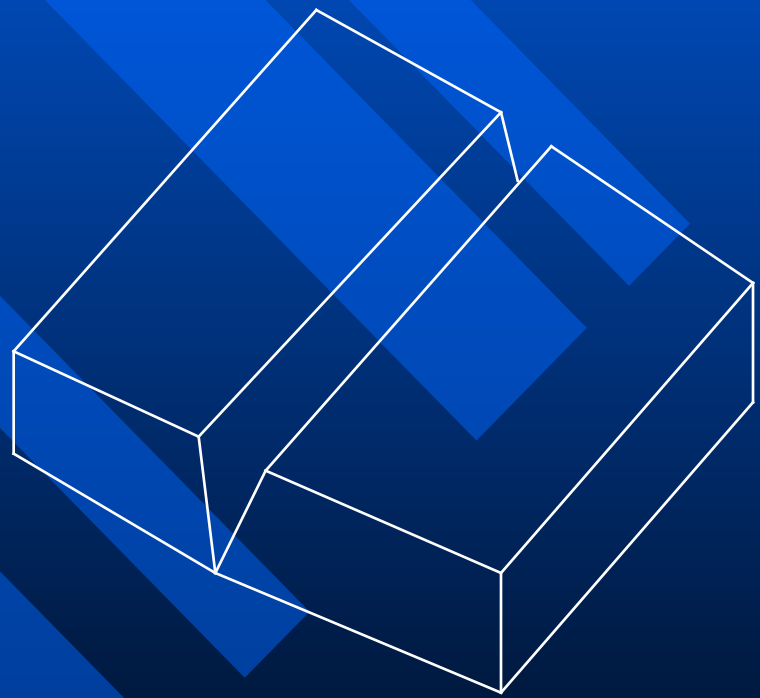
- For P-Nos. 1,3,4,5,6,9,10 & 11
  - No PWHT
  - PWHT below the lower transformation temp
  - PWHT above the upper transformation temp
    - » normalizing
  - PWHT above the upper transformation temp followed by HT below the lower transformation temp
    - » Normalizing or quenching followed by tempering
  - PWHT between the upper and lower transformation temp

QW-407.1 cont'd

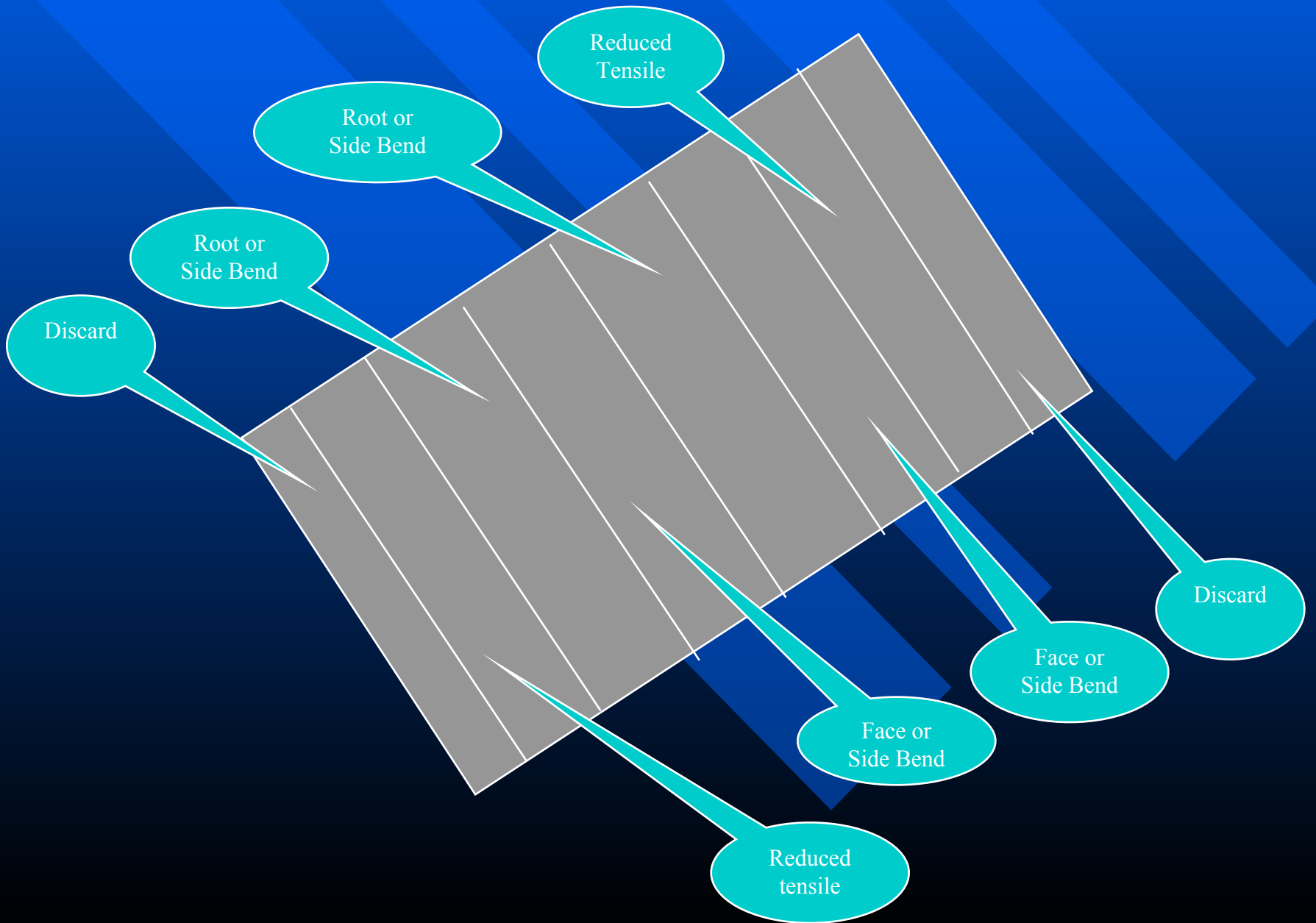
- For all other materials
  - No PWHT
  - PWHT within a specified temperature range

Test Plate or Pipe Joint

- 1G position when possible (Flat)
- Plan sequence of weld passes if multi pass
- Back grind and PT if two sided weld
- Grind stops and starts



PQR Test Coupons



Two Birds With 1 Stone

- The Procedure Qualification and Welder Qualification can be done at the same time
  - Plate 1G
  - Pipe 6G
- Tests required for Procedure Qualification
  - Bend
  - Tensile
  - Notch Toughness if required by referencing Code

Read The Notes!

Required Testing for PQR (ASME Sect IX)

QW-450 SPECIMENS

QW-451 Procedure Qualification Thickness Limits and Test Specimens

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

Thickness T of Test Coupon Welded, in.	Range of Thickness T of Base Metal Qualified, in. [Notes (1) and (4)]		Thickness t of Deposited Weld Metal Qualified, in. [Notes (1) and (4)]	Type and Number of Tests Required (Tension and Guided-Bend Tests) [Note (4)]			
	Min.	Max.	Max.	Tension QW-150	Side Bend QW-160	Face Bend QW-160	Roo QW
Less than $^1/_{16}$	T	$2T$	$2t$	2	...	2	
$^1/_{16}$ to $^3/_8$, incl.	$^1/_{16}$	$2T$	$2t$	2	Note (3)	2	
Over $^3/_8$, but less than $^3/_4$	$^3/_{16}$	$2T$	$2t$	2	Note (3)	2	
$^3/_4$ to less than $1^1/_2$	$^3/_{16}$	$2T$	$2t$ when $t < ^3/_4$	2 (5)	4	...	
$^3/_4$ to less than $1^1/_2$	$^3/_{16}$	$2T$	$2T$ when $t \geq ^3/_4$	2 (5)	4	...	
$1^1/_2$ and over	$^3/_{16}$	8 (2)	$2t$ when $t < ^3/_4$	2 (5)	4	...	
$1^1/_2$ and over	$^3/_{16}$	8 (2)	8 (2) when $t \geq ^3/_4$	2 (5)	4	...	

NOTES:
(1) See QW-403 (.2, .3, .6, .9, .10), QW-404.32, and QW-407.4 for further limits on range of thickness qualified. Also, see QW-202 (.2, .3, .4) for allowable exceptions.
(2) For the welding processes of QW-403.7 only; otherwise per Note (1) or $2T$, 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 $^3/_8$ in. and over.
(4) For combination of welding procedures, see QW-200.4.
(5) See QW-151 (.1, .2, .3) for details on multiple specimens when coupon thicknesses are over 1 in.

Pre-qualified WPS

- May be written to perform a specific weld within a limited range of variables
  - One joint design (i.e., V-Groove with backing)
  - Material thickness limited or un-limited
  - Process (i.e., SMAW)
  - Position may be limited or all position
  - Current and voltage range limited
- May be written to perform multiple welds, taking advantage of a broad range of materials, joint types, positions, etc.

AWS D1.1 Pre-qualified WPS

WELDING PROCEDURE SPECIFICATION (WPS) Yes ☒
PREQUALIFIED ☒ **QUALIFIED BY TESTING** ☐
or PROCEDURE QUALIFICATION RECORDS (PQR) Yes ☐

Identification # SM-CS-1-1
Revision 0 Date ____ By ____

Company Name: Guy's Welding
Welding Process(es): SMAW
Supporting PQR No.(s): Prequalified

Authorized by: Guy S Mulee Date: 11-1-02
Type—Manual ☒ Semi-Automatic ☐
Machine ☐ Automatic ☐

JOINT DESIGN USED
Type: Any listed in ANSI/AWS D1.1 Fig. 3.3 or 3.4
Single ☒ Double Weld ☒
Backing: Yes ☒ No ☐
Backing Material: Weld or Any Group 1 Matl of ANSI/AWS D1.1 Table 3.1
Root Opening ____ Root Face Dimension ____
Groove Angle: ____ Radius (J-U) ____
Back Gouging: Yes ☒ No ☐ Method: Carbon arc or grind

BASE METALS
Material Spec.: Any Group 1 Matl of ANSI/AWS D1.1 Table 3.1
Type or Grade: ____
Thickness: Groove 1/8" to ¾" Fillet Unlimited
Diameter (Pipe): Over 24" O.D.

FILLER METALS
AWS Specification: A5.1 and A5.5
AWS Classification: EXX10, EXX18, EXX18W

SHIELDING
Flux: N/A
Gas: N/A
Composition: N/A
Electrode-Flux (Class): N/A
Flow Rate: N/A
Gas Cup Size: N/A

PREHEAT
Preheat Temp., Min: 50 F
Interpass Temp., Min: 50 F Max: 750 F

POSITION
Position of Groove: All Fillet: All
Vertical Progression: Up ☒ Down ☐

ELECTRICAL CHARACTERISTICS
Transfer Mode (GMAW): Short-Circuiting ☐ Globular ☐ Spray ☐
Current: AC ☐ DCEP ☒ DCEN ☐ Pulsed ☐
Other: ____
Tungsten Electrode (GTAW)
Size: N/A
Type: N/A

TECHNIQUE
Stringer or Weave Bead: Both (3X for F4 & 4X for F3 electrodes)
Multi-pass or Single Pass (per side): Multi and Single
Number of Electrodes: Single
Electrode Spacing: Longitudinal N/A; Lateral N/A; Angle N/A
Contact Tube to Work Distance: N/A
Peening: Not permitted
Interpass Cleaning: Chip, grind and wire brush

POSTWELD HEAT TREATMENT
Temp.: Not permitted
Time: N/A

WELDING PROCEDURE

Pass or Weld Layer(s)	Process	Filler Metals		Current		Volts	Travel Speed	Joint Details
		Class	Diam.	Type & Polarity	Amps or Wire Feed Speed			
All	SMAW	EXX18	3/32"	DCEP	70 - 110	17 - 30	3-6 ipm	All prequlaified joints listed in ANSI/AWS D1.1 Figures 3.3 & 3.4 within limits of this WPS
All	SMAW	EXX18	1/8"	DCEP	90 - 150	17 - 30	3-6 ipm	
Al	SMAW	EXX18	5/32"	DCEP	120 - 190	17 - 30	3-6 ipm	
All	SMAW	EXX10	3/32"	DCEP	40 - 80	17 - 30	3-6ipm	
All	SMAW	EXX10	1/8"	DCEP	75 - 120	17 - 30	3-6 ipm	Typical joints shown in standard drawing #1
All	SMAW	EXX10	5/32"	DCEP	110 - 170	17 - 30	3-6 ipm	

AWS D1.1 Pre-qualified WPS

WELDING PROCEDURE SPECIFICATION (WPS) Yes ☒
PREQUALIFIED ☒ **QUALIFIED BY TESTING** ☐
or PROCEDURE QUALIFICATION RECORDS (PQR) Yes ☐

Identification # SM-CS-1-1
Revision 0 Date By
Authorized by Date 11-02-02
Type—Manual ☒ Semi-Automatic ☐
Machine ☐ Automatic ☐

Company Name Guy's Welding
Welding Process(es) SMAW
Supporting PQR No.(s) Prequalified

JOINT DESIGN USED
Type: Butt
Single ☒ Double Weld ☐
Backing: Yes ☒ No ☐
Backing Material: A-36
Root Opening ¼" Root Face Dimension 0
Groove Angle: 45° Radius (J-U) N/A
Back Gouging: Yes ☐ No ☒ Method

BASE METALS
Material Spec. A-36
Type or Grade
Thickness: Groove 1/8" to ¾" Fillet N/A
Diameter (Pipe) Over 24" O.D.

FILLER METALS
AWS Specification A5.1
AWS Classification E7018

SHIELDING
Flux N/A
Gas N/A
Composition N/A
Electrode-Flux (Class) N/A
Flow Rate N/A
Gas Cup Size N/A

PREHEAT
Preheat Temp., Min 70°F if ambient temperature is below 32°F
Interpass Temp., Min 70°F if ambient temp is below 32°F Max 750 F

POSITION
Position of Groove: All Fillet: All
Vertical Progression: Up ☒ Down ☐

ELECTRICAL CHARACTERISTICS
Transfer Mode (GMAW) Short-Circuiting ☐
Globular ☐ Spray ☐
Current: AC ☐ DCEP ☒ DCEN ☐ Pulsed ☐
Other
Tungsten Electrode (GTAW)
Size: N/A
Type: N/A

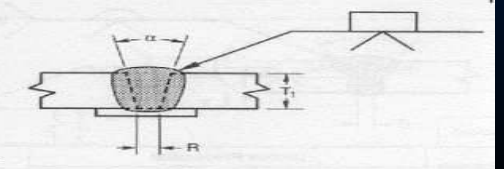
TECHNIQUE
Stringer or Weave Bead: Stringer only
Multi-pass or Single Pass (per side) Multi and Single
Number of Electrodes Single
Electrode Spacing Longitudinal N/A
Lateral N/A
Angle N/A
Contact Tube to Work Distance N/A
Peening Not permitted
Interpass Cleaning: Chip, grind and wire brush

POSTWELD HEAT TREATMENT
Temp. Not permitted
Time N/A

WELDING PROCEDURE

Pass or Weld Layer(s)	Process	Filler Metals Class	Filler Metals Diam.	Current Type & Polarity	Current Amps or Wire Feed Speed	Volts	Travel Speed
All	SMAW	E7018	3/32"	DCEP	70 - 110	17 - 30	3-6 ipm
All	SMAW	E7018	1/8"	DCEP	90 - 150	17 - 30	3-6 ipm
Al	SMAW	E7018	5/32"	DCEP	120 - 190	17 - 30	3-6 ipm

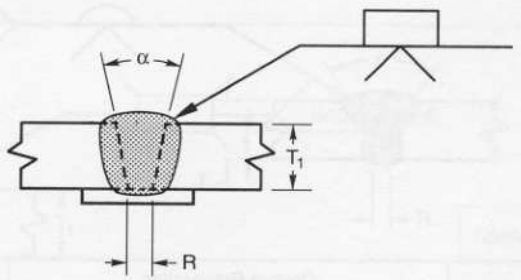
Joint Details for B-U2a



Form prepared by Guy Mulee Weld Tech Consulting AWS CWI 92121061 April 1999 Rev 1

AWS D1.1 Pre-qualified joint design

Single-V-groove weld (2)
Butt joint (B)



Tolerances	
As Detailed (see 3.13.1)	As Fit-Up (see 3.13.1)
R = +1/16, –0	+1/4, –1/16
α = +10°, –0°	+10°, –5°

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited) T_1	Base Metal Thickness (U = unlimited) T_2	Groove Preparation: Root Opening	Groove Preparation: Groove Angle	Permitted Welding Positions	Gas Shielding for FCAW	Notes
SMAW	B-U2a	U	—	R = 1/4	α = 45°	All	—	D, N
				R = 3/8	α = 30°	F, V, OH	—	D, N
				R = 1/2	α = 20°	F, V, OH	—	D, N
GMAW FCAW	B-U2a-GF	U	—	R = 3/16	α = 30°	F, V, OH	Required	A, N
				R = 3/8	α = 30°	F, V, OH	Not req.	A, N
				R = 1/4	α = 45°	F, V, OH	Not req.	A, N
SAW	B-L2a-S	2 max	—	R = 1/4	α = 30°	F	—	N
SAW	B-U2-S	U	—	R = 5/8	α = 20°	F	—	N

Figure 3.4 (Continued)—Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details (see 3.13)

Notes

Notes

Notes for Figures 3.3 and 3.4

Notes:

A: Not prequalified for gas metal arc welding using short circuiting transfer nor GTAW. Refer to Annex A.

B: Joint is welded from one side only.

Br: Cyclic load application limits these joints to the horizontal welding position (see 2.27.5).

C: Backgouge root to sound metal before welding second side.

D: SMAW detailed joints may be used for prequalified GMAW (except GMAW-S) and FCAW.

E: Minimum weld size (E) as shown in Table 3.4. S as specified on drawings.

J: If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, these shall be equal to 1/4 T_1, but need not exceed 3/8 in. Groove welds in corner and T-joints of cyclically loaded structures shall be reinforced with fillet welds equal to 1/4 T_1, but not more than 3/8 in.

M: Double-groove welds may have grooves of unequal depth, but the depth of the shallower groove shall be no less than one-fourth of the thickness of the thinner part joined.

Mp: Double-groove welds may have grooves of unequal depth, provided these conform to the limitations of Note E. Also the weld size (E) applies individually to each groove.

N: The orientation of the two members in the joints may vary from 135° to 180° for butt joints, or 45° to 135° for corner joints, or 45° to 90° for T-joints.

V: For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.

Z: Weld size (E) is based on joints welded flush.

Pre-qualified Base Metals

Table 3.1
Prequalified Base Metal—Filler Metal Combinations for Matching Strength[8] (see 3.3)

Steel Specification Requirements						Filler Metal Requirements				
		Minimum Yield Point/Strength		Tensile Range			Minimum Yield Point/Strength		Tensile Strength Range	
Steel Specification[1, 2]		ksi	MPa	ksi	MPa	Electrode Specification[3, 6]	ksi	MPa	ksi	MPa
ASTM A36[4]		36	250	58–80	400–550					
ASTM A53	Grade B	35	240	60 min	415 min	SMAW				
ASTM A106	Grade B	35	240	60 min	415 min	AWS A5.1				
ASTM A131	Grades A, B, CS, D, DS, E	34	235	58–71	400–490	E60XX	48	331	60 min	414 min
ASTM A139	Grade B	35	241	60 min	414 min	E70XX	53–72	365–496	70 min	482 min
ASTM A381	Grade Y35	35	240	60 min	415 min	AWS A5.5[7]				
ASTM A500	Grade A	33	228	45 min	310 min	E70XX-X	57–60	390–415	70–75 min	480–520 min
	Grade B	42	290	58 min	400 min	SAW				
ASTM A501		36	250	58 min	400 min	AWS A5.17				
ASTM A516	Grade 55	30	205	55–75	380–515	F6XX-EXXX	48	330	60–80	415–550
	Grade 60	32	220	60–80	415–550	F7XX-EXXX	58	400	70–95	480–650
ASTM A524	Grade I	35	240	60–85	415–586	AWS A5.23[7]				
	Grade II	30	205	55–80	380–550	F7XX-EXX-XX	58	400	70–95	480–660
ASTM A529		42	290	60–85	415–585					
ASTM A570	Grade 30	30	205	49 min	340 min	GMAW				
	Grade 33	33	230	52 min	360 min	AWS A5.18				
	Grade 36	36	250	53 min	365 min	ER70S-X	58	400	70 min	480 min
	Grade 40	40	275	55 min	380 min					
	Grade 45	45	310	60 min	415 min					
	Grade 50	50	345	65 min	450 min					
ASTM A573	Grade 65	35	240	65–77	450–530	FCAW				
	Grade 58	32	220	58–71	400–490	AWS A5.20				
ASTM A709	Grade 36[4]	36	250	58–80	400–550	E6XT-X	48	330	60 min	415 min
API 5L	Grade B	35	240	60	415	E7XT-X	58	400	70 min	480 min
	Grade X42	42	290	60	415	(Except -2, -3, -10, -13, -14, -GS)				
ABS	Grades A, B, D, CS, DS			58–71	400–490	AWS A5.29[7]				
	Grade E[5]			58–71	400–490	E7XTX-XX	58	400	70–90	490–620

(continued)

Pre-qualified pre-heat table

Table 3.2
Prequalified Minimum Preheat and Interpass Temperature[3] (see 3.5)

Category	Steel Specification				Welding Process	Thickness of Thickest Part at Point of Welding		Minimum Preheat and Interpass Temperature
						in.	mm	°F
A	ASTM A36		ASTM A516		Shielded metal arc welding with other than low-hydrogen electrodes	1/8 to 3/4 incl.	3 to 19 incl.	None[1]
	ASTM A53	Grade B	ASTM A524	Grades I & II				
	ASTM A106	Grade B	ASTM A529			Over 3/4	Over 19	
	ASTM A131	Grades A, B, CS, D, DS, E	ASTM A570	All grades		thru 1-1/2 incl.	thru 38.1 incl.	150
			ASTM A573	Grade 65				
	ASTM A139	Grade B	ASTM A709	Grade 36		Over 1-1/2	Over 38.1	
	ASTM A381	Grade Y35	API 5L	Grade B		thru 2-1/2 incl.	thru 63.5 incl.	225
	ASTM A500	Grade A		Grade X42				
		Grade B	ABS	Grades A, B, D, CS, DS				
	ASTM A501			Grade E		Over 2-1/2	Over 63.5	300
B	ASTM A36		ASTM A570	All grades	Shielded metal arc welding with low-hydrogen electrodes, submerged arc welding,[2] gas metal arc welding, flux cored arc welding	1/8 to 3/4 incl.	3 to 19 incl.	None[1]
	ASTM A53	Grade B	ASTM A572	Grades 42, 50				
	ASTM A106	Grade B	ASTM A573	Grade 65				
	ASTM A131	Grades A, B, CS, D, DS, E	ASTM A588					
			ASTM A595	Grades A, B, C				
		AH 32 & 36	ASTM A606					
		DH 32 & 36	ASTM A607	Grades 45, 50, 55				
		EH 32 & 36	ASTM A618	Grades Ib, II, III				
	ASTM A139	Grade B	ASTM A633	Grades A, B				
				Grades C, D		Over 3/4	Over 19 thru	
	ASTM A381	Grade Y35	ASTM A709	Grades 36, 50, 50W		thru 1-1/2 incl.	38.1 incl.	50
			ASTM A710	Grade A, Class 2 (> 2 in.)				
			ASTM A808					
			ASTM A913	Grade 50				
	ASTM A441		API 5L	Grade B				
	ASTM A500	Grade A		Grade X42				
		Grade B	API Spec. 2H	Grades 42, 50		Over 1-1/2	Over 38.1 thru	
			API 2W	Grades 42, 50, 50T				
			API 2Y	Grades 42, 50, 50T				
	ASTM A501		ABS	Grades AH 32 & 36		thru 2-1/2 incl.	63.5 incl.	150
	ASTM A516	Grades 55 & 60		DH 32 & 36				
		65 & 70		EH 32 & 36				
	ASTM A524	Grades I & II	ABS	Grades A, B, D,				
	ASTM A529			CS, DS		Over 2-1/2	Over 63.5	225
	ASTM A537	Classes 1 & 2		Grade E				

(continued)

Notes for base metals and pre-heating

lotes:
. In joints involving base metals of different groups, either of the following filler metals may be used: (1) that which matches the higher strength base metal, or (2) that which matches the lower base metal and produces a low-hydrogen deposit. Preheating shall be in conformance with the requirements applicable to the higher strength group.
. Match API standard 2B (fabricated tubes) according to steel used.
. When welds are to be stress-relieved, the deposited weld metal shall not exceed 0.05 percent vanadium.
Only low-hydrogen electrodes shall be used when welding A36 or A709 Grade 36 steel more than 1 in. (25.4 mm) thick for cyclically loaded structures.
Special welding materials and WPS (e.g., E80XX-X low-alloy electrodes) may be required to match the notch toughness of base metal (for applications involving impact loading or low tempera
for atmospheric corrosion and weathering characteristics (see 3.7.3).
The designation of ER70S-1B has been reclassified as ER80S-D2 in A5.28-79. Prequalified WPSs prepared prior to 1981 and specifying AWS A5.18, ER70S-1B, may now use AWS A5.28-79 ER
when welding steels in Groups I and II.
Filler metals of alloy group B3, B3L, B4, B4L, B5, B5L, B6, B6L, B7, B7L, B8, B8L, or B9 in ANSI/AWS A5.5, A5.23, A5.28, or A5.29 are not prequalified for use in the as-welded condition.
See Tables 2.3 and 2.5 for allowable stress requirements for matching filler metal.
The heat input limitations of 5.7 shall not apply to ASTM A913 Grade 60 or 65.

Not pre-qualified

when tested according to ANSI/ AWS A4.3.

Notes:
1. When the base metal temperature is below 32°F (0°C), the base metal shall be preheated to at least 70°F (21°C) and this minimum temperature maintained during welding.
2. For modification of preheat requirements for submerged arc welding with parallel or multiple electrodes, see 3.5.3.
3. See 5.12.2 and 5.6 for ambient and base-metal temperature requirements.
4. The heat input limitations of 5.7 shall not apply to ASTM A913 Grade 60 or 65.

Welder Qualification Essential Variables

- Joints
  - With or without backing
- Base metal
  - Pipe diameter
  - P number

Welder Qualification Essential Variables

- Filler metal
  - With or without
  - F number
  - Inserts
  - Solid or metal cored
  - “t” of deposit
  - “t” limits of short circuiting transfer

Welder Qualification Essential Variables

- Position
  - Flat
  - Horizontal
  - Vertical
  - Overhead
- Progression – vertical welding
  - Up
  - Down

Welder Qualification Essential Variables

- Gas
  - Deletion of inert backing gas
- Electrical characteristics
  - GMAW – transfer mode
  - GTAW – current or polarity

Welder Qualification

- Main controlling factors
  - Process
  - Filler metal
  - P number qualified
    - » It is your responsibility to ensure that the filler metal and base metal are suitable for the application

Welder Qualification Base Metal

- Test on pipe or plate?
- Any P-No. 1 through 11, P-No. 34, or P-No. 41 through 47 qualifies for any P-No. 1 through 11, P-No. 34, or P-No. 41 through 47 base metal
- P-No. 21 through P-No. 25 (same)
- P-No. 51 through P-No. 53 or P-No. 61 through P-No. 62 (same)

Welder Qualification F-Numbers

- Some cross qualification exists with F numbers for example
  - Any F6 qualifies for F6
  - Any F21 – F25 qualifies for F21 – F25
  - Any F34 or F41 – F47 qualifies for F34 & F41 - F47

Welder Qualification F-Numbers

- SMAW electrode F numbers 1 – 4 are inter-related (ASME) and with or without backing applies
  - F4 without backing qualifies for F1, F2, F3 & F4 with backing and F4 without
  - F4 with backing qualifies for F1, F2, F3 & F4 with backing only

Welder Qualification Weld Deposit "t"

- ASME
  - Up to and including 3/8" thick qualifies 2t
  - Over 3/8" qualifies 2t
  - 1/2" & over with minimum of 3 layers of weld metal qualifies for the maximum to be welded
- AWS D1.1
  - 1/8" $\leq t \geq$ 3/8" qualifies for 2t
  - 3/8" $< t <$ 1" qualifies for 2t
  - 1" and over qualifies for unlimited

Welder Qualification Position (ASME)

- 1G plate qualifies
  - F plate & pipe 2 7/8” OD & over groove welds and F fillets
- 2G plate qualifies
  - F & H plate & pipe 2 7/8” OD & over groove welds and F & H fillets

Welder Qualification Position (ASME)

- 3G plate qualifies
  - F & V plate & pipe groove welds 24” OD & over and F, H, V fillets
  - F pipe 2 7/8” OD & over groove welds
- 4G plate qualifies
  - F & O plate & pipe groove welds 24” OD & over and F, H, O fillets
  - F pipe 2 7/8” OD & over groove welds

Welder Qualification Position (ASME)

- 1G pipe
  - F groove & fillet
- 2G pipe
  - F & H groove & fillet
- 5G pipe
  - F, V & O groove & fillet
- 2G & 5G pipe or 6G pipe
  - All groove & fillet

Welder Qualification (ASME)

- Diameter limits based on OD of test coupon for groove welds
  - < 1” OD = size welded to unlimited
  - 1 < 2 7/8” OD = 1” OD to unlimited
  - 2 7/8” OD & over = 2 7/8” OD to unlimited
- Groove weld test qualifies fillets for all base material thickness, sizes and diameters

Welder Qualification

- Most testing can be done on carbon steel test coupons to save money
  - e.g., welder qualifications can be completed for most nickel alloys by using a filler from the F-41 through F-47 group welding a carbon steel test coupon
- 6G pipe position is the most economical test position

Weld it Right Co.

1 Weld St. Rochester, N.Y 14619

WELDER OR WELDING OPERATOR PERFORMANCE QUALIFICATION (QW-484)

Welder's name john Doe INS/SS number 101 Stamp no. 1
Welding process(es) used GMAW Type Semi-Automatic
Identification of WPS followed by during welding of test coupon A-2-1:1-1
Base material(s) welded SA-36 Thickness 3/8"
Other WPS's qualified to weld under

Welding Variables for Each Process (QW-350)	Actual Values	Range Qualified
Backing (metal, weld metal, welded from both sides, flux, etc.) (QW-402)	With	With
ASME P-No. to ASME P-No. (QW-403)	P- No. 1 to P-No. 1	P- No. 1-11, 34, 41-47
(☒) Plate (☐) Pipe (enter diameter, if pipe)		Groove 2 7/8" O.D. & over F only Groove 24" O.D. & over Fillet all dia.
Filler metal specification (SFA): A5.18 Classification (QW-404)	ER70S-6	ER70S-X
Filler metal F-no.	6	6
Consumable insert for GTAW or PAW	None	Not Permitted
Weld deposit thickness for each welding process	3/8"	0.412"
Welding position (1G, 5G, etc.) (QW-405)	3G	F & V
Progression (uphill/downhill)	Uphill	Uphill
Backing gas for GTAW, PAW, or GMAW; fuel gas for OFW (QW-408)	None	None
GMAW Transfer mode (QW-409)	Short Circuiting	Short Circuiting
GTAW welding current type/polarity	N/A	N/A

Machine Welding Variables for the Process Used (QW-360)	Actual Values	Range Qualified
Direct/remote visual control		
Automatic voltage control (GTAW)		
Automatic joint tracking		
Welding position (1G, 5G, etc.)		
Consumable insert		
Backing (metal, weld metal, welded from both sides, flux, etc.)		

Notes:

Guided Bend Test Results

Guided Bend Tests Type ☐ QW-462.2 (Side) Results ☒ QW-462.3(a) Trans. R & F) Type ☐ QW-462.3(b) (long. R & F) Results

3G Root	Acceptable	3G Face	Acceptable

Visual examination results (QW-302.4) Acceptable
Radiographic test results (QW-304 and QW-305)
(For alternative qualification of groove welds by radiography)
Fillet Weld - Fracture test Length and percent of defects in.
Macro fusion test Fillet leg size in. x in. Concavity/convexity in.
Welding test conducted by Guy Mulee Date of Test 1/10/2003 Lab Test No. WTC00103
Mechanical tests conducted by Guy Mulee Test Specimens Evaluated by Guy Mulee
We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Organization Weld it Right Co.

Date 1/11/2003 By Joe Welder Joe Welder

Qualification by Workmanship Test

- Only permitted when allowed by the referencing document
- Requires completion of a workmanship test addressing typical production joints and conditions
- Primarily accepted on the basis of visual inspection
- Other tests or examinations may be required by the referencing document (e.g., macro examination)

Continued Qualification

- ASME, AWS (except D9.1) requires that the welder must satisfactorily weld using the process at least once each six months to remain qualified
  - D9.1 is 12 months
- Re-qualification may be done on pipe or plate in any position, material thickness or diameter to regain qualification for all positions, thickness, materials and diameters previously qualified for with that process

American Welding Society
550 NW LeJeune Rd Miami, Fl 33126
(800) 443-9353 or (305) 443-9353, ext. 273
FAXED APPLICATIONS ARE NOT ACCEPTED

WELDING INSPECTOR EXAM APPLICATION

LAST NAME **FIRST NAME** **MI**

DATE OF BIRTH MM/DD/YY **U.S. SOCIAL SECURITY NUMBER** **INTERNATIONAL CANDIDATE PASSPORT NUMBER**

1. PLEASE INDICATE THE EXAM LOCATION OF YOUR CHOICE:

1st Site Code: _____ Exam Date: _____ City/State: _____ *Submission Deadline: _____

2nd Site Code: _____ Exam Date: _____ City/State: _____ *Submission Deadline: _____

3rd Site Code: _____ Exam Date: _____ City/State: _____ *Submission Deadline: _____

NOTE: AWS strongly recommends the applicant selects a second and third site location alternative. If the first choice is not available, the next location will be selected. ***The application submission deadline is six weeks prior to the scheduled exam date.** Applicants who do not meet this criteria must contact the Certification Department for Fast Track processing procedure and an additional fee will apply.

2. PLEASE CHECK AND COMPLETE THE FOLLOWING:

- ❑ CAWI *(only)*
- ❑ CWI *(only)*
- ❑ CWE *(only)*
- ❑ CWI and CWE combo
- ❑ SCWI *(only)*

ARE YOU OR HAVE YOU EVER BEEN AN AWS MEMBER? ❑ NO ❑ YES

If yes, please provide AWS Member # _____

HAVE YOU OBTAINED AN AWS CERTIFICATION? ❑ NO ❑ YES

If so, Certification #: _____

Are you employed by an AWS SENSE program participating organization? ❑ NO ❑ YES

If yes, the Facility name: _____

3. PLEASE SELECT ONE OF THE FOLLOWING FOR YOUR CODE APPLICATION TEST SUBJECT:

- ❑ AWS D1.1 – Structural Steel: 2002, 2004, or 2006 editions permissible
- ❑ API-1104 – Pipelines 20th edition
- ❑ AWS D15.1 – Railroad: 1993 edition
- ❑ AWS D1.5 – Bridges: 2002 edition
- ❑ ASME Section IX, B31.1, and B31.3
- ❑ AWS B2.1 and B4.0: 2004 editions * SCWI APPLICANTS ONLY * OPEN BOOK FORMAT

4. PLEASE INDICATE THE FOLLOWING AWS SEMINAR OF YOUR CHOICE:

(only for CAWI, CWI and CWE applicants)

❑ **PLATINUM PAK** *(two code clinics)*

1. D1.1 Code Clinic (Sun, 1pm – 5pm & Mon, 8am – 12 noon)
2. API-1104 Code Clinic (Mon, 1pm – 5pm)
   ***Code book NOT supplied**; applicants must furnish a 20th edition*
3. Welding Inspection Tech Course (Tues – Thurs, 8am – 5pm)
4. Visual Inspection Workshop (Fri, 8am – 5pm)
5. Certification Exam (Sat, 8am – 5pm)

❑ **GOLD PAK** *(one code clinic)*

1. API-1104 Code Clinic (Mon, 1pm – 5pm)
   ***Code book NOT supplied**; applicants must furnish a 20th edition*
2. Welding Inspection Tech Course (Tues – Thurs, 8am – 5pm)
3. Visual Inspection Workshop (Fri, 8am – 5pm)
4. Certification Exam (Sat, 8am – 5pm)

❑ **SILVER PAK** (*No Code Clinic*)

1. Welding Inspection Tech Course (Tues – Thurs, 8am – 5pm)
2. Visual Inspection Workshop (Fri, 8am – 5pm)
3. Certification Exam (Sat, 8am – 5pm)

FOR INDIVIDUAL SEMINAR WORKSHOPS:

- ❑ D1.1 code clinic workshop *(code book not supplied)*
- ❑ API-1104 Code clinic workshop *(code book not supplied)*
- ❑ Welding Inspection workshop
- ❑ Visual inspection workshop

❑ **NONE / EXAMINATION ONLY**

5. METHOD OF PAYMENT

❑ Bill Me / PO *(Staple PO to front page of application)*

❑ Check or money order #_____

❑ VISA ❑ MC ❑ AMEX ❑ Diners ❑ Discover

CC#:_____/_____/_____/_____Exp:_____/_____

SIGNATURE_____

AWS USE ONLY

Date: _____ Acct #: _____

Amt$: _____ PAID / OWE

QCA/CWE/QCH/QC-COMBO

6. PERSONAL INFORMATION: *(PO BOX NOT ACCEPTED. STREET ADDRESS REQUIRED)*

ADDRESS

ADDRESS *(cont'd)* **APT NO.**

CITY AND STATE / PROVINCE / COUNTRY **ZIP CODE**

HOME TELEPHONE NUMBER **WORK TELEPHONE** **FAX TELEPHONE NUMBER**

E-MAIL ADDRESS

7. ASSOCIATIONS

TYPE OF BUSINESS CHECK ONE BOX	**JOB CLASSIFICATION** CHECK ONE BOX	**YOUR TECHNICAL INTERESTS** FILL IN ORDER OF PRIORITY (1,2,3,ETC.)
A. ❑ Contract Construction	01. ❑ President, owner, partner, officer	A. ____ Ferrous metals
B. ❑ Chemicals, Allied Products	02. ❑ Manager, director, superintendent	B. ____ Aluminum
C. ❑ Petroleum & Coal Industries	03. ❑ Sales	C. ____ Nonferrous metals except aluminum
D. ❑ Primary Metal Industries	04. ❑ Purchasing	D. ____ Advanced materials, intermetallics
E. ❑ Fabricated Metal Products	05. ❑ Engineer – welding	E. ____ Ceramics
F. ❑ Machinery except electrical	06. ❑ Engineer – other	F. ____ High energy beam processes
G. ❑ Electrical equipment, supplies, electrodes	07. ❑ Inspector, tester	G. ____ Arc Welding
H. ❑ Transport equipment, air, aerospace	08. ❑ Supervisor, foreman	H. ____ Brazing and soldering
I. ❑ Transport equipment, automotive	09. ❑ Welder, welding or cutting operator	I. ____ Resistance welding
J. ❑ Transport equipment, boats, ships	10. ❑ Architect, designer	J. ____ Thermal spraying
K. ❑ Transport equipment, railroad	11. ❑ Consultant	K. ____ Cutting
L. ❑ Utilities	12. ❑ Metallurgist	L. ____ NDE
M. ❑ Welding distributorship & retail trade	13. ❑ Research and development	M. ____ Safety and health
N. ❑ Misc. repair services inc. welding	14. ❑ Technician	N. ____ Bending and shearing
O. ❑ Education services inc. schools, libraries	15. ❑ Educator	O. ____ Roll forming
P. ❑ Engineering & architectural services	16. ❑ Student	P. ____ Stamping and punching
Q. ❑ Misc. business services inc. laboratories	17. ❑ Librarian	Q. ____ Aerospace
R. ❑ Governmental (federal, state, local)	18. ❑ Customer service	R. ____ Automotive
S. ❑ Other	19. ❑ Other	S. ____ Machinery
YOUR COMPANY'S #1 PRODUCT/SERVICE		T. ____ Marine
		U. ____ Piping and tubing
		V. ____ Pressure vessels and tanks
		W. ____ Sheet Metal
		X. ____ Structures
		Y. ____ Other
		Z. ____ Automation
		AA. ____ Robotics
		BB. ____ Computerization of welding

LAST NAME:	FIRST NAME:

8. EDUCATION LEVEL: *(only CWI, CAWI and CWE applicants are to complete the following section)*

PLEASE CHECK THE APPROPRIATE BOX BELOW :
❑ High school graduate or achieved GED certificate. CWI and CWE applicants must document five years and CAWI applicants must document two years of work experience in the Qualifying Work Experience Section below. *(Please refer to the AWS B5.1)*
❑ Did not graduate high school, but completed the 8th grade. CWI and CWE applicants must document nine years and CAWI applicants must document four years of work experience in the Qualifying Work Experience Section below. *(Please refer to the AWS B5.1)*
❑ Did not complete the 8th grade. CWI and CWE applicants must document twelve years and CAWI applicants must document six years of work experience in the Qualifying Work Experience Section below. *(Please refer to the AWS B5.1)*

Note: Applicants applying for the CWE examination must be a high school graduate or achieved a GED certificate along with the five years of work experience. You shall also complete the CWE Welding Instructor Credentials Form that is attached to this application or submit a written verification letter signed by your teaching supervisor / personnel manager. For further information regarding the CWE program, please refer to the QC5-91.

A maximum of two (2) years of post-high school education may be substituted for an equal number of years of the required five years of work experience relevant to any of the functions described in the AWS B5.1 and the AWS QC5-91 section 5.2 CWE.

❑ VoTech credits - **MUST** attach transcripts of welding related courses or diploma	Circle no. of years attended 0 1 2 3 4	Maximum one (1) year work substitution credit *only* if courses *completed* and *within* a curriculum related to welding.
❑ College credits - **MUST** attach transcripts of engineering-level courses or diploma	Circle no. of years attended 0 1 2 3 4	Maximum two (2) years work substitution credit *only* if the degree is in engineering technology, engineering, or physical science

SCWI APPLICANTS ONLY

PLEASE BE SURE TO MEET THE FOLLOWING REQUIREMENTS:
❑ High school graduate or hold a state or military approved high school equivalency diploma. *(Please refer to the AWS B5.1)*
❑ Minimum of fifteen (15) years experience in an occupational function that has a direct relationship to welded assemblies fabricated to national or international standards. *(Please refer to the AWS B5.5)*
❑ Shall have been certified as a CWI for a minimum of six (6) years.

9. QUALIFYING WORK EXPERIENCE – RESUMES NOT ACCEPTED

**** NOTE: PLEASE DUPLICATE THIS SECTION FOR EACH ADDITIONAL EMPLOYER IN ORDER TO MEET THE QUALIFYING WORK EXPERIENCE REQUIREMENTS FOR CWI/CAWI/CWE/SCWI ELIGIBILITY.**

_____ I understand that all work experience documented on this application may be verified with both past and present employers.
(Initials)

Company Name: _____ Phone: ( ) _____

Mailing Address: _____

City: _____ST/Prov.: _____Zip: _____Country: _____

Supervisor / Personnel Manager: _____ Dept/Div.: _____

Supervisor / Personnel Manager's E-mail: _____

JOB TITLE: *(only for the employer listed above)*	FROM MONTH/YEAR	TO MONTH/YEAR

LAST NAME:	FIRST NAME:

10. EMPLOYMENT VERIFICATION: *(this section to be completed by a supervisor or personnel manager from the most recent employer)*

** NOTE: SELF-EMPLOYED OR CONTRACT APPLICANTS MUST SUBSTITUTE THIS SECTION WITH TWO LETTERS OF REFERENCE ON COMPANY LETTERHEAD FROM SEPARATE CLIENTS ATTESTING TO THE NATURE OF WORK ASSIGNMENTS DURING THE PERIOD OF PERFORMANCE. IF THE EMPLOYEE IS NO LONGER IN BUSINESS, PLEASE INCLUDE A COPY OF THE W2 FORM.

Employee's Last Name: _____ First Name: _____ MI: _____

Employer Name: _____Phone: ( ) _____

Employer Address: _____

City: _____ ST/Prov.: _____ Zip: _____ Country: _____

Supervisor / Personnel Manager: _____ Dept/Div: _____

Supervisor / Personnel Manager's Email: _____

You verify that _____ is or was an employee at your company and conducts the duties during the employment periods stated in this application? ❑ NO ❑ YES

Name: _____ Title: _____

Signature: _____ Date: _____

11. TESTIMONIAL: *(this section must be notarized)*

I hereby certify I have read the requirements contained in AWS QC1, *Standard for AWS Certification of Welding Inspectors.* Further, I agree to comply with the existing requirements and any subsequent requirements that may be instituted by AWS. I certify the information I have included in this application is true. I understand any false statements will nullify this application. I further understand that if any information is incomplete or missing, my application will not be processed until all documentation (except the Visual Acuity Record) is complete. Therefore, the examination will not be scheduled until all obligations are fulfilled. I agree to comply with the provisions set forth in AWS QC1 concerning the administration of my examination and certification. Upon obtaining my certification, I give AWS the right to reveal my certification status as it relates to my validity and expiration date only. Also, if applying for or when achieving a CAWI certification, I am aware that the CAWI certification is only valid for three years and is not eligible for renewal.

Applicant's Signature _____ Date: _____

THE FOLLOWING IS TO BE COMPLETED BY THE NOTARY PUBLIC

Sworn to and subscribed before me this _____ day of_____ 200___.

My commission expires _____ Notary Public Signature _____ *(seal and/or stamp is REQUIRED)*

BODY OF KNOWLEDGE

AWS Certified Welding Inspector

The following is an **approximate** breakdown of the examination categories and the number of questions drawn from each subject area.

PART A: FUNDAMENTALS	
Subject	***Percentage***
Welding Processes	10%
Heat Control & Metallurgy (carbon and low-alloy steel)	6%
Weld Examination	9%
Welding Performance	9%
Definitions and Terminology	12%
Symbols – Welding and NDE	10%
Test Methods – NDE	8%
Reports and Records	6%
Duties and Responsibilities	4%
Safety	5%
Destructive Tests	4%
Cutting	3%
Brazing	2%
Soldering	1%

PART B: PRACTICAL	
Subject	***Percentage***
Procedure and Welder Qualifications	30%
Mechanical Test and Properties	10%
Welding Inspection and Flaws	36%
NDE	10%
Utilization of Specification and Drawings	10%

PART C: CODE APPLICATIONS	
Subject	***Percentage***
Materials and Design	10%
Fabrication	30%
Inspection	25%
Qualification	30%

CODE SUBJECTS AVAILABLE
AWS D1.1/D1.1M:2002, 2004 or 2006 Edition
API-1104:2005 (20th Edition)
AWS D15.1/D15.1M:1993 Edition
AWS D1.5/D1.5M:2001 Edition

AWS – RECOMMENDED SELF-STUDY Examination Preparatory Material

Note: D1.1:2002, 2004 or 2006 editions may be used as study material.

AWS PUBLICATIONS	ORDER NUMBER
Certification Manual for Welding Inspectors	CM:2000
Welding Inspection Handbook	WI: 2000
* *D1.1/D1.1M Structural Welding Code-Steel*	D1.1M
* *D1.1 Code Clinic Reference Manual*	CC-RM
* *Welding Inspection Technology*	WIT-T:2000
* *Welding Inspection Technology (Workbook)*	WIT-W-99
* *Standard Welding Terms and Definitions*	A3.0:2001
* *Standard Welding Symbols*	A2.4-98
* *Visual Inspection Workshop Reference Manual*	VIW-M
* *API 1104 Code Clinic Reference Manual*	API-M
* *Guide for the Nondestructive Examination of Welds*	B1.10:1999

* = ***Books are provided to participants at the AWS Seminars***

OTHER RECOMMENDATIONS	ORDER NUMBER
AWS Welding Handbook Series	WHB-ALL
Guide for the Visual Examination of Welds	B1.11: 2000
Safety in Welding, Cutting and Allied Processes	Z49.1: 1999

TO PURCHASE ANY OF THE PUBLICATIONS NOTED ABOVE:

- Contact WEX at 888-WELDING or 305-824-1177
- Or visit the website at www.awspubs.com

WELDING INSPECTION TECHNOLOGY Sample CWI Fundamentals Examination

FIFTH EDITION

Published By
American Welding Society
Education Services

American Welding Society

F1 Which of the following metals cannot be efficiently cut with OFC?

a. high-carbon steel
b. low-carbon steel
c. stainless steel
d. cast iron
e. tempered steel

F2 Electrical conductivity of a part is the primary requirement for which NDE method?

a. ET
b. UT
c. PT
d. RT
e. VT

F3 The melting point of carbon steel is approximately:

a. 2250°F
b. 2375°F
c. 2780°F
d. 3005°F
e. 3333°F

F4 Decibel is a term associated with which NDE method?

a. UT
b. RT
c. MT
d. PT
e. ET

F5 Which GMAW metal transfer mode results in the least amount of penetration?

a. globular
b. short circuiting
c. spray
d. pulsed spray
e. globular spray

F6 Which of the following gas(es) is commonly used as a shielding gas for GTAW?

a. argon
b. carbon dioxide
c. oxygen
d. argon/carbon dioxide
e. Tri-mix

F7 After a rejected weld has been repaired, reinspected and found to be acceptable, the welding inspector should:

a. change the original inspection report to indicate the part's acceptance
b. mark directly on the part
c. fill out a second inspection report
d. tell the foreman to have the part moved to its next operation
e. no further action is required

F8 When a metal is alloyed, how are the atoms of the alloy incorporated into the original metal lattice structure?

a. by inclusion or exclusion
b. substitutionally or interstitially
c. by diffusion
d. by becoming martensitic
e. by casting

F9 A wire IQI is used in which NDE method?

a. UT
b. ET
c. RT
d. MT
e. PT

F10 In general, which of the following is not commonly used as a semiautomatic process?

a. GMAW
b. FCAW
c. SMAW
d. SAW
e. MIG

F11 The performance of which of the following test methods is least affected by high part temperatures?

a. ET
b. RT
c. PT
d. UT
e. VT

F12 Crater cracks are most often the result of:

a. improper technique
b. improper filler metal
c. improper base metal
d. trapped slag
e. trapped hydrogen

F13 The tail of a welding symbol should not be used for:

a. denoting welding process requirements
b. denoting welding procedure requirements
c. denoting welding electrode requirements
d. denoting welding specification requirements
e. denoting groove angle

F14 During tempering, as the temperature increases, which of the following are correct?

a. hardness increases
b. hardness decreases
c. elongation decreases
d. strength increases
e. ductility decreases

F15 In GMAW, the distance from the end of the contact tube to the arc is:

a. arc length
b. electrode extension
c. stickout
d. stand off
e. work angle

F16 Of the following, which is not a type of metal transfer in GMAW?

a. spray
b. short circuiting
c. globular
d. pulsed arc
e. open circuiting

F17 Ultraviolet light may be used with which NDE methods?

a. VT and UT
b. PT and UT
c. MT and PT
d. RT and UT
e. ET and MT

F18 The technique which does not aid in reducing residual stress is:

a. peening
b. vibratory stress relief
c. thermal stress relief
d. external restraint
e. preheating

F19 Which of the following may not be detected with VT?

a. large surface crack
b. undercut
c. overlap
d. underfill
e. Lamellar tear

F20 Heat treatment conditions can be determined using which of the following?

a. MT
b. PT
c. ET
d. RT
e. LT

F21 Of the following tests, which can be used for the actual determination of a material's toughness?

a. Charpy test
b. MT
c. chemical analysis
d. tensile test
e. bend test

F22 Which of the following elements are commonly used as alloying elements with tungsten to produce GTAW electrodes?

a. cesium
b. thorium
c. columbium
d. vanadium
e. chromium

F23 For single bevel-groove weld symbols, the line of the AWS weld symbol running perpendicular to the reference line is always drawn on which side of the weld symbol?

a. on the right
b. on the left
c. on either side, depending on company policy
d. on the side in which the straight side actually appears in the joint
e. does not matter

F24 The portion of the groove face within the joint root is called:

a. weld interface
b. faying surface
c. groove weld edge
d. root face
e. groove angle

F25 Which of the following are common cases of undercut when using SMAW?

a. weld current too high
b. improper electrode manipulation
c. welding electrode too large
d. improper electrode angle
e. all of the above

F26 NDE technicians are usually qualified in accordance with the requirements of:

a. AWS D1.1
b. API 1104
c. ASNT SNT-TC-1A
d. ASME Section VIII
e. ASME Section IX

F27 Which of the factors listed below has the least amount of effect on the residual stress and distortion that results from welding?

a. heat input
b. phase changes
c. welding position
d. tensile strength
e. coefficient of thermal expansion

F28 Capillary action plays a role in which NDE method?

a. ET
b. UT
c. RT
d. PT
e. MT

F29 If a welder is continually turning out rejectable work, the welding inspector should:

a. inspect his work more critically
b. ask that the welder be fired
c. require that the welder be retested for qualification
d instruct the welder in the proper techniques
e. ask that the welder use another process

F30 Which of the following tests would be least effective for judging the soundness of a weld in the as-welded condition?

a. nick break
b. side bend
c. face bend
d. radiography
e. straight beam UT

F31 Arc blow can not be caused by:

a. magnetic field distortion
b. improper worklead (ground) location
c. welding at the end of a joint
d. welding in corners
e. welding on AC

F32 Which of the following shielding gases is used for GMAW spray transfer on steel?

a. carbon dioxide—100%
b. argon—100%
c. helium—100%
d. oxygen—2%, argon—98%
e. argon 75%, carbon dioxide—25%

F33 Developing is one of the steps in which NDE method?

a. UT and ET
b. RT and PT
c. PT and MT
d. MT and ET
e. VT and PT

F34 Which discontinuity below will provide the sharpest MT indication?

a. surface porosity
b. surface crack
c. subsurface porosity
d. subsurface crack
e. indications will be identical for all of the above

F35 In SMAW, an increase in arc length results in:

a. increased current; increased voltage
b. decreased current; increased voltage
c. increased heat input; decreased voltage
d. decreased current; decreased voltage
e. decreased current; increased heat input

F36 Weld inspection reports should always:

a. be completed in ink, or typewritten and signed
b. be done in pencil so mistakes can be easily corrected
c. be filled out only if the weld is rejected
d. retyped by a clerk so that everything is readable
e. include the welder's identification

F37 The ability to be cyclically loaded without failing is related to which of the following properties of a metal?

a. hardness
b. toughness
c. tensile strength
d. fatigue strength
e. ductility

F38 In GMAW, the type of metal transfer requiring a special power source is:

a. spray
b. globular
c. pulsed arc
d. short circuiting
e. open arc

F39 Which of the following is truly a volumetric test method?

a. RT
b. UT
c. VT
d. MT
e. PT

F40 Use of preheat will result in:

a. a faster cooling rate and wider heat-affected zone
b. a faster cooling rate and narrower heat-affected zone
c. a slower cooling rate and wider heat-affected zone
d. a slower cooling rate and narrower heat-affected zone
e. none of the above

F41 Which of the following methods is most likely to use a transducer to scan for flaws?

a. RT
b. MT
c. UT
d. PT
e. VT

F42 For plain carbon steels, how are hardness and tensile strength related?

a. increase hardness; decrease tensile strength
b. increase hardness; increase tensile strength
c. decrease hardness; increase tensile strength
d. hardness and tensile strength can both be increased by tempering
e. hardness and strength are not related

F43 In GMAW, the welding variable controlled by the wire feed speed is:

a. arc length
b. voltage
c. current
d. stickout
e. travel speed

F44 The welding variables used to calculate heat input are:

a. voltage and current
b. current and travel speed
c. voltage, current and travel speed
d. travel speed, preheat temperature and voltage
e. voltage, current and preheat temperature

F45 As the temperature of the base metal is increased:

a. impact strength decreases
b. tensile strength decreases
c. ductility decreases
d. hardness increases
e. tensile strength increases

F46 During RT, which of the following provides the best protection from radiation for a given thickness?

a. lead shielding
b. steel shielding
c. concrete shielding
d. copper shielding
e. wood shielding

F47 A weld inspection plan should be developed:

a. before welding begins
b. during welding
c. after welding is completed
d. before shipping the work
e. only when there is a problem

F48 If the weld symbol straddles the reference line, it means:

a. weld both sides
b. weld arrow side first
c. weld other side first
d. weld has no side significance
e. the symbol was drawn incorrectly

F49 Which of the following represents the proper eye protection for SAW?

a. a welding helmet with filter lens of the appropriate shade
b. clear safety glasses
c. no eye protection is required because there is no visible arc
d. tinted safety glasses
e. a full face shield with a shade #5 minimum

F50 An E7018 SMAW electrode exhibits which of the following characteristics?

a. low hydrogen; use on AC only; iron powder
b. low hydrogen; use on AC and DCEN
c. low hydrogen; AC and DCEP; iron powder
d. rutile; DCEP
e. rutile; DCEP; iron powder

F51 Piezoelectricity is a material property used by which NDE method?

a. UT
b. ET
c. RT
d. MT
e. PT

F52 A thermal treatment that follows quenching and restores some of the metal's ductility is referred to as:

a. stress relief
b. tempering
c. hardening
d. normalizing
e. postheat

F53 Which of these methods is most often used to eliminate the high residual stress created by welding?

a. prebending
b. shot blasting
c. quenching rapidly after welding
d. postweld heat treating
e. preheating

F54 The physical principle that permits the migration of liquid penetrant into very fine surface discontinuities is:

a. magnetic permeability
b. optical fluorescence
c. capillary action
d. emulsification
e. solubility

F55 The process whereby a large gap is filled with braze material without the help of capillary action is:

a. torch brazing
b. arc brazing
c. braze welding
d. dip brazing
e. flow brazing

F56 Which of the following contains ferrous base metal specifications?

a. AWS D1.2
b. ASME Section II, Part C
c. AWS A5.1
d. ASME Section V
e. ASME Section II, Part A

F57 Which of the following is considered to be the most portable method of magnetization when conducting a magnetic particle test?

a. AC coil
b. AC yoke
c. DC coil
d. DC prod
e. Head Shot

F58 Advantages of MT include:

a. the detection of surface flaws
b. both AC and DC methods
c. the detection of surface flaws tightly closed by carbon, slag or contaminants
d. the fact that it is faster than PT
e. all of the above

F59 In general, an increase in the carbon equivalent of a carbon steel will result in an increase in its:

a. ductility
b. hardness
c. defects
d. toughness
e. all of the above

F60 A welding process commonly used to join light gage stainless steel tubing for critical applications is:

a. SMAW
b. GMAW
c. GTAW
d. OFW
e. FCAW

F61 Hydrogen in the molten weld metal can cause:

a. undercut and overlap
b. cracking and porosity
c. incomplete penetration and incomplete fusion
d. porosity and slag inclusions
e. hydrogen will diffuse during welding and will not cause problems

F62 Which of the following results from improper termination of the SMAW electrode and shrinking of the molten weld pool during welding?

a. porosity
b. slag inclusions
c. delayed cracking
d. crater cracking
e incomplete fusion

F63 Entrapped slag can result when using all of the following except:

a. SMAW
b. SAW
c. FCAW
d. ESW
e. GMAW

F64 The material property that best describes its ability to withstand a static load is:

a. hardness
b toughness
c. tensile strength
d fatigue strength
e. torsional strength

F65 The presence of paint on the surface of a part will most greatly affect the results of which NDE method?

a. PT and MT
b. RT and UT
c. MT and ET
d. UT and ET
e. ET and VT

F66 If no information appears to the left of a groove weld symbol, this means:

a. no weld is required on that side
b. the weld is to be complete joint penetration
c. the weld is to be continuous for the entire length of the joint
d. bevelling is not required
e. weld size is to be determined by the welder

F67 Which of the following is not easily detected using RT that is perpendicular to the weld center line?

a. throat crack
b. porosity
c. side wall incomplete fusion at a bevel angle of 35°
d. a crack with its depth parallel to radiation beam
e. incomplete joint penetration

F68 Dwell time is a term associated with which NDE method?

a. MT
b. PT
c. RT
d. ET
e. UT

F69 The material property expressed in terms of an endurance limit is:

a. fatigue strength
b. toughness
c. tensile strength
d. ductility
e. hardness

F70 Fracture toughness results will often be expressed in terms of:

a. breaking energy
b. tensile strength
c. percent elongation
d. endurance limit
e. reduction of area

F71 Shielding of the molten pool in OFW is accomplished by:

a. a granular flux
b. a chemical reaction
c. an inert gas
d. a vacuum chamber
e. a flux paste

F72 The welding inspector is usually not responsible for which of the following?

a. checking for proper electrode storage
b. verification of a welder's qualification
c. witnessing all repairs
d. reinspecting repairs
e. checking fit up

F73 The last digit of an SMAW electrode designation is an indication of:

a. tensile strength of the weld deposit
b. position the welder is qualified to weld in
c. Operating characteristics
d. impact strength of the weld deposit
e. position suitable for electrode use

F74 ET can be used to detect which of the following?

a. a material's conductivity
b. a material's hardness
c. a thin material's thickness
d. a material's heat treatment
e. all of the above

F75 For an SMAW electrode designation **E60X3** the "X" refers to:

a. the tensile strength of the weld deposit
b. the position in which the electrode can be used
c. the type of coating
d. the recommended type of current
e. flux chemistry

F76 The property of a material that best relates to its resistance to impact loading is:

a. endurance limit
b. fatigue strength
c. fracture toughness
d. tensile strength
e. ductility

F77 Of the following discontinuities, which is most likely to be a flaw caused during the manufacture of steel?

a. porosity
b. lamination
c. undercut
d. crack
e. inclusion slag

F78 Which of the following is considered to be an advantage of VT?

a. discontinuities can be located and noted when they occur
b. it is capable of detecting subsurface discontinuities
c. welders can accept their own work
d. equipment can be expensive
e. it can determine material strength

F79 Which of the following is considered to be part of the welding inspector's responsibility to the public?

a. undertaking only those assignments for which the inspector is qualified
b. making public statements as to the quality of a weldment
c. signing for all inspections on the job
d. reporting all discontinuities
e. verify conformance based on past experience

F80 Which of the following processes is performed primarily in the flat and horizontal positions?

a. SAW
b. OAW
c. GTAW
d. GMAW-S
e. SW

F81 A groove weld symbol with no information appearing to the right means:

a. the weld is to be complete joint penetration
b. no weld is required on that side
c. the weld is to be continuous for the entire joint length
d. no weld joint preparation is required
e. weld length can be determined by the welder

F82 The welding process that requires a tubular electrode is:

a. SMAW
b. GMAW
c. FCAW
d. SAW
e. ESW

F83 The property relating to a metal's resistance to indentation is:

a. tensile strength
b. ductility
c. hardness
d. toughness
e. fatigue strength

F84 LT is the abbreviation for:

a. leak testing
b. liquid penetrant testing
c. liquid test inspection
d. lithium testing
e. lender test method

F85 Filler metal specifications are found in which of the following documents?

a. AWS A5.1 through A5.30
b. ASME Section II, Part A
c. AWS A3.0
d. AWS A2.4
e. AWS D1.1 Section 2

F86 The flux covering on an SMAW electrode provides which of the following?

a. gas shielding for the molten pool
b. arc stabilization
c. alloying
d. deoxidation
e. all of the above

F87 When a weld joint preparation is found to be defective, the inspector should:

a. allow welding to proceed if he feels that the welder can produce a satisfactory weld
b. instruct the welder in how to overcome the problem
c. report the deficiency to the proper supervisory personnel
d. require that the parts be disassembled and properly assembled
e. none of the above

F88 The orientation of the probing energy source with respect to that of a flaw is considered to be a significant variable for which NDE method?

a. RT
b. UT
c. ET
d. MT
e. all of the above

F89 Information that appears to the left of the weld symbol refers to:

a. the weld length
b. the weld size
c. the electrode size
d. the number of passes required
e. none of the above

F90 Which process uses a granular flux that can be manually added to the weld pool?

a. SMAW
b. GTAW
c. ESW
d. SW
e. FCAW

F91 Of those microstructural constituents listed below, the hardest is:

a. martensite
b. ferrite
c. bainite
d. austenite
e. pearlite

F92 In radiography, the image on the film of a completely through-cracked weld will:

a. appear as a well-defined, low density, lightly shaded, sharp line
b. appear as a well-defined, high density, darkly shaded, sharp line
c. appear as a row of low density light spots or dots
d. appear as a row of high density dark spots or dots
e. appear as a white line

F93 A material's ductility is commonly expressed in terms of:

a. percent elongation and reduction of area
b. width and thickness
c. tensile strength and yield strength
d. toughness
e. fatigue

F94 Who is responsible for verifying welding procedures have been properly qualified?

a. independent test lab
b. contractor
c. welding inspector
d. architect
e. engineer

F95 What MT technique could be used for the discovery of longitudinal flaws?

a. coil shot
b. circular magnetization
c. longitudinal magnetization
d. parallel magnetism
e. using a central conductor

F96 Which code gives prequalified status to certain weld joint configurations?

a. API 1104
b. AWS D1.1
c. AWS D17.1
d. ANSI B31.1
e. AWS B2.1

F97 Information that appears to the right of the weld symbol refers to the:
- a. process to be used
- b. type of electrode to be used
- c. length of weld required
- d. size of weld required
- e. required joint configuration

F98 When a clerical mistake is made while completing an inspection report, the inspector should:
- a. erase the error and fill in the correct information
- b. cross out the error and supply the proper information
- c. line out the error with a single line, supply the proper information, and initial and date the occurrence in ink
- d. attach a note to the report explaining the reason for the change
- e. erase the error or use white out, initial, and date the occurrence in black ink

F99 The rapid quenching of a high carbon steel from the austenitizing range will result in the formation of:
- a. pearlite
- b. martensite
- c. cementite
- d. ferrite
- e. austenite

F100 When an austenitized carbon steel is cooled to room temperature, an increase in the cooling rate will result in:
- a. an increase in hardness and a decrease in ductility
- b. an increase in tensile strength and a decrease in hardness
- c. a decrease in tensile strength and an increase in hardness
- d. an increase in ductility and a decrease in hardness
- e. a decrease in hardness and an increase in ductility

F101 Which of the following is least affected by the surface finish of the specimen?
- a. tensile strength
- b. fatigue strength
- c. impact strength
- d. nick break test
- e. macroetch

F102 The heat treatment in which a carbon steel's temperature is raised to the austenitizing range, held for a prescribed time and then allowed to cool to room temperature while remaining in the furnace is referred to as:
- a. stress relief
- b. annealing
- c. normalizing
- d. tempering
- e. austenitizing

F103 In which direction does a rolled plate of carbon steel usually exhibit its least amount of ductility?
- a. parallel to the rolling direction
- b. transverse to the rolling direction
- c. in the through thickness direction
- d. in the direction of welding
- e. rolling direction has no significance regarding ductility

F104 When a weld has been rejected by a qualified NDE technician, the welding inspector should:
- a. review the test results and maintain the test record
- b. reinspect to verify the defect
- c. accept the weld if its visual appearance is in compliance with the applicable code or specification
- d. require another inspection by a third party
- e. accept the weld since it is in a low stress region

F105 If equal thicknesses of steel, cast iron, aluminum, lead, and copper are radiographed using the same exposure conditions, which material will result in the darkest radiograph?
- a. lead
- b. steel
- c. aluminum
- d. copper
- e. cast iron

F106 The welding process that uses a nonconsumable electrode is:
- a. GMAW
- b. SAW
- c. GTAW
- d. FCAW
- e. SMAW

F107 The heat treatment in which the metal's temperature is raised to the austenitizing range, held for a prescribed time and then allowed to cool to room temperature in still air is referred to as:
- a. austenitizing
- b. normalizing
- c. annealing
- d. quenching
- e. tempering

F108 In a guided bend test, the bend radius is:
- a. always 5 in.
- b. as specified in the appropriate code or specification
- c. 0.5 in.
- d. 0.65 in.
- e. as stated on the MTR

F109 An E71T-1 electrode designation is for which welding process?
a. PAW
b. FCAW
c. SMAW
d. GMAW
e. SAW

F110 The AWS Certified Welding Inspector is responsible for:
a. welding
b. performing PT
c. positively identifying base materials
d. supervising welding
e. determining the disposition of a radiographed part

F111 A break in the arrow line of a welding symbol has what significance?
a. Welding must first be done on the arrow side
b. Welding must first be done on the other side
c. Welding must be done alternately on both the arrow and the other sides
d. The broken arrow line segment points to that member which receives preparation
e. an intermittent weld is required

F112 It is discovered that a GMAW mild steel weld was produced with a shielding gas containing excess moisture. To determine the extent of the surface and subsurface porosity that resulted, which NDE method would be most effective?
a. MT
b. RT
c. VT
d. PT
e. ET

F113 Which welding process utilizes a vertical joint orientation with welding occurring in the flat position?
a. ESW
b. SAW
c. SMAW
d. FCAW
e. OFW

F114 The heat treatment for carbon steels in which the metal's temperature is raised to just below the lower transformation temperature and held for a prescribed time before allowing it to cool at a controlled rate is referred to as:
a. tempering
b. austenitizing
c. stress relieving
d. normalizing
e. preheating

F115 The position on a metal's stress-strain curve referring to its change in behavior from elastic to plastic is the:

a. yield point
b. modulus of elasticity
c. endurance limit
d. transformation temperature
e. Young's Modulus

F116 Low-hydrogen electrodes can be properly identified by which digit of a classification number?

a. first digit
b. second digit
c. first and second together
d. second to last digit
e. last digit

F117 All welding symbol information referring to the arrow side of the joint is found:

a. in the tail
b. above the reference line
c. below the reference line
d. in a note
e. to the left of the weld symbol

F118 The marking of a rejectable weld should:

a. be clear and understandable to all involved
b. be made with a steel impression stamp
c. note the proper repair procedure
d. always be in red
e. always include the welder's identification

F119 MT can be used effectively to inspect which of the following metals?

a. welds on A36 steel
b. steel welds on stainless steel plate
c. welds on aluminum
d. Welds on all alloy materials
e. materials properly qualified for use with E308 electrodes

F120 Of the welding processes listed below, the one most commonly having the highest deposition rate is:

a. OAW
b. FCAW
c. SAW
d. SMAW
e. GMAW

F121 The use of preheat on a medium carbon steel weld test plate will perform all of the following except:

a. reduce distortion
b. reduce the possibility of hydrogen cracking
c. result in the formation of martensite
d. produce a wide heat-affected zone
e. diffuse hydrogen

F122 The tensile test can be used to provide values for which of the following?

a. yield point
b. ultimate tensile strength
c. modulus of elasticity
d. elastic limit
e. all of the above

F123 Which of the following is not an acceptable method for control of raw materials?

a. color coding
b. alpha-numeric coding
c. first in, first out
d. location segregation
e. bar coding

F124 In what document are the duties and responsibilities of a CWI described?:

a. AWS D1.1
b. AWS A3.0
c ANSI Z49.1
d. AWS QC-1
e. AWS QC-7

F125 All welding symbols require which of the following basic elements in their construction?

a. reference line, arrow, and tail
b. reference line and arrow
c reference line, arrow, and weld symbol
d. reference line, arrow, weld symbol, dimensions, and supplementary data
e. reference line only

F126 The size of the weld represented in Figure 1:

a. is not important
b. cannot be determined directly from the symbol
c. can be determined from the symbol
d. is not specified therefore may be determined by the welder
e. must be found in the WPS

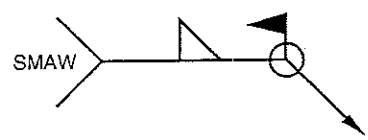


Figure 1

F127 Welding symbol information provided in Figure 1 requires:
- a. field welding
- b. weld-all-around
- c. a fillet weld
- d. the use of shielded metal arc welding
- e. all of the above

F128 A SMAW weld was produced in which the welder failed to properly clean between passes in a multipass weld. Which nondestructive test would best reveal the flaws that may be present in the completed weld?
- a. RT
- b. VT
- c. MT
- d. PT
- e. ET

F129 SMAW is typically used in which type of application?
- a. semiautomatic
- b. machine
- c. manual
- d. automatic
- e. mechanical

F130 What position is depicted in Figure 2?
- a. 6G
- b. 5G
- c. 6F
- d. 6GR
- e. 5GR

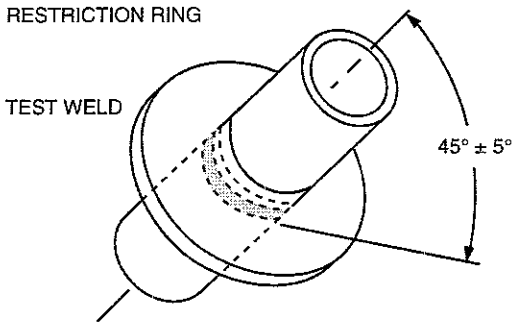


Figure 2

F131 Using the appropriate conversion factor provided in the chart on page 41, determine the approximate diameter in inches for an electrode that measures 1.2 mm.
- a. 0.047 in.
- b. 4.7 in.
- c. 0.0047 in.
- d. 0.47 in.
- e. 47.2 in.

F132 Underbead cracking is primarily caused by:
- a. a source of hydrogen
- b. restraint
- c. excessive preheat
- d. fatigue
- e. excessive loading

F133 Which of the following is a correct statement about brazing?
- a. the base metal is not melted
- b. the filler metal melts at a temperature below 800°F
- c. it must be done in an inert gas atmosphere
- d. in order to achieve capillary action large root opening is required
- e. inert gases may be substituted for oxygen

F134 Which of the following welding processes commonly use a constant current power source?
- a. GMAW and FCAW
- b. SMAW and GTAW
- c. GTAW and GMAW
- d. FCAW and SMAW
- e. SAW and SMAW

F135 The first operation required by the symbol in Figure 3 is:
- a. ultrasonic inspection of the base metal
- b. visual inspection of joint preparation
- c. welding a V-groove from the other-side of the joint
- d. welding a backing weld from the arrow-side of the joint
- e. backgouging and back welding from the arrow-side of the joint

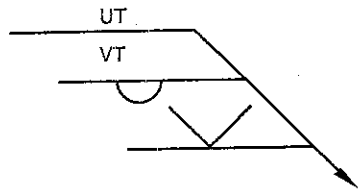


Figure 3

F136 For Figure 3, ultrasonic inspection is to be performed:
- a. on the back weld only
- b. on the entire length of the other side weld
- c. on 10% of the weld length
- d. from the arrow side
- e. on the single V groove, from the arrow side

F137 Which of the following discontinuities are associated with shrinkage stresses in the through thickness direction of thick plate?
- a. crater cracks
- b. lamellar tears
- c. toe cracks
- d. root cracks
- e. none of the above

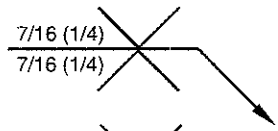
F138 Which of the welding techniques below describes a welding process in which the filler metal feeding is machine operated while the joint travel speed and guidance are the responsibility of the welder?
- a. semiautomatic
- b. manual
- c. machine
- d. automatic
- e. mechanized

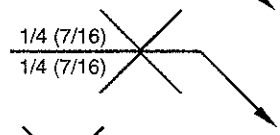
F139 The welding symbol shown in Figure 4 depicts:

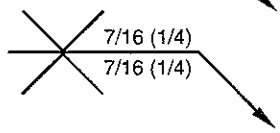
a. a backing weld other-side followed by a V-groove weld arrow-side
b. a V-groove weld arrow-side followed by a back weld other-side
c. a V-groove weld arrow-side with melt-through
d. a bevel groove weld made one-half the way around the diameter of a pipe
e. a V-groove weld arrow-side with the root finished to a convex contour

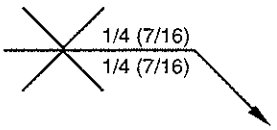
Figure 4

F140 Which of the following symbols correctly describes the joint configuration shown in Figure 5?

a.


b.


c.


d.


e. none of the above

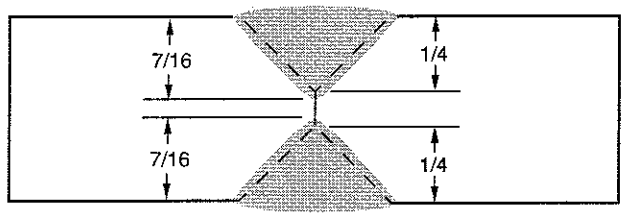


Figure 5

F141 The width of the cut produced during a cutting process is referred to as:

a. root opening
b. kerf
c. bevel
d. bevel angle
e. chamfer

F142 For the 2G position in pipe welding:

a. the axis of the pipe is vertical and the plane of the weld is horizontal
b. the axis of the pipe is horizontal and the plane of the weld is vertical
c. the pipe is not fixed
d. the axis of the pipe and the plane of the weld are at 45° angles with the vertical plane
e. the axis of the pipe is horizontal and the pipe is rotated

F143 During operation, the heat for electroslag welding is provided by:
a. the arc
b. the electrical resistance heating of the molten slag
c. the consumable guide tube melting
d. current passing through the base metal
e. current passing through the filler wire

F144 Using the appropriate conversion factor provided in the chart on page 41, determine the approximate cubic feet per hour (cfh) for a flow rate of 22 liters per minute.
a. 466 cfh
b. 46.6 cfh
c. 10.38 cfh
d. 103.8 cfh
e. 4.66 cfh

F145 It is suspected that a GMAW weld was produced in an area where there was an excessive draft. Which nondestructive test would best reveal the internal discontinuities which may have resulted?
a. PT
b. MT
c. RT
d. UT
e. none of the above

F146 The size of the arrow side weld in Figure 6 is:
a. 1/4 in.
b. 5/16 in.
c. 1 in.
d. 2 in.
e. 1 in. deposited every 6 in.

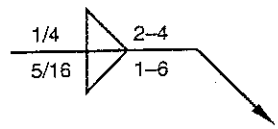


Figure 6

F147 The length of the other side weld in Figure 6 is:
a. 1 in.
b. 6 in.s
c. 2 in.
d. 4 in.
e. continuous down the length of the joint

F148 The pitch of the other side weld in Figure 6 is:
a. 1/4 in.
b. 4 in.
c. 5/16 in.
d. 1 in.
e. 6 in.

F149 If a contour symbol is used but the finishing method is not specified on the welding symbol:
- a. it is the inspector's choice
- b. it is the fabricator's choice
- c. the desired contour must be as-welded
- d. it should be found in the code specified
- e. it is the welder's choice

F150 In order to learn the exact location of a subsurface flaw in three directions, the best NDE method would be:
- a. RT
- b. MT
- c. PT
- d. UT
- e. VT

F151 The surface of a member included in the groove of a weldment best describes:
- a. root opening
- b. groove angle
- c. weld interface
- d. groove face
- e. none of the above

F152 Crater cracks can be the result of:
- a. poor welding technique
- b. abrupt termination of welding
- c. shrinkage of the molten pool
- d. underfill of the crater
- e. all of the above

F153 Figure 7 depicts which welding process?
- a. SAW
- b. SMAW
- c. PAW
- d. GMAW
- e. FCAW

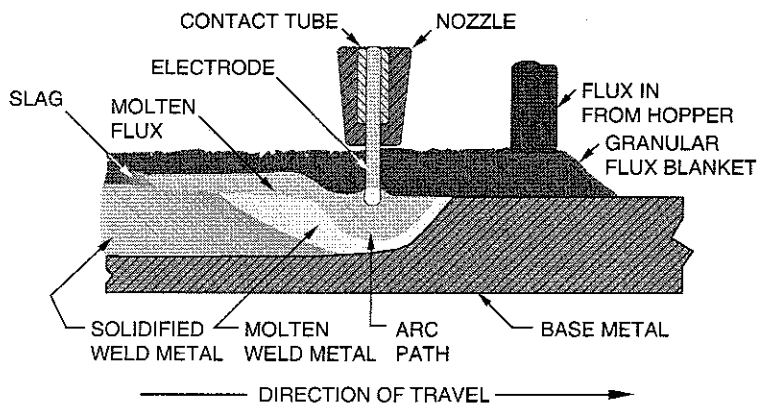


Figure 7

F154 The boundaries indicated by "A" in Figure 8 are:
- a. fusion line
- b. depth of fusion
- c. weld interface
- d. fusion face
- e. none of the above

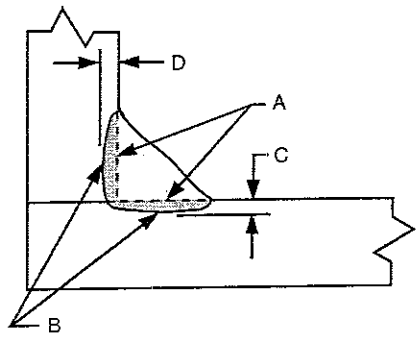


Figure 8

F155 The dimension "D" in Figure 8 is referred to as:
- a. fusion face
- b. fusion zone
- c. depth of fusion
- d. weld interface
- e. fusion line

F156 The weld interface in Figure 8 is indicated by:
- a. "A"
- b. "B"
- c. "C"
- d. "D"
- e. none of the above

F157 Using the appropriate conversion factor provided in the chart on page 41, determine the approximate degrees Celsius for a preheat temperature of 225°F.
- a. 225°C
- b. 107°C
- c. 437°C
- d. 10.7°C
- e. 1.07°C

F158 Which of the following welds is not considered applicable for a butt joint?
- a. V-groove
- b. plug
- c. edge-flange
- d. U-groove
- e. J-groove

F159 The dimension "A" in Figure 9 refers to:
- a. root penetration
- b. weld penetration
- c. depth of fusion
- d. joint penetration
- e. side wall penetration

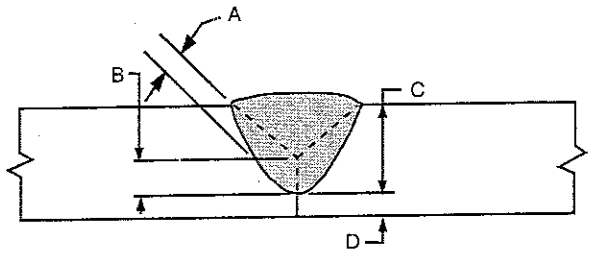


Figure 9

F160 The dimension "C" in Figure 9 identifies:
- a. joint penetration and weld size
- b. weld size and root penetration
- c. depth of fusion
- d. complete joint penetration
- e. incomplete joint penetration

F161 If the groove weld in Figure 9 has been properly welded, the dimension "D" is referred to as:
- a. underfill because the weld is left unfilled
- b. lack of penetration because weld size is inadequate
- c. partial joint penetration because weld size is indicated
- d. complete joint penetration because the joint is filled
- e. incomplete joint penetration because the joint should have been filled

F162 Which of the following is not a type of weld joint?
- a. lap
- b. T-
- c. fillet
- d. butt
- e. edge

F163 When using SMAW, wet electrodes will most likely cause:
- a. undercut
- b. overlap
- c. underfill
- d. porosity
- e. all of the above

F164 Which of the following is considered to be an acceptable way to provide backing for a V- groove weld in a carbon steel butt joint?
- a. copper backing bar
- b. ceramic backing
- c. flux backing
- d. backing weld
- e. all of the above

F165 A welder deposits an average of 12 pounds of weld metal per hour. Using the appropriate conversion factor provided in the chart on page 41, determine the approximate kilograms of weld metal that will be deposited in 6 hours of continuous welding.
- a. 5 kg
- b. 33 kg
- c. 6 kg
- d. 26 kg
- e. 37 kg

F166 A single-wire, submerged arc welding machine is operating at 32 volts, 600 amps, and is traveling at 8 inches per minute. Using the formula provided on pages 40 and 41, what is the heat input for this situation?

$$\text{Heat input} = \text{J/in.} \qquad \text{J/in.} = \frac{V \times A \times 60}{\text{Travel Speed} - (\text{ipm})}$$

a. 2,400 J/in.
b. 1,152,000 J/in.
c. 1.44×10^5 J/in.
d. 110,000 J/in.
e. 14,400 J/in.

F167 If an MT indication is noted at the toe of a fillet weld that exhibits an excessively convex profile, what is the appropriate action?

a. ignore it, since it is a nonrelevant indication
b. reject the weld
c. correct the excess convexity and retest
d. accept the weld
e. none of the above

F168 The pipe welding test position in which the axis of the pipe is horizontal and the pipe is rotated so that welding takes place at or near the top is designated as:

a. 2G
b. 2F
c. 1G
d. 3G
e. 6GR

F169 The most efficient NDE method for discovery of undercut on the face of a weld is:

a. VT
b. RT
c. UT
d. MT
e. PT

F170 The design strength of a fillet weld is always based on the throat dimension because:

a. it has a columnar microstructure, which is more prone to cracking
b. it is the shortest failure path through the weld
c. it is the location of most defects
d. the design calculations cannot be checked
e. it is a theory of failure that cannot be supported by actual laboratory testing

F171 Arc strikes are discontinuities most commonly associated with:
- a. ESW
- b. SAW
- c. SMAW
- d. OAW
- e. GMAW

F172 Double-groove welds in butt joints always require:
- a. backgouging
- b. special welding processes
- c. high deposition rate processes
- d. weld to be deposited from both sides of the joint
- e. a spacer to hold critical root openings

F173 What welding process is depicted in Figure 10?
- a. FCAW
- b. GMAW
- c. SMAW
- d. SAW
- e. ESW

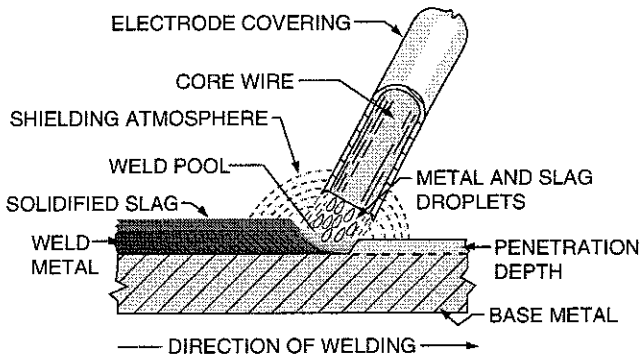


Figure 10

F174 Light-colored areas within the weld zone in a radiograph could represent:
- a. porosity and trapped slag
- b. tungsten inclusions and melt-through
- c. melt-through and trapped slag
- d. porosity and tungsten inclusions
- e. underfill and excessive reinforcement

F175 A single V-groove weld always requires:
- a. special welding processes
- b. backgouging
- c. a backing bar
- d. no root opening
- e. CPJ unless otherwise specified

F176 The substance used in UT to aid in the transmission of sound from the search unit to the work-piece and back is called:
- a. solvent
- b. attenuation
- c. couplant
- d. cable
- e. transducer

F177 Using the appropriate conversion factor from the chart on page 41, determine the approximate kilogram weight of a 30 pound roll of welding wire.

a. 1.36 kg
b. 66 kg
c. 136 kg
d. 66.15 kg
e. 13.6 kg

F178 The junction of the weld face with the exterior surface of the base metal is referred to as the:

a. face
b. root
c. leg
d. toe
e. edge

F179 Internal plate laminations are best revealed using:

a. UT
b. RT
c. MT
d. PT
e. ET

F180 Porosity in GMAW can be caused by:

a. drafts
b. contamination
c. too little shielding gas flow
d. too much shielding gas flow
e. all of the above

F181 The overhead fillet position is designated as:

a. 5F
b. 4F
c. 3F
d. 2F
e. 1F

F182 The radiograph in Figure 11 shows:

a. crack
b. incomplete fusion
c. incomplete joint penetration
d. slag inclusions
e. none of the above

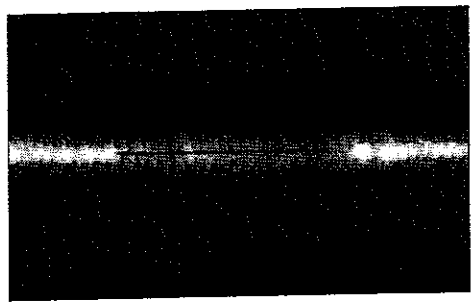


Figure 11

F183 The welding process depicted in Figure 12 is:

a. GMAW
b. SAW
c. SMAW
d. GTAW
e. PAW

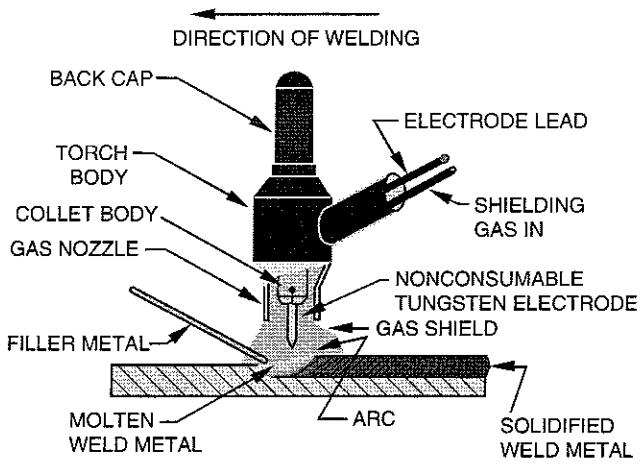


Figure 12

F184 The radiograph in Figure 13 shows:

a. slag inclusions due to improper fitup
b. tungsten inclusions due to poor tungsten grinding
c. porosity due to inadequate shielding
d. longitudinal crack due to stress
e. lack of penetration due to poor starts and stops

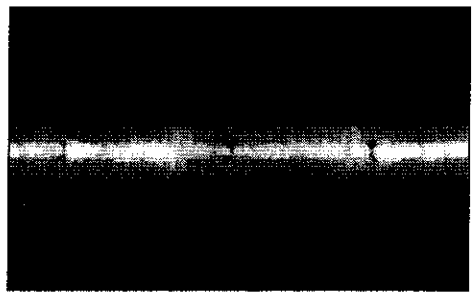


Figure 13

F185 Which of the following is an example of an electrode classification number for GTAW?

a. EWTH-2
b. A5.1
c. A5.9
d. E7018
e. ER70S-2

F186 In a groove-weld cross section, the 'line' separating weld metal from base metal is called:

a. the fusion face
b. the depth of fusion
c. the depth of penetration
d. the weld interface
e. none of the above

F187 In the radiograph in Figure 14, the arrows point to:
- a. transverse cracks
- b. crater cracks
- c. longitudinal cracks
- d. underbead cracks
- e. toe cracks

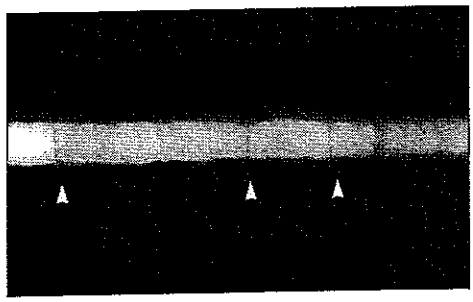


Figure 14

F188 Incomplete fusion can be caused by:
- a. not preheating
- b. not filling the joint completely
- c. improper gas shielding
- d. poor fitup
- e. excessive amperage

F189 In pipe groove welding, the 45° fixed position is designated as:
- a. 1G
- b. 2G
- c. 2F
- d. 5G
- e. 6G

F190 Using the appropriate conversion factor provided in the chart on page 41 determine the approximate feed speed in inches per minute for a wire fed at a speed of 120 mm/s.
- a. 28.3 ipm
- b. 283 ipm
- c. 2,834 ipm
- d. 5.076 ipm
- e. 50.76 ipm

F191 The defect noted in the radiograph in Figure 15 is:
- a. incomplete penetration
- b. a crack
- c. incomplete fusion
- d. porosity
- e. slag inclusions

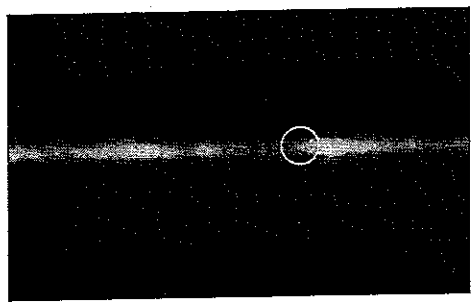


Figure 15

F192 The "A" dimension in Figure 16 is referred to as:

a. actual weld throat
b. weld size
c. weld leg
d. theoretical weld throat
e. effective weld throat

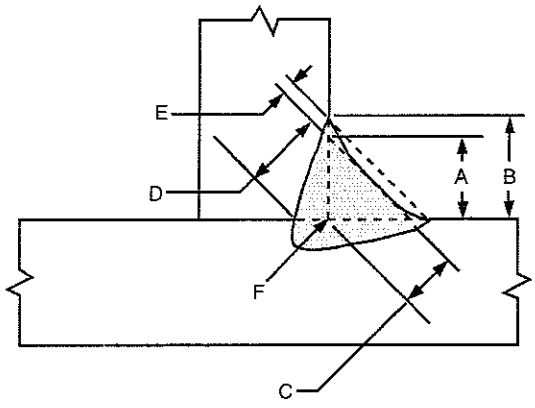


Figure 16

F193 "F" in Figure 16 points to:

a. the root penetration
b. the weld penetration
c. the weld root
d. the joint root
e. none of the above

F194 The dimension "C" in Figure 16 shows:

a. the theoretical throat
b. the actual throat
c. the effective throat
d. weld leg
e. convexity

F195 The dimension "D" in Figure 16 is called:

a. the theoretical throat and the effective throat
b. the effective throat and the actual throat
c. the actual throat and the theoretical throat
d. weld size
e. convexity

F196 The dimension "E" in Figure 16 refers to:

a. the actual throat
b. the effective throat
c. convexity
d. leg and weld size
e. concavity

F197 One common cause of centerline weld cracks is:

a. the use of preheat
b. a highly restrained weld joint
c. using the wrong polarity
d. stress relief heat treatment
e. the presence of incomplete sidewall fusion

F198 Using the appropriate conversion factor from the chart on page 41, determine the approximate pounds per square in. (psi) for a yield strength of 198 MPa.

a. 2.871×10^3 psi
b. 2.871×10^4 psi
c. 4,136 psi
d. 41.36 psi
e. 2,871 psi

F199 Which NDE method will best reveal subsurface porosity?

a. RT
b. PT
c. MT
d. UT
e. none of the above

F200 Liquid penetrant testing is not recommended when inspecting which of the following materials?

a. Aluminum plate that has been chemically cleaned
b. Steel weld test plates brushed clean
c. Stainless steel pipe as welded by GTAW
d. a casting that has been sand blasted
e. a weld test plate with defects removed by machining

F201 Using the conversion factors provided in the chart on page 41, determine the approximate MPa for a tensile strength of 65,000 psi.

a. 448,000
b. 4.48×10^8
c. 448
d. 9,425,000
e. 9.425×10^6

F202 An MT indication of a subsurface discontinuity 1 in. below the surface will appear how as compared to a surface discontinuity?

a. intermittent
b. sharper
c. less distinct
d. MT cannot detect a subsurface flaw 1 in. below the surface
e. only the central conductor method can be used to detect flaws in 1 in material

F203 Which of the following conditions can cause slag inclusions in a weld?

a. insufficient groove angle in an SMAW single V-groove weld
b. careful interpass cleaning of subsequent layer and beads of FCAW
c. insufficient preheat of test plate
d. insufficient shielding gas flow in GTAW
e. improper fitup of GMAW test plates

F204 What is meant by the term essential variable?
- a. Data on a WPS that if changed during production will render a WPS disqualified.
- b. Data on an inspection report that if changed render the report disqualified.
- c. Data on an MTR that is essential to the chemistry of the material.
- d. the recommended amperage and voltage for welding as published by the manufacturer.
- e. describes what should be included in a WPS.

F205 The dimension "B" in Figure 17 is:
- a. the weld throat
- b. the weld size
- c. point of tangency
- d. groove weld size
- e. fillet weld profile

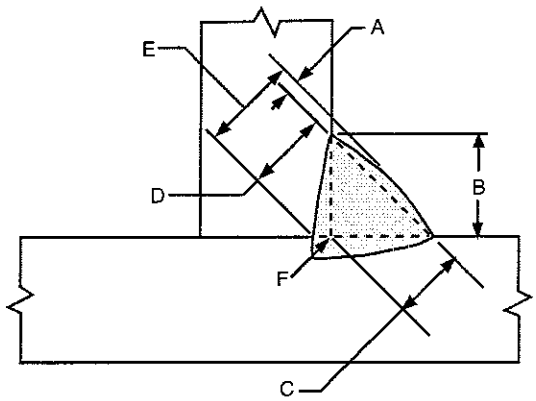


Figure 17

F206 The dimension "A" in Figure 17 is the:
- a. convexity
- b. concavity
- c. face reinforcement
- d. weld size
- e. overlap

F207 The dimension "E" in Figure 17 is:
- a. the actual throat
- b. the effective throat
- c. the theoretical throat
- d. weld size
- e. convexity

F208 The dimension "D" in Figure 17 is:
- a. the actual throat
- b. the effective throat
- c. the theoretical throat
- d. weld size
- e. weld leg

F209 Where should the preheat temperature be measured?
- a. in the weld groove
- b. 12 in. from the weld groove
- c. where the arc will be initiated
- d. 2–3 in. from the weld groove
- e. preheat temperature need not be measured

F210 A discontinuity is:
- a. always rejectable
- b. never rejectable, but its condition should be noted in the inspection report
- c. always a defect
- d. an indication that renders a part unusable
- e. an interruption in the uniformity of a weldment

F211 What weld discontinuity is shown in the radiograph in Figure 18?
- a. crack
- b. incomplete joint penetration
- c. porosity
- d. burn through
- e. tungsten inclusions

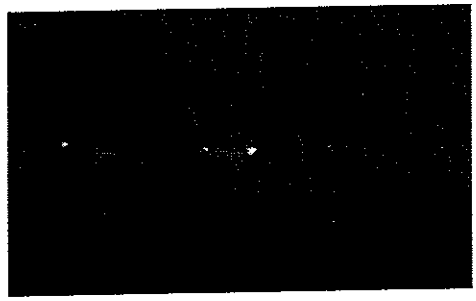


Figure 18

F212 An oxygen regulator is set for 40 psi. Using the appropriate conversion factor from the chart on page 41, determine the pressure in kPa.
- a. 2,758
- b. 27,580
- c. 2.758
- d. 27.58
- e. 275.8

F213 Which of the following discontinuities can be caused by poor welding technique?
- a. incomplete fusion
- b. porosity
- c. undercut
- d. overlap
- e. all of the above

F214 If a welder is continually turning out rejectable work, the welding inspector should:
- a. inspect his work more critically
- b. ask that the welder be terminated
- c. require requalification
- d. instruct the welder in proper techniques
- e. ask that the welder use another process

F215 How does a welder become certified?
- a. certification can only be obtained by taking a weld test given by a CWI
- b. by graduating from a welding school
- c. by having documented proof of 5 years in welding industry
- d. by documenting successful completion of a weld test according to the requirements of an applicable standard
- e. certification can only be obtained by taking a weld test at an approved test center

F216 Which discontinuity occurs in the heat-affected zone and can result from excess moisture in the weld zone?

a. throat crack
b. crater crack
c. underbead crack
d. porosity
e. centerline crack

F217 Which of the following measurements are taken from a tensile specimen to determine area?

a. mass and volume
b. length and thickness
c. width and length
d. width and thickness
e. load and pressure

F218 When establishing a PQR?

a. the type and number of tests required is determined by the applicable standard
b. a face and root bend will qualify all plates
c. testing requirements are determined by the contractor and approved by the inspector
d. destructive testing is required only if a problem is suspected
e. a weld test plate does not have to be mechanically tested to establish a PQR

F219 Which of the following discontinuities is not associated with GTAW?

a. lack of fusion
b. slag inclusions
c. tungsten inclusions
d. porosity
e. undercut

F220 Using the appropriate conversion factor from the chart on page 41, convert a travel speed of 21 ipm to mm/s.

a. 88.9
b. 8.9
c. 0.88
d. 0.088
e. 49.61

F221 Using the appropriate conversion factor from the chart on page 41, calculate the ultimate tensile strength in MPa of a tensile specimen having a cross-sectional area of 0.300 sq. in. and broke at a tensile load of 24,600 lbs.

$$\frac{\text{Load (lbs.)}}{\text{Area of specimen (sq. in.)}} = \text{Tensile strength (psi)}$$

a. 565 Pa
b. 565 MPa
c. 5.65 Pa
d. 565 kPa
e. 5,650 kPa

F222 Which of the following discontinuities are not found with GMAW?

a. incomplete fusion
b. porosity
c. tungsten inclusions
d. incomplete penetration
e. cracks

F223 The CAWI:

a. is solely responsible for determination of a weldment's conformance to acceptable standards
b. inspects weldments only under the direction of a CWI or SCWI
c. cannot inspect critical weldments
d. performs all inspections the same as a CWI
e. all of the above

F224 NDE technicians are certified in accordance with:

a. AWS D1.1
b. API 1104
c. ASNT SNT-TC-1A
d. ASME Section VI
e. ASME Section IX

WIT—Useful Formulae

Area of Square or Rectangle

$$\text{Area} = \text{length} \times \text{width} \quad \text{or:} \quad \text{Area} = \text{width} \times \text{thickness}$$

Area or Circle

$$\text{Area} = \pi \times \text{radius}^2 \quad \text{or:} \quad \text{Area} = \pi \times \frac{\text{diameter}^2}{4} \quad \text{or:} \quad \text{Area} = 0.7854 \times \text{diameter}^2$$

Percent Elongation

$$\% \text{ Elongation} = \frac{\text{Final Gage Length} - \text{Original Gage Length}}{\text{Original Gage Length}} \times 100$$

Percent Reduction of Area

$$\% \text{ Reduction of Area} = \frac{\text{Original Area} - \text{Final Area}}{\text{Original Area}} \times 100$$

Tensile Strength

General

$$\text{UTS} = \frac{\text{P max}}{\text{Area}}$$

where: P max = load to break specimen
Area = specimen's original cross-sectional area

Pipe

$$\text{UTS for full section pipe} = \frac{\text{P max}}{0.7854\ (\text{OD}^2 - \text{ID}^2)}$$

Yield Strength

$$\text{YS} = \frac{\text{Load at specified offset}}{\text{Original cross-sectional area}}$$

Welding Heat Input

$$\text{J/in.} = \frac{\text{V} \times \text{A} \times 60}{\text{Travel Speed (ipm)}}$$

where: J = Joules (energy)
V = welding voltage
A = welding amperage
ipm = inches per minute

Carbon Equivalent

$$\text{CE} = \%\text{C} + \frac{\%\text{Mn}}{6} + \frac{\%\text{Ni}}{15} + \frac{\%\text{Cu}}{13} + \frac{\%\text{Mo}}{14}$$

Welding Usage Conversion Chart—U.S. Customary and SI

Property*	To Convert From:	To:	Multiply By:
area dimensions	$in.^2$ mm^2	mm^2 $in.^2$	6.452×10^{2} 1.550×10^{-3}
current density	$A/in.^2$ A/mm^2	A/mm^2 $A/in.^2$	1.550×10^{-3} 6.452×10^{2}
deposition rate	lb/hr kg/hr	kg/hr lb/hr	0.454 2.205
flow rate	ft^3/h l/min	l/min ft^3/h	4.719×10^{-1} 2.119
heat input	J/in. J/m	J/m J/in.	39.37 2.54×10^{-2}
linear measure	in. mm ft mm	mm in. mm ft	25.4 3.937×10^{-2} 3.048×10^{2} 3.281×10^{-3}
mass	lb kg	kg lb	0.454 2.205
pressure	psi psi kPa MPa bar psi	kPa MPa psi psi psi bar	6.895 6.895×10^{-3} 0.145 1.450×10^{2} 14.50 6.9×10^{-2}
temperature	°F °C	°C °F	(°F – 32)/1.8 (°C × 1.8) + 32
tensile strength	psi MPa	MPa psi	6.895×10^{-3} 1.450×10^{2}
travel speed	in./min mm/s	mm/s in./min	4.233×10^{-1} 2.362
vacuum	Pa	torr	7.501×10^{-3}
wire feed speed	in./min mm/s	mm/s in./min	0.423 2.362

ANSWER KEY

F1	c	F47	a	F93	a	F139	c	F185	a
F2	a	F48	d	F94	c	F140	b	F186	d
F3	c	F49	d	F95	b	F141	b	F187	a
F4	a	F50	c	F96	b	F142	a	F188	d
F5	b	F51	a	F97	c	F143	b	F189	e
F6	a	F52	b	F98	c	F144	b	F190	b
F7	c	F53	d	F99	b	F145	c	F191	d
F8	b	F54	c	F100	a	F146	b	F192	b
F9	c	F55	c	F101	d	F147	c	F193	d
F10	c	F56	e	F102	b	F148	b	F194	a
F11	a	F57	b	F103	c	F149	c	F195	b
F12	a	F58	e	F104	a	F150	d	F196	e
F13	e	F59	b	F105	c	F151	d	F197	b
F14	b	F60	c	F106	c	F152	e	F198	b
F15	b	F61	b	F107	b	F153	a	F199	a
F16	e	F62	d	F108	b	F154	d	F200	d
F17	c	F63	e	F109	b	F155	c	F201	c
F18	d	F64	c	F110	c	F156	b	F202	d
F19	e	F65	a	F111	d	F157	b	F203	a
F20	c	F66	b	F112	b	F158	b	F204	a
F21	a	F67	c	F113	a	F159	c	F205	b
F22	b	F68	b	F114	c	F160	a	F206	a
F23	b	F69	a	F115	a	F161	c	F207	a
F24	d	F70	a	F116	e	F162	c	F208	b
F25	e	F71	b	F117	c	F163	d	F209	d
F26	c	F72	c	F118	a	F164	e	F210	e
F27	c	F73	c	F119	a	F165	b	F211	e
F28	d	F74	e	F120	c	F166	c	F212	e
F29	c	F75	b	F121	c	F167	c	F213	e
F30	e	F76	c	F122	e	F168	c	F214	c
F31	e	F77	b	F123	c	F169	a	F215	d
F32	d	F78	a	F124	d	F170	b	F216	c
F33	b	F79	a	F125	b	F171	c	F217	d
F34	b	F80	a	F126	b	F172	d	F218	a
F35	b	F81	c	F127	e	F173	c	F219	b
F36	a	F82	c	F128	a	F174	b	F220	b
F37	d	F83	c	F129	c	F175	e	F221	b
F38	c	F84	a	F130	d	F176	c	F222	c
F39	b	F85	a	F131	a	F177	e	F223	b
F40	c	F86	e	F132	a	F178	d	F224	c
F41	c	F87	c	F133	a	F179	a		
F42	b	F88	e	F134	b	F180	e		
F43	c	F89	b	F135	c	F181	b		
F44	c	F90	c	F136	b	F182	c		
F45	b	F91	a	F137	b	F183	d		
F46	a	F92	b	F138	a	F184	e		

IMPORTANT NOTICE:

Note to Exam Candidates regarding Part B Practical Exam:
Effective 01 June 2006, candidates testing on the CWI Part B will be required to use the new *Part B Practical: Book of Specifications*. You must have the correct version of the *Book of Specifications* in order to pass the Part B Practical examination.

Those registering for the seminar and exam will be provided with the *Book of Specifications* at the seminar. For those candidates registering for examination only, a *Book of Specifications* will be sent in an examination confirmation package. On the exam date, all candidates will be provided & required to use an original copy of the *Book of Specifications*.

To view the 2006 version:
http://www.aws.org/certification/docs/partb2006.pdf

To view the 1998 version:
http://www.aws.org/certification/docs/partb1998.pdf

AMERICAN WELDING SOCIETY

WELDING INSPECTOR EXAMINATION

Part B

EXAMINATION BOOK OF SPECIFICATIONS

TABLE OF CONTENTS

Appendices

Revision D: January 2006

Conversions and Calculations

The International System of Units (SI) makes use of conversion factors and metric prefixes. Use the following tables:

Table of SI Conversions

PROPERTY	U.S. CUSTOMARY UNITS	SI UNITS	
	To convert from	*To*	*Multiply by*
force	pound-force (lbf)	newton (N)	4.5
	kip (1000 lbf)	newton	4450
linear dimension	inch (in.)	millimeter (mm)	25.4
tensile strength	pounds per square inch (psi)	pascal (Pa)	6895
	(psi)	kilopascal (kPa)	6.89
	(psi)	megapascal (MPa)	0.00689
mass	pound mass (avdp)	kilogram	0.454
angle, plane	degree (angular) (°)	radian (rad)	0.0175
flow rate	cubic feet per hour (ft^3/hr)	liters per minute (L/min)	0.472
heat input	joules per inch (J/in)	joules per meter (J/m)	39.4
travel speed, wire	inches per minute (in/min)	millimeter per second (mm/s)	0.423
temperature	degree Fahrenheit (°F)	degree Celsius (°C)	°C = (°F – 32)/1.8

Table of SI Prefixes

EXPONENTIAL EXPRESSION	MULTIPLICATION FACTOR	PREFIX	SYMBOL
10^9	1 000 000 000	giga	G
10^6	1 000 000	mega	M
10^3	1 000	kilo	k
10^{-3}	0.001	milli	m
10^{-6}	0.000 001	micro	μ
10^{-9}	0.000 000 001	nano	n

Formulas

PROPERTY	FORMULA		
ultimate tensile strength (uts)	uts = maximum load/original cross-sectional area		
cross-sectional area (csa)	csa = $\pi D^2/4$ (for circle) csa = width × thickness (for square or rectangle)		
temperature	degree Fahrenheit (°F)	degree Celsius (°C)	°C = (°F – 32)/1.8
	degree Celsius (°C)	degree Fahrenheit (°F)	°F = 9/5°C + 32

This book is for examination purposes only.
It is not a working set of specifications nor a code.

The information contained herein may not match the current editions of the referenced documents.

Do not write in this book.

APPENDIX I

WELDING PROCEDURE QUALIFICATION RECORD (PQR)

PROCEDURE SPECIFICATION

Material specification [1]
Welding process [2]
Manual, semiautomatic, automatic: [3]
Position of welding [4]

Filler metal specification [5]
Filler metal classification [6]
Weld metal analysis [7]
Shielding gas [8]
Flow rate [9]
Single or multiple pass [10]
Single or multiple arc [11]
Welding current [12]
Welding progression [13]
Preheat temperature [14]
Welder's ID [15]
Welder's name [16]

VISUAL INSPECTION RESULTS

Appearance [17]
Undercut [18]
Piping porosity [19]

ALL-WELD-METAL TENSION TEST RESULTS

Tensile strength, psi [20]
Yield point/strength, psi [21]
Elongation in 2 in., % [22]
Laboratory Test No: [23]

GROOVE WELD TEST RESULTS

Tensile Strength, psi

1. [24]
2. [25]

Guided-Bend Tests (2 root-, 2 face-, or 4 side-bends)

Root	Face	Side
1. [26]	1. [28]	1. [30]
2. [27]	2. [29]	2. [31]
		3. [32]
		4. [33]

Radiographic-Ultrasonic Examination

RT Report No: [34]
UT Report No: [35]

FILLET WELD TEST RESULTS

Minimum size multiple pass Macroetch	Maximum size single pass Macroetch
1. [36]	1. [39]
2. [37]	2. [40]
3. [38]	3. [41]

Test Date [42]
Witnessed by [43]

WELDING PROCEDURE

Pass No.	Electrode Size	Welding Current		Speed of Travel	Joint Detail
		Amperes	Volts		
[44]	[45]	[46]	[47]	[48]	[49]

We, the undersigned, certify that the statements in this record are correct.

Procedure No. [50]
Revision No. [52]

Manufacturer or Contractor [51]
Authorized by [53]
Date [54]

APPENDIX II-A

PERFORMANCE QUALIFICATION TEST RECORD

(SMAW, GMAW, GTAW, FCAW, SAW, OFW, PAW)

Name _____[1]_____ Welder ☐ Welding Operator ☐
I.D. No. _____[2]_____ WPS Used _____[3]_____
Process(es) _____[4]_____ Transfer Mode (GMAW) _____[5]_____
Test Base Metal Specification _____[6]_____ to _____[7]_____
Material Number _____[8]_____ to _____[9]_____
Fuel Gas (OFW) _____[10]_____
AWS Filler Metal Classification(s) _____[11]_____ F No. _____[12]_____
Backing Yes ☐ No ☐ Double Side ☐ Single Side ☐
Current Polarity AC ☐ DCEP ☐ DCEN ☐
Consumable Insert Yes ☐ No ☐ Backing Gas Yes ☐ No ☐

Test Joint Sketch

Test Weldment		Position Tested						Width (W)	Thickness (T)
Groove	Pipe	1G	2G	5G	6G			Thickness	Diameter
	Plate	1G	2G	3G	4G			Thickness	
Fillet	Pipe	1F	2F	2FR	4F	5F		Thickness	Diameter
	Plate	1F	2F	3F	4F			Thickness	
Cladding		1C	2C	3C	4C	5C	6C	Thickness	
Hardfacing		1C	2C	3C	4C	5C	6C	Thickness	

Progression Vertical Up ☐ Vertical Down ☐

TEST RESULTS

Visual Test	Pass ☐	Fail ☐	N/A ☐
Macro Test	Pass ☐	Fail ☐	N/A ☐
Break Test	Pass ☐	Fail ☐	N/A ☐
Visual Test	Pass ☐	Fail ☐	N/A ☐
Radiographic Test	Pass ☐	Fail ☐	N/A ☐

REMARKS

_____[13]_____
_____[14]_____
_____[15]_____
_____[16]_____
_____[17]_____

QUALIFICATION LIMITS

Process(es)

Weldment		Position					Deposited Thickness		
Groove	Pipe	F	H	V	O	All	t min.	t max.	Dia. min.
	Plate		H	V	O	All	t min.	t max.	
Cladding		F	H	V	O	All	t min.	t max.	
Hardfacing		F	H		O	All	t min.	t max.	
Weldment		**Position**					**Base Metal Thickness**		
Fillet	Pipe	F	H	V	O	All	T min.	T max.	Dia. min.
	Plate	F		V	O	All	T min.	T max.	

Progression Vertical Up ☐ Vertical Down ☐
Base Metal M No(s). _____[18]_____
Filler Metal F No(s). _____[20]_____
Current Polarity AC ☐ DCEP ☐ DCEN ☐
Backing Gas _____[21]_____

Fuel Gas (OFW) _____[19]_____
Backing Yes ☐ No ☐
Consumable Insert Yes ☐ No ☐
Transfer Mode (GMAW) _____[22]_____

We, the undersigned, certify that the statements in this record are correct.

Date tested _____[23]_____ Qualifier signature _____[24]_____

APPENDIX II-B

Spectec, Inc.

905 Ridge Way, Eastern, Somewhere 84328, xxx-yyy-zzzz, FAX xxx-yyy-zzzz

WELDER PERFORMANCE QUALIFICATION RECORD

Welder's Name C. W. Practical ID No. 222-33-4444 Date 11-08-00
WPS No. D1.1-3G-U-CJP-B-307
Welding Process FCAW Type Manual
Specification or Code AWS D1.1:2000, Structural Welding Code—Steel

Base Metal
Material Spec/Type/Grade A 36 To: Material Spec/Type/Grade A 36
Thickness 1 in. Thickness Range Qualified 1/8 in.-Unlimited
Base Metal Preparation Base metal shall be clean and free of moisture, oil, dirt, paint, coatings, rust, scale. etc. Cleaning shall leave no residue.

Joint Welded Single V-Groove with steel backing
Type of Weld Joint (See Figure 4.21, Test Plate for Unlimited Thickness)
Bevel Angle 22.5° Root Face 0 Root Opening 1/4 in.
Backing Yes [X] No [ ] Backing Type 1/4 x 1 in. Steel Strap

Electrode
F No. 4 Specification A5.18 Classification E71T-1 Size Range 1/16th

Filler Metal
F No. 4 Specification A5.18 Classification E71T-1 Size Range 1/16th

Preheat
Preheat 50°F min. Interpass Temperature Max. 400°F

Position
Position 3G Progression Up

TEST RESULTS

Visual	Bends	Radiographic	Metallographic
Pass [X] Fail [ ]	N/A [ ] Pass [X] Fail [ ]	N/A [X] Pass [ ] Fail [ ]	N/A [X] Pass [ ] Fail [ ]

Test conducted by _____ Laboratory test no. _____
per _____ Test date _____

QUALIFIED FOR

Base Metal Group No.	Type Weld	Current	Backing	Penetration	Vertical
I(a) (Carbon and Low-Alloy Steel)	Single Side [X] Double Side [ ]	AC [ ] DCEN [ ] DCEP [X]	With [X] Type Steel Open Root [ ]	Complete [X] Partial [ ]	Down [ ] Up [X]

	Position				t, in.		OD, in.	
					Min.	Max.	Min.	Max.
Plate—Groove	1G [X]	2G [X]	3G [X]	4G [ ]	1/8	Unlimited		
Pipe/Tube—Groove	1G [X]	2G [X]	5G [ ]	6G [ ]	1/8	Unlimited	Over 24	Unlimited
Plate—Fillet	1F [X]	2F [X]	3F [X]	4F [ ]	1/8	Unlimited		
Pipe/Tube—Fillet	1F [X]	2F [X]	5F [ ]	6F [ ]	1/8	Unlimited		

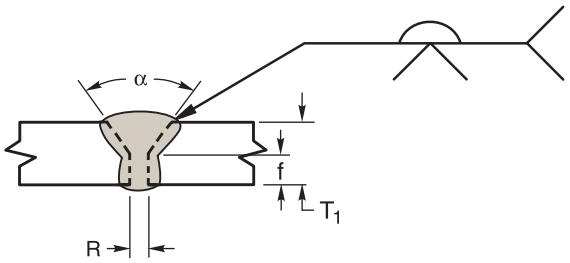
The above individual is qualified to the above limits in accordance with AWS D1.1:2000, *Structural Welding Code—Steel*.

Qualified By *John Smith* Position Weld Supervisor Date 11-10-00
(signature)

APPENDIX III

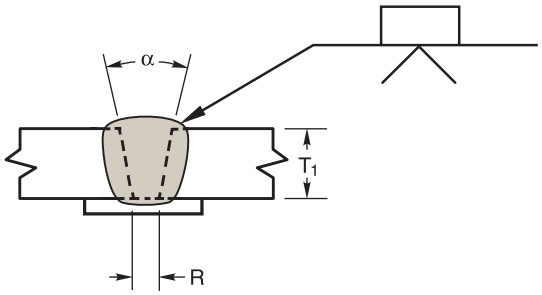
PREQUALIFIED COMPLETE JOINT PENETRATION GROOVE WELDED JOINTS

Single-V-groove weld (2)
Butt joint (B)



Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Gas Shielding for FCAW	Notes
				Root Opening Root Face Groove Angle	Tolerances				
		T_1	T_2		As Detailed	As Fitup			
SMAW	B-U2	U	—	R = 0 to 1/8 f = 0 to 1/8 α = 60°	+1/16, –0 +1/16, –0 +10°, –0°	+1/16, –1/8 Not limited +10°, –5°	All	—	2, 3, 4
GMAW FCAW	B-U2-GF	U	—	R = 0 to 1/8 f = 0 to 1/8 α = 60°	+1/16, –0 +1/16, –0 +10°, –0°	+1/16, –1/8 Not limited +10°, –5°	All	Not required	1, 2, 4
SAW	B-L2c-S	Over 1/2 to 1	—	R = 0 f = 1/4 max α = 60°	R = ±0 f = +0, –f α = +10°, –0°	+1/16, –0 ±1/16 +10°, –5°	F	—	2, 4
		Over 1 to 1-1/2	—	R = 0 f = 1/2 max α = 60°					
		Over 1-1/2 to 2	—	R = 0 f = 5/8 max α = 60°					

Single-V-groove weld (2)
Butt joint (B)



Tolerances	
As Detailed	As Fitup
R = +1/16, –0	+1/4, –1/16
α = +10°, –0°	+10°, –5°

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation		Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle			
SMAW	B-U2a	U	—	R = 1/4	α = 45°	All	—	3, 4
				R = 3/8	α = 30°	F, V, OH	—	3, 4
				R = 1/2	α = 20°	F, V, OH	—	3, 4
GMAW FCAW	B-U2a-GF	U	—	R = 3/16	α = 30°	F, V, OH	Required	1, 4
				R = 3/8	α = 30°	F, V, OH	Not req.	1, 4
				R = 1/4	α = 45°	F, V, OH	Not req.	1, 4
SAW	B-L2a-S	2 max	—	R = 1/4	α = 30°	F	—	4
SAW	B-U2-S	U	—	R = 5/8	α = 20°	F	—	4

Notes:
1. Not prequalified for GMAW-S nor GTAW.
2. Backgouge root to sound metal before welding second side.
3. SMAW detailed joints may be used for prequalified GMAW (except GMAW-S) and FCAW.
4. The orientation of the two members in the joints may vary from 135° to 180° for butt joints, or 45° to 135° for corner joints, or 45° to 90° for T-joints.

APPENDIX IV

PIPE SCHEDULES

Pipe Size	O.D. (in.)	5s	5	10s	10	20	30	40s Std.	40	60	80s & E.H.	80	100	120	140	160	Dble. E.H.
1/8	**0.405**		0.035 0.1383	0.049 0.1863	0.049 0.1863			0.068 0.2447	0.068 0.2447		0.095 0.3145	0.095 0.3145					
1/4	**0.540**		0.049 0.2570	0.065 0.3297	0.065 0.3297			0.088 0.4248	0.088 0.4248		0.119 0.5351	0.119 0.5351					
3/8	**0.675**		0.049 0.3276	0.065 0.4235	0.065 0.4235			0.091 0.5676	0.091 0.5676		0.126 0.7388	0.126 0.7388					
1/2	**0.840**	0.065 0.5383	0.065 0.5383	0.083 0.6710	0.083 0.6710			0.109 0.8510	0.109 0.8510		0.147 1.088	0.147 1.088				0.188 1.304	0.294 1.714
3/4	**1.050**	0.065 0.6838	0.065 0.6838	0.083 0.8572	0.083 0.8572			0.113 1.131	0.113 1.131		0.154 1.474	0.154 1.474				0.219 1.937	0.308 2.441
1	**1.315**	0.065 0.8678	0.065 0.8678	0.109 1.404	0.109 1.404			0.133 1.679	0.133 1.679		0.179 2.172	0.179 2.172				0.250 2.844	0.358 3.659
1-1/4	**1.660**	0.065 1.107	0.065 1.107	0.109 1.806	0.109 1.806			0.140 2.273	0.140 2.273		0.191 2.997	0.191 2.997				0.250 3.765	0.382 5.214
1-1/2	**1.900**	0.065 1.274	0.065 1.274	0.109 2.085	0.109 2.085			0.145 2.718	0.145 2.718		0.200 3.631	0.200 3.631				0.281 4.859	0.400 6.408
2	**2.375**	0.065 1.604	0.065 1.604	0.109 2.638	0.109 2.638			0.154 3.653	0.154 3.653		0.218 5.022	0.218 5.022				0.344 7.444	0.436 9.029
2-1/2	**2.875**	0.083 2.475	0.083 2.475	0.120 3.531	0.120 3.531			0.203 5.793	0.203 5.793		0.276 7.661	0.276 7.661				0.375 10.01	0.552 13.70
3	**3.500**	0.083 3.029	0.083 3.029	0.120 4.332	0.120 4.332			0.216 7.576	0.216 7.576		0.300 10.25	0.300 10.25				0.438 14.32	0.600 18.58
3-1/2	**4.000**	0.083 3.472	0.083 3.472	0.120 4.973	0.120 4.973			0.226 9.109	0.226 9.109		0.318 12.51	0.318 12.51					0.636 22.85
4	**4.500**	0.083 3.915	0.083 3.915	0.120 5.613	0.120 5.613			0.237 10.79	0.237 10.79	0.281 12.66	0.337 14.98	0.337 14.98		0.438 19.01		0.531 22.51	0.674 27.54
4-1/2	**5.000**							0.247 12.53			0.355 17.61						0.710 32.53
5	**5.563**	0.109 6.349	0.109 6.349	0.134 7.770	0.134 7.770			0.238 14.62	0.258 14.62		0.375 20.78	0.375 20.78		0.500 27.04		0.625 32.96	0.750 38.55
6	**6.625**	0.109 7.585	0.109 7.585	0.134 9.290	0.134 9.289			0.280 18.97	0.280 18.97		0.432 28.57	0.432 28.57		0.562 36.39		0.719 45.30	0.864 43.16
7	**7.625**							0.301 23.57			0.500 38.05						0.875 63.08
8	**8.625**	0.109 9.914	0.109 9.914	0.148 13.40	0.148 13.40	0.250 22.36	0.277 24.70	0.322 28.55	0.322 28.55	0.406 35.64	0.500 43.39	0.500 43.39	0.594 50.87	0.719 60.93	0.812 67.76	0.906 74.69	0.875 72.42
9	**9.625**							0.342 33.90			0.500 48.72						
10	**10.750**	0.134 15.19	0.134 15.19	0.165 18.65	0.165 18.70	0.250 28.04	0.307 34.24	0.365 40.48	0.365 40.48	0.500 54.74	0.500 54.74	0.594 64.33	0.719 76.93	0.844 89.20	1.000 104.1	1.125 115.7	
11	**11.750**							0.375 45.55			0.500 60.07						
12	**12.750**	0.156 21.07	0.165 22.18	0.180 24.16	0.180 24.20	0.250 33.38	0.330 43.77	0.375 49.56	0.406 53.33	0.562 73.16	0.500 65.42	0.688 88.51	0.844 107.2	1.000 125.5	1.125 139.7	1.312 160.3	
14	**14.000**	0.156 23.07		0.188 27.73	0.250 36.71	0.312 45.68	0.375 54.57	0.375 54.57	0.438 63.37	0.594 84.91	0.500 72.09	0.750 106.1	0.938 130.7	1.094 150.7	1.250 170.2	1.406 189.1	
16	**16.000**	0.165 27.90		0.188 31.75	0.250 42.05	0.312 52.36	0.375 62.58	0.375 62.58	0.500 82.77	0.656 107.5	0.500 82.77	0.844 136.5	1.031 164.8	0.129 192.3	1.438 223.5	1.594 245.1	
18	**18.000**	0.165 31.43		0.188 35.76	0.250 47.39	0.312 59.03	0.438 82.06	0.375 70.59	0.562 104.8	0.750 138.2	0.500 93.45	0.938 170.8	1.156 208.0	1.375 244.1	1.562 274.2	1.781 308.5	
20	**20.000**	0.188 39.78		0.218 46.05	0.250 52.73	0.375 78.60	0.500 104.1	0.375 78.60	0.594 122.9	0.812 166.4	0.500 104.1	1.031 208.9	1.281 256.1	1.500 296.4	1.750 341.1	1.969 379.0	
24	**24.000**	0.218 55.37		0.250 63.41	0.250 63.41	0.375 94.62	0.562 140.8	0.375 94.62	0.688 171.2	0.969 238.1	0.500 125.5	1.219 296.4	1.531 367.4	1.812 429.4	2.062 483.1	2.343 541.9	

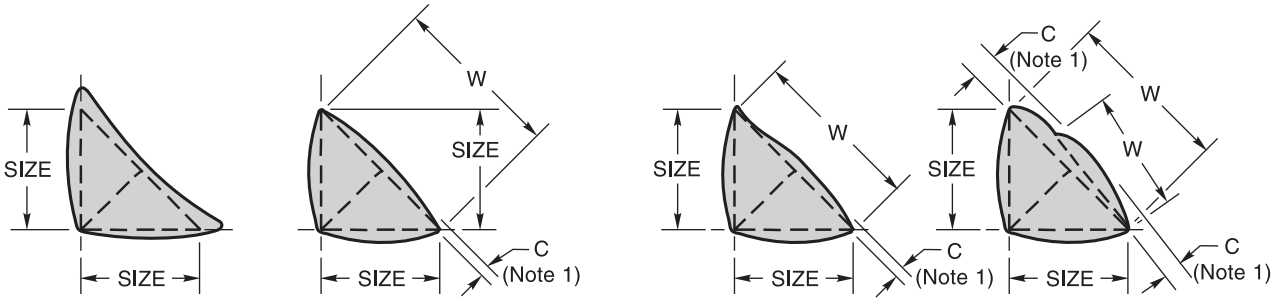
UPPER FIGURES
Wall Thickness
in inches

DIMENSIONS AND WEIGHTS OF SEAMLESS AND WELDED STEEL PIPE

LOWER FIGURES
Weight per foot
in pounds

APPENDIX V

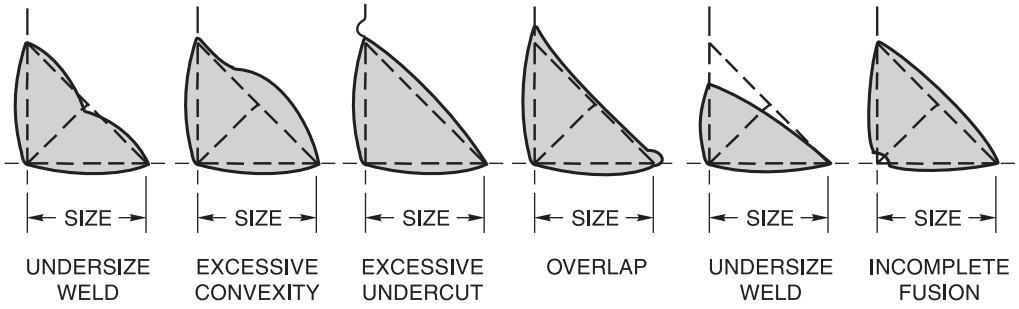
ACCEPTABLE AND UNACCEPTABLE WELD PROFILES



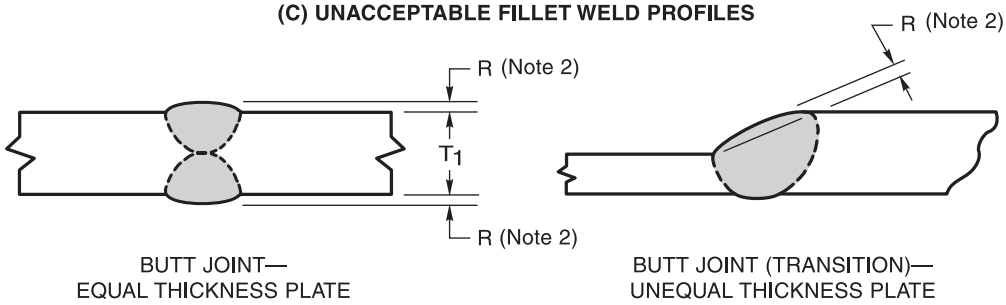
(A) DESIRABLE FILLET WELD PROFILES **(B) ACCEPTABLE FILLET WELD PROFILES**

Note 1. Convexity, C, of a weld or individual surface bead with dimension W shall not exceed the value of the following table:

WIDTH OF WELD FACE OR INDIVIDUAL SURFACE BEAD, W	MAX CONVEXITY, C
W ≤ 5/16 in.	1/16 in.
W > 5/16 in. TO W < 1 in.	1/8 in.
W ≥ 1 in.	3/16 in.

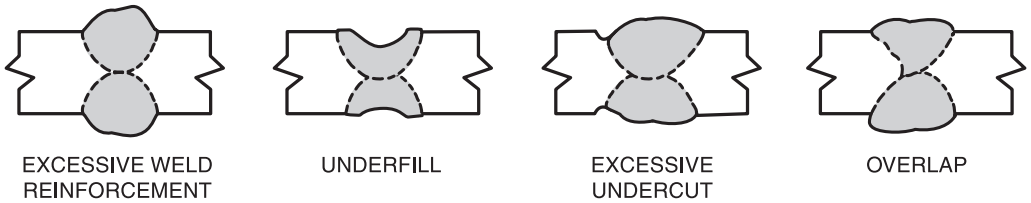


(C) UNACCEPTABLE FILLET WELD PROFILES



Note 2. Reinforcement R shall not exceed 1/8 in.

(D) ACCEPTABLE GROOVE WELD PROFILE IN BUTT JOINT



(E) UNACCEPTABLE GROOVE WELD PROFILES IN BUTT JOINTS

APPENDIX VI

WELD PROFILE ACCEPTANCE DESCRIPTION

(1) The faces of fillet welds may be slightly convex, flat, or slightly concave as shown in Appendix V (A) and (B), with none of the unacceptable profiles shown in (C). Except at outside corner joints, the convexity, C, of a weld or individual surface bead with dimension W, shall not exceed the values noted in the table in Appendix V.

(2) Groove welds shall preferably be made with slight or minimum reinforcement except as may be otherwise provided. In the case of butt and corner joints, the reinforcement shall not exceed 1/8 in. (3.2 mm) in height and shall have gradual transition to the plane of the base metal surface. See Appendix V. They shall be free of the discontinuities shown for butt joints in (E).

(3) Surfaces of groove welds required to be flush shall be finished so as not to reduce the thickness of the thinner base metal or weld metal by more than 1/32 in. (0.8 mm) or 5% of the thickness, whichever is smaller, nor leave reinforcement that exceeds 1/32 in. However, all reinforcement must be removed where the weld forms part of a faying or contact surface. Any reinforcement must blend smoothly into the plate surfaces with transition areas free from weld undercut. Chipping may be used provided it is followed by grinding. Where surface finishing is required, its roughness value shall not exceed 250 μin. (6.3 μm). Surfaces finished to values of over 125 μin. (3.2 μm) through 250 μin. shall be finished so that the grinding marks are parallel to the direction of primary stress. Surfaces finished to values of 125 μin. or less may be finished in any direction.

(4) Ends of groove welds required to be flush shall be finished so as not to reduce the width beyond the detailed width or the actual width furnished, whichever is greater, by more than 1/8 in. (3.2 mm) or so as not to leave reinforcement at each end that exceeds 1/8 in. (3.2 mm). Ends of welds in butt joints shall be faired to adjacent plate or shape edges at a slope not to exceed 1 in 10.

(5) Welds shall be free from overlap.

APPENDIX VII

VISUAL WELD INSPECTION ACCEPTANCE CRITERIA

Slag shall be removed from all completed welds. All welds and the adjacent base metal shall be cleaned by brushing or by any other suitable means prior to visual inspection. All welds shall meet visually acceptance criteria prior to any non-destructive or destructive testing. To be visually acceptable, a weld shall meet the following criteria:

(1) The weld has no cracks.

(2) Thorough fusion exists between adjacent layers of weld metal and between weld metal and base metal.

(3) All craters are filled to the full cross section of the weld.

(4) Weld profiles are in accordance with Appendixes V and VI.

(5) When the weld is transverse to the primary stress in the part that is undercut, the undercut shall be no more than 0.010 in. (0.25 mm) deep.

(6) When the weld is parallel to the primary stress in the part that is undercut, the undercut shall be no more than 1/32 in. (0.80 mm) deep.

(7) The sum of the diameters of visible porosity shall not exceed 3/8 in. (9.5 mm) in any linear inch of weld nor shall the sum exceed 3/4 in. (19.0 mm) in any 12 in. (305 mm) length of weld.

(8) Any single continuous fillet weld shall be permitted to underrun the nominal fillet weld size specified by 1/16 in. (1.6 mm).

(9) Visual inspections of welds in all steels may begin immediately after the completed welds have cooled to ambient temperature. Final visual inspection for ASTM A 514 and A 517 steel welds shall be performed not less than 48 hours after completion of the weld and removal of preheat.

(10) Arc strikes outside the weld groove are prohibited.

APPENDIX VIII

TEST RESULTS REQUIRED, GUIDED BENDS

All Guided Bend Tests. The convex surface of the bend test specimen shall be visually examined for surface discontinuities. For acceptance, the surface shall meet the following criteria:

(1) No single discontinuity shall exceed 1/8 in. (3.2 mm) measured in any direction.

(2) The sum of the greatest dimensions of all discontinuities exceeding 1/32 in. (0.8 mm) but less than or equal to 1/8 in. (3.2 mm) shall not exceed 3/8 in. (9.5 mm).

(3) Corner cracks shall not exceed 1/4 in. (6.4 mm) unless the crack results from a visible slag inclusion or other fusion type discontinuities, then the 1/8 in. (3.2 mm) maximum shall apply.

The specimens with corner cracks exceeding 1/4 in. (6.4 mm) with no evidence of slag inclusions or other fusion type discontinuities shall be disregarded, and a replacement test specimen from the original weldment shall be tested.

APPENDIX IX

WELD METAL ANALYSIS

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

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

NOTE:
(1) Single values shown above are maximum.

APPENDIX X

ELECTRODE GROUPS

F-NUMBERS
Grouping of Electrodes and Welding Rods for Qualification

F-No.	AWS Specification	AWS Classification
Steel		
1	A5.1	EXX20, EXX22, EXX24, EXX27, EXX28
1	A5.4	EXXX(X)-25, EXXX(X)-26
1	A5.5	EXX20-XX, EXX27-XX
2	A5.1	EXX12, EXX13, EXX14, EXX19
2	A5.5	E(X)XX13-XX
3	A5.1	EXX10, EXX11
3	A5.5	E(X)XX10-XX, E(X)XX11-XX
4	A5.1	EXX15, EXX16, EXX18, EXX18M, EXX48
4	A5.4 other than austenitic and duplex	EXXX(X)-15, EXXX(X)-16, EXXX(X)-17
4	A5.5	E(X)XX15-XX, E(X)XX16-XX, E(X)XX18-XX, E(X)XX18M, E(X)XX18M1
5	A5.4 austenitic and duplex	EXXX(X)-15, EXXX(X)-16, EXXX(X)-17
6	A5.2	RX
6	A5.9	ERXXX(XXX), ECXXX(XXX), EQXXX(XXX)
6	A5.17	FXXX-EXX, FXXX-ECX
6	A5.18	ERXXS-X, EXXC-X, EXXC-XX
6	A5.20	EXXT-X, EXXT-XM
6	A5.22	EXXXTX-X, RXXXT1-5
6	A5.23	FXXX-EXXX-X, FXXX-ECXXX-X
6	A5.23	FXXX-EXXX-XN, FXXX-ECXXX-XN
6	A5.25	FESXX-EXXX, FESXX-EWXX
6	A5.26	EGXXS-X, EGXXT-X
6	A5.28	ERXXS-XXX, EXXC-XXX
6	A5.29	EXXTX-X
6	A5.30	INXXX
Aluminum and Aluminum Alloys		
21	A5.3	E1100, E3003
21	A5.10	ER1100, R1100, ER1188, R1188
22	A5.10	ER5183, R5183, ER5356, R5356, ER5554, R5554, ER5556, R5556, ER5654, R5654
23	A5.3	E4043
23	A5.10	ER4009, R4009, ER4010, R4011, R4010, ER4043, R4043, ER4047, R4047, ER4145, R4145, ER4643, R4643
24	A5.10	R206.0, R-C355.0, R-A356.0, R357.0, R-A357.0
25	A5.10	ER2319, R2319

APPENDIX X (Continued)

ELECTRODE GROUPS

F-NUMBERS
Grouping of Electrodes and Welding Rods for Qualification

F-No.	AWS Specification	AWS Classification
Copper and Copper Alloys		
31	A5.6 and A5.7	RCu, ECu
32	A5.6	ECuSi and ERCuSi-A
33	A5.6 and A5.7	ECuSn-A, ECuSn-C, ERCuSn-A
34	A5.6, A5.7, and A5.30	ECuNi, ERCuNi, IN67
35	A5.8	RBCuZn-A, RBCuZn-B, RCuZn-C, RBCuZn-D
36	A5.6 and A5.7	ERCuAl-A1, ERCuAl-A2, ERCuAl-A3, ECuAl-A2, ECuAl-B
37	A5.6 and A5.7	RCuNiAl, ECuMnNiAl, ERCuNiAl, ERCuMnNiAl
Nickel and Nickel Alloys		
41	A5.11, A5.14, and A5.30	ENi-1, ERNi-1, IN61
42	A5.11, A5.14, and A5.30	ENiCu-7, ERNiCu-7, ERNiCu-8, IN60
43	A5.11	ENiCrFe-1, 2, 3, 4, 7, 9, and 10; ENiCrMo-2, 3, 6, and 12; ENiCrCoMo-1
43	A5.14	ERNiCr-3, 4, and 6; ERNiCrFe-5, 6, 7, 8, and 11; ERNiCrCoMo-1; ERNiCrMo-2 and 3
43	A5.30	IN6A, IN62, IN82
44	A5.11	ENiMo-1, 3, 7, 8, 9, and 10; ENiCrMo-4, 5, 7, 10, 13, and 14
44	A5.14	ERNiMo-1, 2, 3, 7 (B2), 8, 9, and 10; ERNiCrMo-4, 7 (alloy C4), 10, 13, 14; ERNiCrWMo-1
45	A5.11	ENiCrMo-1, 9, and 11
45	A5.14	ERNiCrMo-1, 8, 9, and 11; ERNiFeCr-1
Titanium and Titanium Alloys		
51	A5.16	ERTi-1, ERTi-2, ERTi-3, ERTi-4
52	A5.16	ERTi-7
53	A5.16	ERTi-9, ERTi-9ELI
54	A5.16	ERTi-12
55	A5.16	ERTi-5, ERTi-5ELI, ERTi-6, ERTi-6ELI, ERTi-15
Zirconium and Zirconium Alloys		
61	A5.24	ERZr2, ERZr3, ERZr4
Hardfacing Weld Metal Overlay		
71	A5.13 and A5.21	RXXX-X, EXXX-X
Magnesium Alloys		
91	A5.19	ER AZ61A, ER AZ92A, ER EZ33A, ER AZ101A, R AZ61A, R AZ92A, R AZ101A, R EZ33A

APPENDIX XI

WELDER QUALIFICATION TEST REQUIREMENTS

1. Tests on plate

Type of Weld	Thickness of Test Plate (T) As Welded, in.	Visual Inspection	Number of Specimens				Macroetch Test	Plate Thickness Qualified, in.
			Bend Tests			T-Joint Break		
			Face	Root	Side			
Groove	3/8	Yes	1	1	—	—	—	3/4 max[1]
Groove	3/8 < T < 1	Yes	—	—	2	—	—	1/8–2T[1]
Groove	1 or over	Yes	—	—	2	—	—	Unlimited[1]
Fillet Option No. 1	1/2	Yes	—	—	—	1	1	Unlimited
Fillet Option No. 2	3/8	Yes	—	2	—	—	—	Unlimited

Note:
(1) Also qualifies for welding fillet welds on material of unlimited thickness.

2. Tests on pipe or tubing

Type of Weld	Pipe or Tubing Size, As Welded		Visual Inspection	Number of Specimens						Pipe or Tube Size Qualified, in.	Plate, Pipe, or Tube Wall Thickness Qualified, in.	
				All Positions Except 5G and 6G			5G and 6G Positions Only					
	Diam	Nominal Thickness		Face Bend	Root Bend	Side Bend	Face Bend	Root Bend	Side Bend		Min	Max[1]
Groove	2 in. or 3 in.	Sch. 80 Sch. 40	Yes	1	1	—	2	2	—	4 or smaller	1/8	3/4[1]
Groove	6 in. or 8 in.	Sch. 120 Sch. 80	Yes	—	—	2	—	—	4	4 or larger	3/16	Unlimited[1]

Note:
(1) Also qualifies for welding fillet welds on material of unlimited thickness.

APPENDIX XI (Continued)

Welder Qualification—Type and Position Limitations

Qualification Test		Type of Weld and Position of Welding Qualified			
		Plate		Pipe	
Weld	Plate or Pipe Positions	Groove	Fillet	Groove	Fillet
Plate-Groove	1G 2G 3G 4G 3G and 4G	F F, H F, H, V F, OH All	F, H F, H F, H, V F, H, OH All	F [Note (1)] F, H [Note (1)] F, H, V (Note (1)]	F, H F, H F, H F F, H
Plate-Fillet(2)	1F 2F 3F 4F 3F and 4F		F F, H F, H, V F, H, OH All		F F, H F, H, V F, H, OH All
Pipe-Groove	1G 2G 5G 6G 2G and 5G 6GR	F F, H F, V, OH Note (3) Note (3) All	F, H F, H F, V, OH Note (3) Note (3) All	F F, H F, V, OH Note (3) Note (3) All	F, H F, H F, V, OH Note (3) Note (3) All
Pipe-Fillet	1F 2F 2F Rolled 4F 4F and 5F		F F, H F, H F, H, OH All		F F, H F, H F, H, OH All

Notes:
(1) Welders qualified to weld tubulars over 24 in. (600 mm) in diameter with backing or backgouging, for the test position indicated.
(2) Not applicable for fillet welds between parts having a dihedral angle (ψ) of 60° or less.
(3) Qualified for all except groove welds for T-, Y-, and K-connections.

APPENDIX XII

FILLET PROCEDURE QUALIFICATION REQUIREMENTS

Test Specimen	Fillet Size	Number of Welds per Procedure	Test Specimens Required			Sizes Qualified	
			Macroetch	All-Weld-Metal Tension	Side-Bend	Plate Thickness	Fillet Size
Plate T-test	Single-pass, max size to be used in construction	1 in each position to be used	3 faces	—	—	Unlimited	Max tested single-pass and smaller
	Multiple-pass, min size to be used in construction	1 in each position to be used	3 faces	—	—	Unlimited	Min tested multiple-pass and larger

APPENDIX XIII

GROOVE PROCEDURE QUALIFICATION REQUIREMENTS

1. Tests on plate

Plate Thickness (T) Tested, in.	Number of Sample Welds per Position	NDT*	Test Specimens Required				Nominal Plate Thickness Qualified, T in.**
			Reduced-Section Tension	Root-Bend	Face-Bend	Side-Bend	
1/8 ≤ T < 3/8	1	Yes	2	2	2	—	1/8 to 2T
3/8	1	Yes	2	2	2	—	1/8 to 3/4
3/8 < T < 1	1	Yes	2	—	—	4	1/8 to 2T
1 and over	1	Yes	2	—	—	4	1/8 to Unlimited

Note: All welded test plates shall be visually inspected.
*A minimum of 6 in. of effective weld length shall be tested by radiographic or ultrasonic testing prior to mechanical testing.
**For square groove welds, the maximum thickness qualified shall be limited to thickness tested.

2. Tests on pipe or tubing

Pipe Size of Sample Weld		Number of Sample Welds per Position	NDT*	Test Specimens Required				Diameter, in.	Thickness Qualified, in.	
Diam.	Wall Thickness, T			Reduced-Section Tension	Root-Bend	Face-Bend	Side-Bend		Min	Max
2 in. or 3 in.	Sch. 80 Sch. 40	2	Yes	2	2	2	—	3/4 through 4	1/8	3/4
6 in. or 8 in.	Sch. 120 Sch. 80	1	Yes	2	—	—	4	4 and over	3/16	Unlimited
Job Size Pipe or Tubing										
Diam.	Wall Thickness, T									
< 24 in.	1/8 ≤ T ≤ 3/8 in.	1	Yes	2	2	2	—	Test diam. and over	1/8	2T
	3/8 < T < 3/4 in.	1	Yes	2	—	—	4		T/2	2T
	T ≥ 3/4 in.	1	Yes	2	—	—	4		3/8	Unlimited
≥ 24 in.	1/8 ≤ T ≤ 3/8 in.	1	Yes	2	2	2	—	Test diam. and over	1/8	2T
	3/8 < T < 3/4 in.	1	Yes	2	—	—	4	24 and over	T/2	2T
	T ≥ 3/4 in.	1	Yes	2	—	—	4	24 and over	3/8	Unlimited

Note: All welded test plates shall be visually inspected.
*For pipe or tubing, the full circumference of the completed weld shall be tested by RT or UT prior to mechanical testing.

APPENDIX XIV

PREQUALIFIED BASE METAL—FILLER METAL COMBINATIONS FOR MATCHING STRENGTH[7, 9]

Group	Steel Specification Requirements						Filler Metal Requirements		
			Minimum Yield Point/Strength		Tensile Range				
	Steel Specification[1, 2]		ksi	MPa	ksi	MPa	Process	AWS Electrode Specification[3]	Electrode Classification[10]
I	ASTM A 36[4]		36	250	58–80	400–550	SMAW	A5.1	E60XX, E70XX
	ASTM A 53	A5.5	35	240	60 min	415 min		A5.5[6]	E70XX-X
	ASTM A 106	Grade B	35	240	60 min	415 min			
	ASTM A 131	Grades A, B, CS, D, DS, E	34	235	58–71	400–490			
	ASTM A 139	Grade B	35	241	60 min	414 min	SAW	A5.17	F6XX-EXXX, F6XX-ECXXX, F7XX-EXXX, F7XX-ECXXX
	ASTM A 381	Grade Y35	35	240	60 min	415 min			
	ASTM A 500	Grade A	33	228	45 min	310 min		A5.23[6]	F7XX-EXXX-XX, F7XX-ECXXX-XX
		Grade B	42	290	58 min	400 min			
	ASTM A 501		36	250	58 min	400 min			
	ASTM A 516	Grade 55	30	205	55–75	380–515			
		Grade 60	32	220	60–80	415–550			
	ASTM A 524	Grade I	35	240	60–85	415–586	GMAW	A5.18	ER70S-X, E70C-XC, E70C-XM (Electrodes with the -GS suffix are excluded)
		Grade II	30	205	55–80	380–550			
	ASTM A 529		42	290	60–85	415–585			
	ASTM A 570	Grade 30	30	205	49 min	340 min		A5.28[6]	ER70S-XXX, E70C-XXX
		Grade 33	33	230	52 min	360 min			
		Grade 36	36	250	53 min	365 min			
		Grade 40	40	275	55 min	380 min	FCAW	A5.20	E6XT-X, E6XT-XM, E7XT-X, E7XT-XM (Electrodes with the -2, -2M, -3, -10, -13, -14X, and -GS suffix are excluded)
		Grade 45	45	310	60 min	415 min			
	ASTM A 573	Grade 65	35	240	65–77	450–530			
		Grade 58	32	220	58–71	400–490			
	ASTM A 709	Grade 36[4]	36	250	58–80	400–550			
	API 5L	Grade B	35	240	60	415		A5.29[6]	E6XTX-X, E6XT-XM, E7XTX-X, E7XTX-XM
		Grade X42	42	290	60	415			
	ABS	Grades A, B, D, CS, DS			58–71	400–490			
		Grade E[5]			58–71	400–490			

Note: ASTM A 570 Grade 50 has been deleted from Group I and added to Group II.

(continued)

APPENDIX XIV (Continued)

Group	Steel Specification Requirements						Filler Metal Requirements		
			Minimum Yield Point/Strength		Tensile Range				
	Steel Specification[1, 2]		ksi	MPa	ksi	MPa	Process	AWS Electrode Specification[3]	Electrode Classification[10]
II	ASTM A 131	Grades AH32, DH32, EH32	46	315	68–85	470–585	SMAW	A5.1	E7015, E7016, E7018, E7028
		Grades AH36, DH36, EH36	51	350	71–90	490–620			
	ASTM A 441		40–50	275–345	60–70	415–485		A5.5[6]	E7015-X, E7016-X, E7018-X
	ASTM A 516	Grade 65	35	240	65–85	450–585			
		Grade 70	38	260	70–90	485–620			
	ASTM A 537	Class 1	45–50	310–345	65–90	450–620	SAW	A5.17	F7XX-EXXX, F7XX-ECXXX
	ASTM A 570	Grade 50	50	345	65	450			
		Grade 55	55	380	70	480		A5.23[6]	F7XX-EXXX-XX, F7XX-ECXXX-XX
	ASTM A 572	Grade 42	42	290	60 min	415 min			
	ASTM A 572	Grade 50	50	345	65 min	450 min			
	ASTM A 588[5]	(4 in. [100 mm] and under)	50	345	70 min	485 min			
	ASTM A 595	Grade A	55	380	65 min	450 min			
		Grades B and C	60	415	70 min	480 min	GMAW	A5.18	ER70S-X, E70C-XC, E70C-XM (Electrodes with the -GS suffix are excluded)
	ASTM A 606[5]		45–50	310–340	65 min	450 min			
	ASTM A 607	Grade 45	45	310	60 min	410 min			
		Grade 50	50	345	65 min	450 min			
		Grade 55	55	380	70 min	480 min		A5.28[6]	ER70S-XXX, E70C-XXX
	ASTM A 618	Grades Ib, II, III	46–50	315–345	65 min	450 min			
	ASTM A 633	Grade A	42	290	63–83	430–570			
		Grades C, D (2-1/2 in. [65 mm] and under)	50	345	70–90	485–620	FCAW	A5.20	E7XT-X, E7XT-XM (Electrodes with the -2, -2M, -3, -10, -13, -14, and -GS suffix are excluded)
	ASTM A 709	Grade 50	50	345	65 min	450 min			
		Grade 50W	50	345	70 min	485 min			
	ASTM A 710	Grade A, Class 2 > 2 in. (50 mm)	55	380	65 min	450 min			
	ASTM A 808	(2-1/2 in. [65 mm] and under)	42	290	60 min	415 min			
	ASTM A 913	Grade 50	50	345	65 min	450 min		A5.29[6]	E7XTX-X, E7XTX-XM
	ASTM A 992		50–65	345–450	65	450			
	API 2H	Grade 42	42	290	62–80	430–550			
		Grade 50	50	345	70 min	485 min			
	API 2W	Grade 42	42–67	290–462	62 min	427 min			
		Grade 50	50–75	345–517	65 min	448 min			
		Grade 50T	50–80	345–552	70 min	483 min			
	API 2Y	Grade 42	42–67	290–462	62 min	427 min			
		Grade 50	50–75	345–517	65 min	448 min			
		Grade 50T	50–80	345–552	70 min	483 min			
	API 5L	Grade X52	52	360	66–72	455–495			
	ABS	Grades AH32, DH32, EH32	45.5	315	71–90	490–620			
		Grades AH36, DH36, EH36[5]	51	350	71–90	490–620			

(continued)

APPENDIX XIV (Continued)

Group	Steel Specification Requirements						Filler Metal Requirements		
			Minimum Yield Point/Strength		Tensile Range				
	Steel Specification[1, 2]		ksi	MPa	ksi	MPa	Process	AWS Electrode Specification[3]	Electrode Classification[7]
III	API 2W	Grade 60	60–90	414–621	75 min	517 min	SMAW	A5.5[6]	E8015-X, E8016-X, E8018-X
	API 2Y	Grade 60	60–90	414–621	75 min	517 min			
	ASTM A 572	Grade 60	60	415	75 min	515 min	SAW	A5.23[6]	F8XX-EXXX-XX, F8XX-ECXXX-XX
		Grade 65	65	450	80 min	550 min			
	ASTM A 537	Class 2[5]	46–60	315–415	80–100	550–690			
	ASTM A 633	Grade E[5]	55–60	380–415	75–100	515–690	GMAW	A5.28[6]	ER80S-XXX, E80C-XXX
	ASTM A 710	Grade A, Class 2 ≤ 2 in. (50 mm)	60–65	415–450	72 min	495 min			
	ASTM A 710	Grade A, Class 3 > 2 in. (50 mm)	60–65	415–450	70 min	485 min	FCAW	A5.29[6]	E8XTX-X, E8XTX-XM
	ASTM A 913[8]	Grade 60	60	415	75 min	520 min			
		Grade 65	65	450	80 min	550 min			
IV	ASTM A 709	Grade 70W	70	485	90–110	620–760	SMAW	A5.5[6]	E9015-X, E9016-X, E9018-X, E9018-M
	ASTM A 852		70	485	90–110	620–760	SAW	A5.23[6]	F9XX-EXXX-XX, F9XX-ECXXX-XX
							GMAW	A5.28[6]	ER90S-XXX, E90C-XXX
							FCAW	A5.29[6]	E9XTX-X, E9XTX-XM

Notes:
1. In joints involving base metals of different groups, either of the following filler metals may be used: (1) that which matches the higher strength base metal, or (2) that which matches the lower strength base metal and produces a low-hydrogen deposit. Preheating shall be in conformance with the requirements applicable to the higher strength group.
2. Match API standard 2B (fabricated tubes) according to steel used.
3. When welds are to be stress-relieved, the deposited weld metal shall not exceed 0.05 percent vanadium.
4. Only low-hydrogen electrodes shall be used when welding ASTM A 36 or ASTM A 709 Grade 36 steel more than 1 in. (25 mm) thick for cyclically loaded structures.
5. Special welding materials and WPS (e.g., E80XX-X low-alloy electrodes) may be required to match the notch toughness of base metal (for applications involving impact loading or low temperature), or for atmospheric corrosion and weathering characteristics (see 3.7.3).
6. Filler metals of alloy group B3, B3L, B4, B4L, B5, B5L, B6, B6L, B7, B7L, B8, B8L, B9, or any BXH grade in AWS A5.5, A5.23, A5.28, or A5.29 are not prequalified for use in the as-welded condition.
7. AWS A5M (SI Units) electrodes of the same classification may be used in lieu of the AWS A5 (U.S. Customary Units) electrode classification.
8. The heat input limitations of 5.7 shall not apply to ASTM A 913 Grade 60 or 65.

APPENDIX XV

MINIMUM PREHEAT AND INTERPASS TEMPERATURE[3,4]

Category	Steel Specification				Welding Process	Thickness of Thickest Part at Point of Welding		Minimum Preheat and Interpass Temperature	
						in.	mm	°F	°C
A	ASTM A 36[2]		ASTM A 516	Grades 55 & 60	Shielded metal arc welding with other than low-hydrogen electrodes	Up to 3/4	19 incl.	None[1]	
	ASTM A 53	Grade B	ASTM A 524	Grades I & II					
	ASTM A 106	Grade B	ASTM A 529			Over 3/4	19		
	ASTM A 131	Grades A, B,	ASTM A 570	All grades		thru 1-1/2.	38 incl.	150	66
		CS, D, DS, E	ASTM A 573	Grade 65					
	ASTM A 139	Grade B	ASTM A 709	Grade 36[2]		Over 1-1/2	38		
	ASTM A 381	Grade Y35	API 5L	Grade B		thru 2-1/2	64	225	107
	ASTM A 500	Grade A	API 5LX	Grade X42					
		Grade B	ABS	Grades A, B, D, CS, DS					
	ASTM A 501			Grade E		Over 2-1/2	64	300	150
B	ASTM A 36[2]		ASTM A 570	All grades	Shielded metal arc welding with low-hydrogen electrodes, submerged arc welding,[2] gas metal arc welding, flux cored arc welding				
	ASTM A 53	Grade B	ASTM A 572	Grades 42, 50					
	ASTM A 106	Grade B	ASTM A 573	Grade 65					
	ASTM A 131	Grades A, B,	ASTM A 588						
		CS, D, DS, E	ASTM A 595	Grades A, B, C		Up to 3/4	19 incl.	None[1]	
		AH 32 & 36	ASTM A 606						
		DH 32 & 36	ASTM A 607	Grades 45, 50, 55					
		EH 32 & 36	ASTM A 618						
	ASTM A 139	Grade B	ASTM A 633	Grades A, B					
	ASTM A 242			Grades C, D		Over 3/4	19		
	ASTM A 381	Grade Y35	ASTM A 709	Grades 36, 50, 50W		thru 1-1/2	38 incl.	50	10
	ASTM A 441		API 5L	Grade B					
	ASTM A 500	Grade A	API 5LX	Grade X42					
		Grade B	API Spec. 2H			Over 1-1/2	38		
	ASTM A 501		ABS	Grades AH 32 & 36		thru 2-1/2	64 incl.	150	66
	ASTM A 516	Grades 55 & 60		DH 32 & 36					
		65 & 70		EH 32 & 36					
	ASTM A 524	Grades I & II	ABS	Grades A, B, D,					
	ASTM A 529			CS, DS		Over 2-1/2	64	225	107
	ASTM A 537	Classes 1 & 2		Grade E					

(continued)

APPENDIX XV (Continued)

Category	Steel Specification		Welding Process	Thickness of Thickest Part at Point of Welding		Minimum Preheat and Interpass Temperature	
				in.	mm	°F	°C
C	ASTM A 572 ASTM A 633 API 5LX	Grades 60, 65 Grade E Grade X52	Shielded metal arc welding with low hydrogen electrodes, submerged arc welding, gas metal arc welding, or flux cored arc welding	Up to 3/4	19 incl.	50	10
				Over 3/4 thru 1-1/2	19 38 incl.	150	66
				Over 1-1/2 thru 2-1/2	38 64 incl.	225	107
				Over 2-1/2	64	300	150
D	ASTM A 514 ASTM A 517 ASTM A 709	Grades 100 & 100W	Shielded metal arc welding with low hydrogen electrodes, submerged arc welding with carbon or alloy steel wire, neutral flux, gas metal arc welding, flux cored arc welding	Up to 3/4	19 incl.	50	10
				Over 3/4 thru 1-1/2	19 38 incl.	125	50
				Over 1-1/2 thru 2-1/2	38 64 incl.	175	80
				Over 2-1/2	64	225	107

Notes:

A. Zero °F (–18°C) does not mean the ambient environmental temperature but the temperature in the immediate vicinity of the weld. The ambient environmental temperature may be below 0°F, but a heated structure or shelter around the area being welded could maintain the temperature adjacent to the weldment at 0°F or higher.

1. When the base metal temperature is below 32°F (0°C), the base metal shall be preheated to at least 70°F (20°C) and this minimum temperature maintained during welding.
2. Only low hydrogen electrodes shall be used when welding A 36 or A 709 Grade 36 steel more than 1 in. thick for bridges.
3. Welding shall not be done when the ambient temperature is lower than 0°F (–32°C). When the base metal is below the temperature listed for the welding process being used and the thickness of material being welded, it shall be preheated (except as otherwise provided) in such manner that the surfaces of the parts on which weld metal is being deposited are at or above the specified minimum temperature for a distance equal to the thickness of the part being welded, but not less than 3 in. (76 mm) in all directions from the point of welding. Preheat and interpass temperatures must be sufficient to prevent crack formation. Temperature above the minimum shown may be required for highly restrained welds. For ASTM A 514, A 517, and A 709 Grades 100 and 100W steel, the maximum preheat and interpass temperature shall not exceed 400°F (205°C) for thickness up to 1-1/2 in. (38 mm) inclusive, and 450°F (230°C) for greater thickness. Heat input when welding ASTM A 514, A 517, and A 709 Grades 100 and 100W steel shall not exceed the steel producer's recommendations. ASTM A 415 and A 517 material are not recommended to be post weld heat treated.
4. In joints involving combinations of base metals, preheat shall be as specified for the higher strength steel being welded.

APPENDIX XVI

RADIOGRAPHIC TESTING

1. Welding Procedure Qualification

1.1 After meeting visual inspection acceptance criteria and before preparing mechanical test specimens, the procedure qualification test specimens, the qualification test plate, pipe, or tubing shall be nondestructively tested for soundness.

1.2 Either radiographic or ultrasonic testing shall be used. The entire length of the weld in the test plates, except the discard lengths at each end, shall be examined.

1.3 For acceptable qualification, the weld, as revealed by radiographic or ultrasonic testing, shall conform to the requirements of paragraph 3.

2. Welder Performance Qualification

2.1 Except for joints welded by GMAW-S, radiographic examination of a welder or welding operator qualification test plate or test pipe may be made in lieu of guided bend tests.

2.1.1 If RT is used in lieu of the prescribed bend tests, the weld reinforcement need not be ground or otherwise smoothed for inspection unless its surface irregularities or juncture with the base mental would cause objectionable weld discontinuities to be obscured in the radiograph. If the backing is removed for radiography, the root shall be ground flush with the base metal.

2.1.2 For welder qualification, exclude 1-1/4 in. (32 mm) at each end of the weld from evaluation in the plate test; for welding operator qualification exclude 3 in. (75 mm) at each end of the test plate length. Welded test pipe or tubing 4 in. (100 mm) in diameter or larger shall be examined for a minimum of one-half of the weld perimeter selected to include a sample of all positions welded.

2.1.3 For acceptable qualification, the weld, as revealed by the radiograph, shall conform to the requirements of 3.1.

3. Radiographic Inspection

Discontinuities other than cracks shall be evaluated on the basis of being either elongated or rounded. Regardless of the type of discontinuity, an elongated discontinuity is one in which its length exceeds three times its width. A rounded discontinuity is one in which its length is three its width or less and may be round or irregular and may have tails.

3.1 **Acceptance Criteria for Cyclically Loaded Nontubular Connections.** Welds that are subject to radiographic testing in addition to visual inspection shall have no cracks and shall be unacceptable if the radiographic testing shows any of the types of discontinuities listed in 3.1.1 and 3.1.2.

APPENDIX XVI (Continued)

3.1.1 For welds subjected to tensile stress under any condition of loading, the greatest dimension of any porosity or fusion-type discontinuity that is 1/16 in. (2 mm) or larger in greatest dimension shall not exceed the size, B indicated in Figure 6.4, for the weld size involved. The distance from any porosity or fusion-type discontinuity described above to another such discontinuity, to an edge, or to the toe or root of any intersecting flange-to-web weld shall be not less than the minimum clearance allowed, C, indicated in Figure 6.4 on page 25, for the size of discontinuity under examination.

3.1.2 Independent of the requirements of 3.1.1, discontinuities having a greatest dimension of less than 1/16 in. (2 mm) shall be unacceptable if the sum of their greatest dimensions exceeds 3/8 in. (10 mm) in any linear inch (25.4 mm) of weld.

APPENDIX XVI (Continued)

HOLE-TYPE IMAGE QUALITY INDICATOR (IQI) REQUIREMENTS

Nominal Material Thickness[1] Range, in.	Nominal Material Thickness[1] Range, mm	Source Side		Film Side[2]	
		Designation	Essential Hole	Designation	Essential Hole
Up to 0.25 incl.	Up to 6 incl.	10	4T	7	4T
Over 0.25 to 0.375	Over 6 through 10	12	4T	10	4T
Over 0.375 to 0.50	Over 10 through 12	15	4T	12	4T
Over 0.50 to 0.625	Over 12 through 16	15	4T	12	4T
Over 0.625 to 0.75	Over 16 through 20	17	4T	15	4T
Over 0.75 to 0.875	Over 20 through 22	20	4T	17	4T
Over 0.875 to 1.00	Over 22 through 25	20	4T	17	4T
Over 1.00 to 1.25	Over 25 through 32	25	4T	20	4T
Over 1.25 to 1.50	Over 32 through 38	30	2T	25	2T
Over 1.50 to 2.00	Over 38 through 50	35	2T	30	2T
Over 2.00 to 2.50	Over 50 through 65	40	2T	35	2T
Over 2.50 to 3.00	Over 65 through 75	45	2T	40	2T
Over 3.00 to 4.00	Over 75 through 100	50	2T	45	2T
Over 4.00 to 6.00	Over 100 through 150	60	2T	50	2T
Over 6.00 to 8.00	Over 150 through 200	80	2T	60	2T

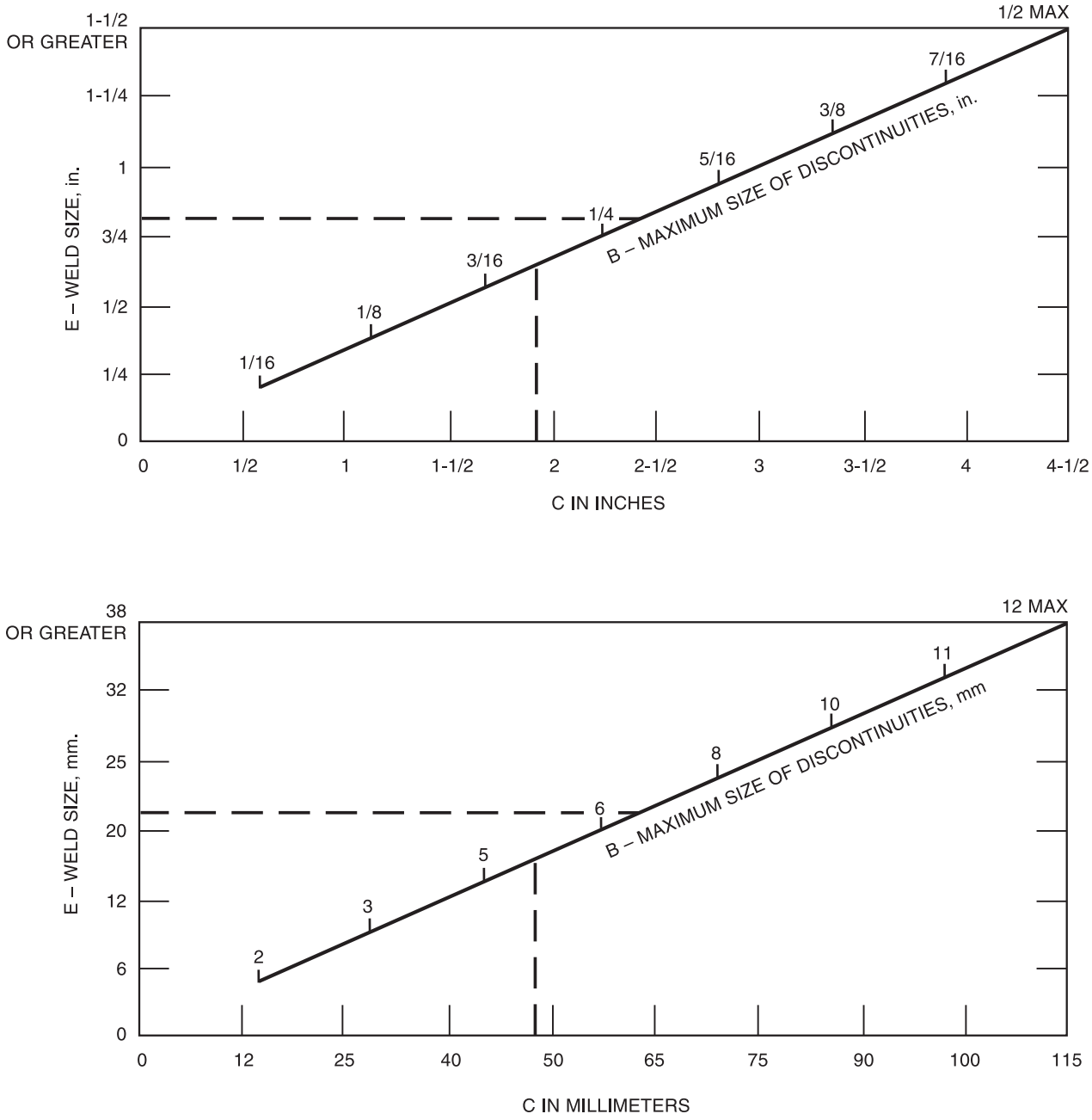
Notes:
(1) Single-wall radiographic thickness (for tubulars).
(2) Applicable to tubular structures only.

WIRE IMAGE QUALITY INDICATOR (IQI) REQUIREMENTS

Nominal Material Thickness[1] Range, in.	Nominal Material Thickness[1] Range, mm	Source Side Maximum Wire Diameter		Film Side[2] Maximum Wire Diameter	
		in.	mm	in.	mm
Up to 0.25 incl.	Up to 6 incl.	0.010	0.25	0.008	0.20
Over 0.25 to 0.375	Over 6 to 10	0.013	0.33	0.010	0.25
Over 0.375 to 0.625	Over 10 to 16	0.016	0.41	0.013	0.33
Over 0.625 to 0.75	Over 16 to 20	0.020	0.51	0.016	0.41
Over 0.75 to 1.50	Over 20 to 38	0.025	0.63	0.020	0.51
Over 1.50 to 2.00	Over 38 to 50	0.032	0.81	0.025	0.63
Over 2.00 to 2.50	Over 50 to 65	0.040	1.02	0.032	0.81
Over 2.50 to 4.00	Over 65 to 100	0.050	1.27	0.040	1.02
Over 4.00 to 6.00	Over 100 to 150	0.063	1.60	0.050	1.27
Over 6.00 to 8.00	Over 150 to 200	0.100	2.54	0.063	1.60

Notes:
(1) Single-wall radiographic thickness (for tubulars).
(2) Applicable to tubular structures only.

APPENDIX XVI (Continued)



General Notes:
- To determine the maximum size of discontinuity allowed in any joint or weld size, project E horizontally to B.
- To determine the minimum clearance allowed between edges of discontinuities of any size, project B vertically to C.
- See Legend below for definitions.

Figure 6.4—Weld Quality Requirements for Discontinuities Occurring in Cyclically Loaded Nontubular Tension Welds (Limitations of Porosity and Fusion Discontinuities)

APPENDIX XVI (Continued)

Legend

Dimensions of Discontinuities

B = Maximum allowed dimension of a radiographed discontinuity.

L = Largest dimension of a radiographed discontinuity.

L' = Largest dimension of adjacent discontinuities.

C = Minimum clearance measured along the longitudinal axis of the weld between edges of porosity or fusion-type discontinuities (larger of adjacent discontinuities governs), or to an edge or an end of an intersecting weld.

C_1 = Minimum allowed distance between the nearest discontinuity to the free edge of a plate or tubular, or the intersection of a longitudinal weld with a girth weld, measured parallel to the longitudinal weld axis.

W = Smallest dimension of either of adjacent discontinuities.

Material Dimensions

E = Weld size.

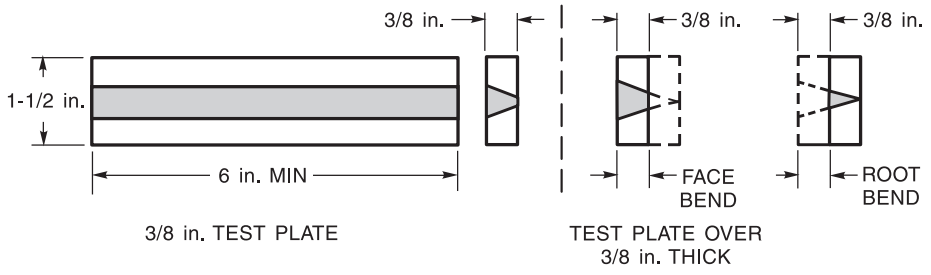
T = Plate or pipe thickness for CJP groove welds.

Definitions of Discontinuities

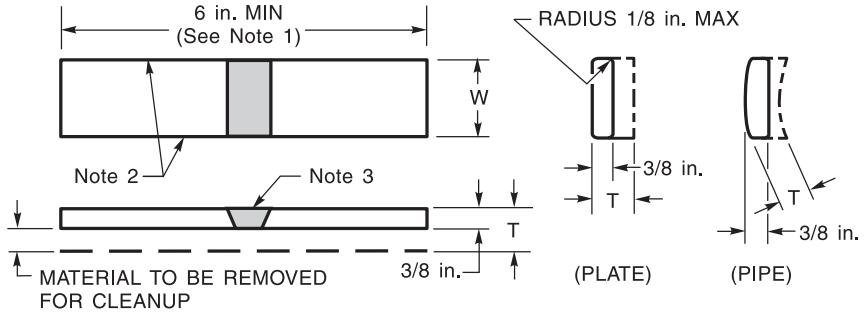
- An elongated discontinuity shall have the largest dimension (L) exceed 3 times the smallest dimension.
- A rounded discontinuity shall have the largest dimension (L) less than or equal to 3 times the smallest dimension.
- A cluster shall be defined as a group of nonaligned, acceptably-sized, individual adjacent discontinuities with spacing less than the minimum allowed (C) for the largest individual adjacent discontinuity (L'), but with the sum of the greatest dimensions (L) of all discontinuities in the cluster equal to or less than the maximum allowable individual discontinuity size (B). Such clusters shall be considered as individual discontinuities of size L for the purpose of assessing minimum spacing.
- Aligned discontinuities shall have the major axes of each discontinuity approximately aligned.

APPENDIX XVII

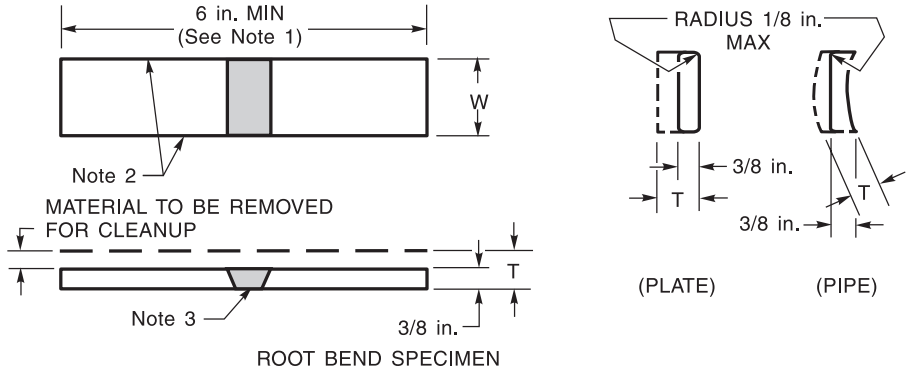
FACE AND ROOT BEND SPECIMENS



(1) LONGITUDINAL BEND SPECIMEN



FACE BEND SPECIMEN



ROOT BEND SPECIMEN

(2) TRANSVERSE BEND SPECIMEN

Dimensions	
Test Weldment	Test Specimen Width, W in.
Plate	1-1/2
Test pipe or tube ≤ 4 in. in diameter	1
Test pipe or tube > 4 in. in diameter	1-1/2

General Notes:
- T = plate or pipe thickness.
- When the thickness of the test plate is less than 3/8 in. [10 mm], the nominal thickness shall be used for face and root bends.

Notes:
1. A longer specimen length may be necessary when using a wraparound type bending fixture or when testing steel with a yield strength of 90 ksi [620 MPa] or more.
2. These edges may be thermal-cut and may or may not be machined.
3. The weld reinforcement and backing, if any, shall be removed flush with the surface of the specimen. If a recessed backing is used, this surface may be machined to a depth not exceeding the depth of the recess to remove the backing; in such a case, the thickness of the finished specimen shall be that specified above. Cut surfaces shall be smooth and parallel.

Creating a WPS

Welding Procedure Specification

1 On the Tool Bar, click on the small drop-down arrow next to the "New" icon. Select **ASME IX WPS**.

For automatic creation of a WPS, please see item 16 on the following page.

2 Begin filling out the record by entering the header information. While filling out this record, make sure to take advantage of the drop-down menus and databases rather than typing the information manually.

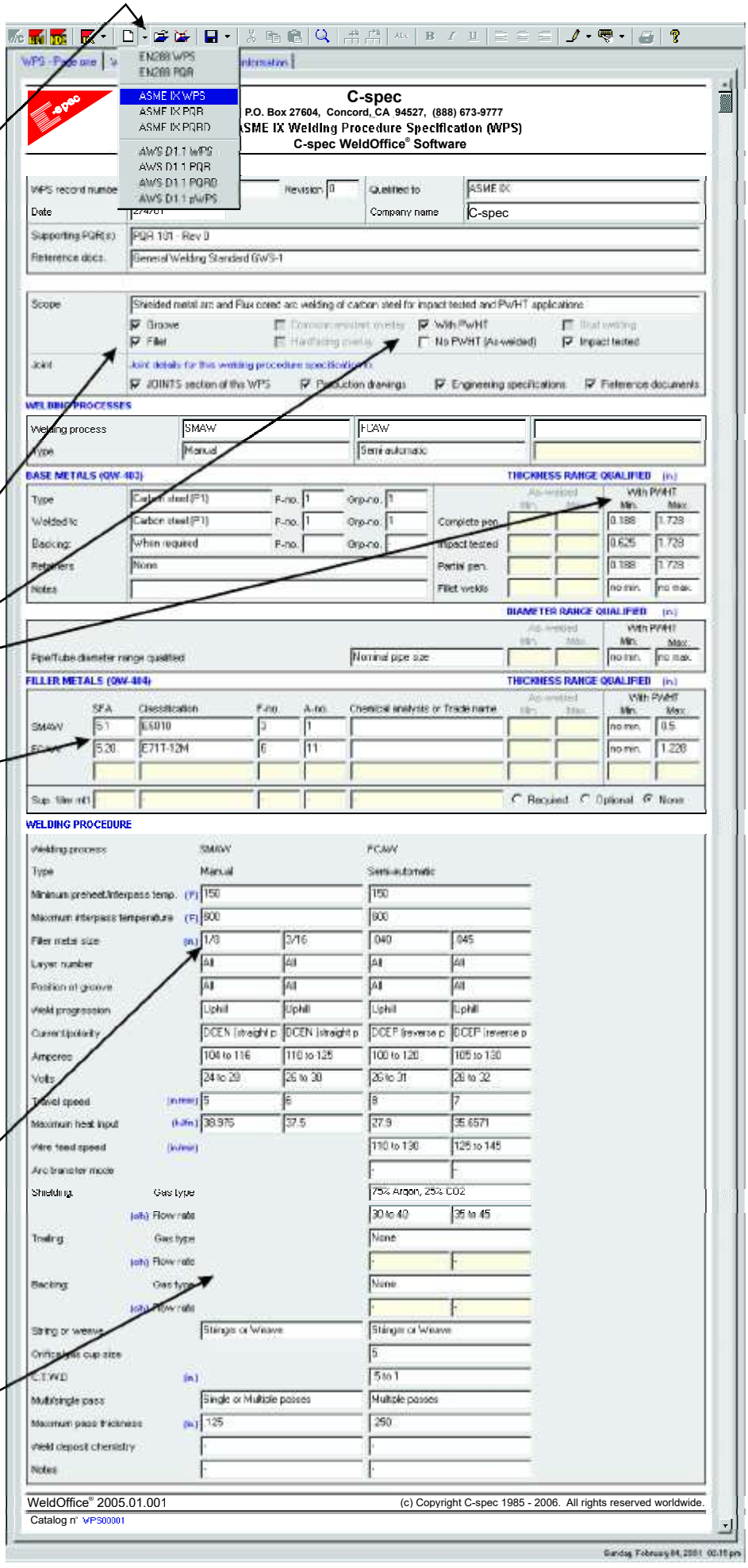
3 Take notice of the check marks in the "Scope" section of this example. The dynamic forms in WeldOffice ® use these marks to determine which fields are needed. For example, when "With PWHT" is **not** selected, WeldOffice® will not require data to be entered for PWHT

4 When specifying the filler metal, remember to select it from the Filler Material Database instead of manually typing the information. To do this, place the cursor in the "SFA" field and click on the database icon . Locate and select the desired filler metal(s) and then press the Accept button. Notice that WeldOffice® enters the proper SFA, Classification, F and A numbers automatically.
Note: Multiple filler metal classifications may be specified. Everything that is selected will appear in the Notes section on page 2.

5 WeldOffice® allows you to specify up to three welding processes. Additionally, you can also specify up to five filler metal sizes for each process. To do this, click inside the "Filler metal size" field and then locate the Add Column icon on the Tool Bar at the top of the screen. Click this icon and watch how this field splits with each click. This will also split all other applicable fields allowing specific data to be entered for each filler metal size.

6 Notice that there are no Gas fields available for SMAW. This is another feature of the dynamic forms. WeldOffice® prevents entry of non-relevant information and minimizes potential introduction of errors.

See next page for page two data entry instructions.



Creating a WPS
(Page 2)

7 To enter data into the second page of the WPS, click on the tab at the top of the page entitled "**WPS - Page Two**".

8 WeldOffice® is equipped with a comprehensive database of typical joint details already drawn for you. For more information on these sketches refer to the **Drawings & Sketches** section.

9 To specify the applicable preheat for the materials entered on page one, simply select up to four standards from WeldOffice®'s drop down lists and the Code Checking will supply the appropriate data.

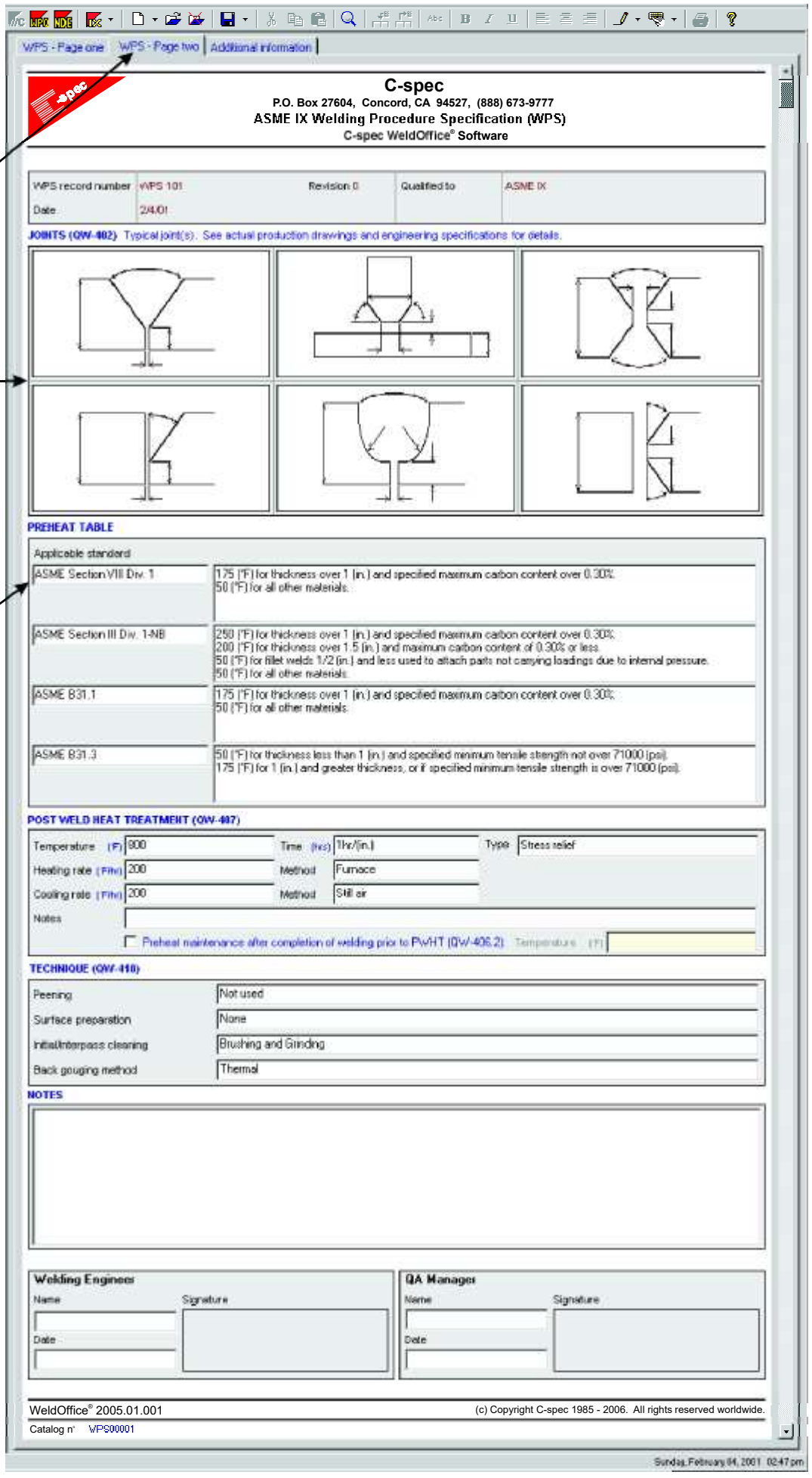
10 **Printing this WPS:**

When you are ready to print this record, go to the top of the screen and click on **File**. Then select the second print option which will say something like Print **Unassigned ASME WPS 00001**.

11 **Automatically create a WPS from a PQR:**

Another way to create a WPS is to have WeldOffice® automatically generate the WPS off of a PQR. To do this you will need to open a completed PQR. If you have not yet made a PQR, please follow the instructions for creating a PQR.

With a PQR opened, go to the top of the screen and click on **File / Save As New**. Then select **WPS**. WeldOffice® will begin to take all applicable data from the PQR and place it on the WPS. Additionally, notice how the Code Checking supplies you with even more data straight out of the code such as the Thickness and Diameter ranges qualified.



C-spec

P.O. Box 27604, Concord, CA 94527

ASME IX Welding Procedure Specification (WPS)

C-spec WeldOffice® Software

WPS record number	WPS-101 Revision 0	Qualified to	ASME IX
Date	1/25/02	Company name	C-spec
Supporting PQR(s) Reference docs.	PQR-101 - Rev 0		

Scope	Shielded metal arc and Flux cored arc welding of carbon steel for impact tested and PWHT application Groove, fillet, no PWHT (As-welded), impact testing, with PWHT
Joint	Joint details for this welding procedure specification in: JOINTS section of this WPS, Production drawings, Engineering specifications, Reference documents

BASE METALS (QW-403)

Type	Carbon steel (P1)	P-no. 1	Grp-no. 1
Welded to	Carbon steel (P1)	P-no. 1	Grp-no. 1
Backing:	None	P-no. -	Grp-no. -
Retainers	None		
Notes			

THICKNESS RANGE QUALIFIED (in.)

	As-welded Min.	As-welded Max.	With PWHT Min.	With PWHT Max.
Complete pen.	0.063	0.75	0.063	0.75
Impact tested	0.375	0.75	0.375	0.75
Partial pen.	0.063	0.75	0.063	0.75
Fillet welds	no min.	no max.	no min.	no max.

DIAMETER RANGE QUALIFIED (in.)

	As-welded Min.	As-welded Max.	With PWHT Min.	With PWHT Max.
Nominal pipe size	no min.	no max.	no min.	no max.

FILLER METALS (QW-404)

	SFA	Classification	F-no.	A-no.	Chemical analysis or Trade name	THICKNESS RANGE QUALIFIED (in.) As-welded Min.	As-welded Max.	With PWHT Min.	With PWHT Max.
SMAW	5.1	E6010 (smaw note)	3	1		no min.	0.25	no min.	0.25
FCAW	5.20	E70T-12 (fcaw note)	6	11		no min.	0.5	no min.	0.5
Sup. filler	-	-	-	-	-	- None -			

WELDING PROCEDURE

Welding process		SMAW		FCAW	
Type		Manual		Semi-automatic	
Preheat temperature	(°F)	70		200	
Maximum interpass temperature	(°F)	425		450	
Filler metal size	(in.)	3/32	1/8	1/8	3/32
Layer number		All	All	All	All
Position of groove		All	All	All	All
Weld progression		Uphill	Uphill	Uphill & Downhill	Uphill & Downhill
Current/polarity		DCEP (reverse polarity)	DCEP (reverse polarity)	DCEP (reverse polarity)	DCEP (reverse polarity)
Amperes		100 - 115	110 - 135	110 - 135	120 - 180
Volts		28 - 32	27 - 33	27 - 32	28 - 34
Travel speed	(in./min)	6 - 8	7 - 9	7 - 10	7 - 11
Maximum heat input	(kJ/in.)	28.0	29.5714	34.7143	40.8
Wire feed speed	(in./min)	-		120 - 145	130 - 160
Arc transfer mode		-		Spray	Spray
Shielding: Gas type		-		75% Argon, 25% CO2	
Flow rate	(cfh)	-		30	30
Trailing: Gas type		-		None	
Flow rate	(cfh)	-		-	-
Backing: Gas type		-		None	
Flow rate	(cfh)	-		-	-
String or weave		Stringer or Weave		Stringer or Weave	
Orifice/gas cup size		-		.5	
C.T.W.D		-		.75	
Multi/single pass		Single or multiple passes		Single or multiple passes	
Maximum pass thickness		0.500		0.500	
Weld deposit chemistry					
Notes					

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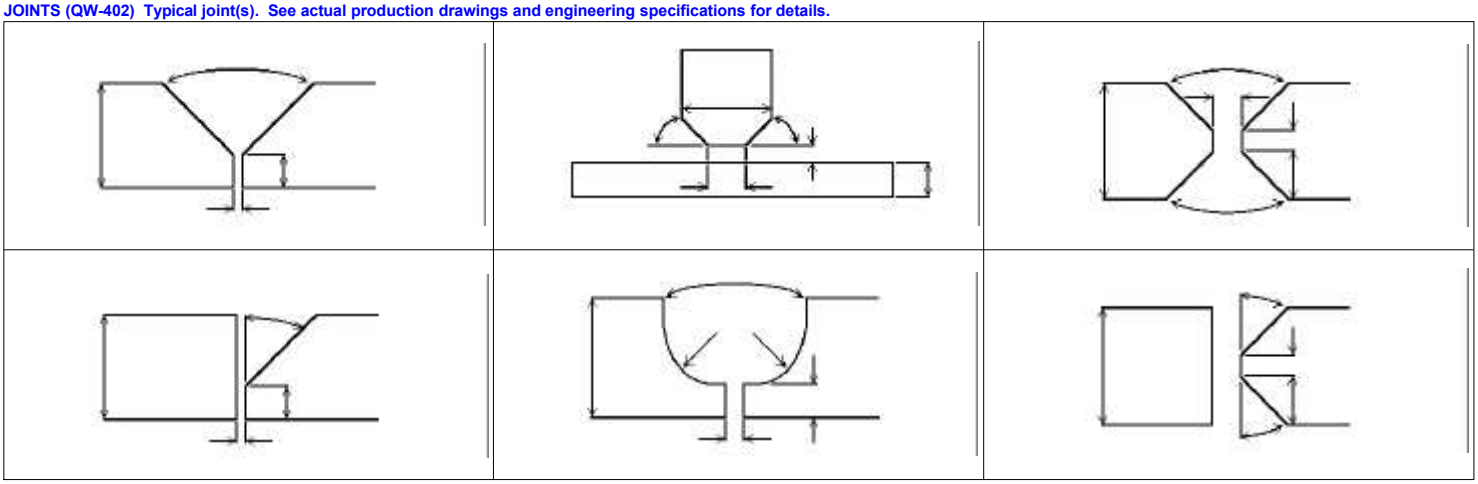
ASME IX Welding Procedure Specification (WPS)

C-spec WeldOffice® Software

WPS record number	WPS-101 Revision 0	Qualified to	ASME IX
Date	1/25/02	Company name	C-spec

JOINTS (QW-402) Typical joint(s). See actual production drawings and engineering specifications for details.



PREHEAT TABLE

Applicable standard	
ASME Section VIII Div. 1	175 (°F) for thickness over 1 (in.) and specified maximum carbon content over 0.30%. 50 (°F) for all other materials.
ASME Section III Div. 1-NB	250 (°F) for thickness over 1 (in.) and specified maximum carbon content over 0.30%. 200 (°F) for thickness over 1.5 (in.) and maximum carbon content of 0.30% or less. 50 (°F) for fillet welds 1/2 (in.) and less used to attach parts not carrying loadings due to internal pressure. 50 (°F) for all other materials.
ASME B31.1	175 (°F) for thickness over 1 (in.) and specified maximum carbon content over 0.30%. 50 (°F) for all other materials.
ASME B31.3	50 (°F) for thickness less than 1 (in.) and specified minimum tensile strength not over 71000 (psi). 175 (°F) for 1 (in.) and greater thickness, or if specified minimum tensile strength is over 71000 (psi).

POST WELD HEAT TREATMENT (QW-407)

Temperature	(°F)	800	Time	(hrs)	1hr/(in.)	Type	Stress relief
Heating rate	(°F/hr)	200	Method		Furnace		
Cooling rate	(°F/hr)	200	Method		Still air		
Notes							

TECHNIQUE (QW-410)

Peening	Not used
Surface preparation	None
Initial/interpass cleaning	Brushing and Grinding
Back gouging method	Thermal

NOTES

NOTES:
The following AWS/SFA classifications can be used with this procedure:

(smaw note) E6010, E6011
(fcaw note) E70T-12, E70T-12M, E71T-12, E71T-12M

Welding Engineer

Name	Signature
Date	

QA Manager

Name	Signature
Date	

Annex VII (Informative)
Welding Procedure Specification (WPS)

WPS Number [1]	Date [2]	Revision [3]	Page 1 of 2

SUPPORTING PQR (s) ID.
[4]

SCOPE
[5]

WELDING PROCESS(ES) & TYPE	
Process(es):	[6]

JOINT DESIGN	
Joint Design:	[7]
Root Spacing:	[8]
Backing Material:	[9]
Treatment of backside, method of gouging/preparation:	[10]
Maximum Mismatch:	[11]
Typical Joint Details:	[12]

[13]

BASE METALS							
M-No.	[14]	Group No.	[15]	To M-No.	[16]	Group No.	[17]

Thickness Range Qualified:	[18]
Diameter (Tubular Only):	[19]
Coating Description or Type:	[20]

FILLER METALS	
Process:	[21]
AWS Specification No.:	[22]
AWS No. (Classification):	[23]
F-No.	[24]
Weld Metal Analysis A-No.:	[25]
Weld Metal Deposit Thickness:	[26]
Filler Metal Size:	[27]
Flux-Electrode Classification:	[28]
Supplemental Filler Metal:	[29]
Consumable Insert & Type:	[30]
Consumable Insert:	[31]
Supplemental Deoxidant:	[32]
Energized Filler Metal “Hot”	[33]

WPS Number [1]	Date [2]	Revision [3]	Page 2 of 2

POSITION

Welding Positions: [34]
Progression for Vertical Welding: [35]

PREHEAT AND INTERPASS

Preheat Minimum: [36]
Interpass Temperature Maximum: [37]
Preheat Maintenance: [38]

HEAT TREATMENT

PWHT Type: [39]
PWHT Temperature: [40]
PWHT Holding Time: [41]
Heating and Cooling Rate: [42]

SHIELDING GAS

	Type and % Composition (if applicable)	**Flow Rate Range**
Torch Shielding Gas:	[43]	[48]
Root Shielding Gas:	[44]	[49]
Environmental Shielding:	[45]	
Vacuum Pressure:	[46]	
Gas Cup Size:	[47]	

ELECTRICAL

Process:	[50]			
Filler Metal Diameter:	[51]			
Current Type and Polarity:	[52]			
Amperage Range:	[53]			
Transfer Mode:	[54]			
Wire Feed Speed (m/min)	[55]			
Voltage Range:	[56]			
Tungsten Specification No.:	[57]			
Tungsten Classification:	[58]			
Tungsten Electrode Diameter:	[59]			
Maximum Heat Input (kJ/mm):	[60]			
Pulsed Current:	[61]			

VARIABLES

Single to Multiple Electrodes: [62]
Electrode Spacing (mm): [63]
Single or Multipass: [64]
Contact Tube to Work Distance (mm): [65]
Cleaning: [66]
Peening: [67]
Conventional or Keyhole Technique: [68]
Stringer or Weave Bead: [69]
Travel-Speed Range (mm/min): [70]

Annex VIII (Informative)
Procedure Qualification Record (PQR)

WELDING PROCESS & Type	
Process 1:	[1]
Process 2:	[2]
BASE METALS	
Base Material Spec.:	[3] to [4]
M-No.: [5]	Group No.: to M-No.: Group No.:
Plate or Pipe: [6]	Pipe Diameter: [7]
Thickness:	[8]
Coating:	[9]
FILLER METALS	
Specification No.:	[10]
AWS No. Classification:	[11]
F-No.:	[12]
Weld Metal Analysis A-No.:	[13]
Filler Metal Size:	[14]
Supplemental Filler:	[15]
Weld Metal Deposit Thickness:	[16]
POSITION	
Position of Joint:	[17]
Vertical Welding Progression:	[18]
PREHEAT	
Min. Preheat Temperature:	[19]
Max. Interpass Temperature:	[20]
ELECTRICAL	
Current & Polarity:	[21]
Amperage Range:	[22]
Pulsed Current:	[23]
Wire Feed Speed (m/min)	[24]
Voltage Range:	[25]
Travel Speed (mm/min)	[26]
Transfer Mode:	[27]
Maximum Heat Input (kJ/mm)	[28]
Tungsten Type:	[29]
Tungsten Diameter:	[30]

JOINTS	
Weld Type:	[31]
Groove Type:	[32]
Root Spacing:	[33]
Metal Backing:	[34]
Thermal Backgouging:	[35]
	[36]
Sketch of Joint	
POSTWELD HEAT TREATMENT	
PWHT Type:	[37]
PWHT Temperature:	[38]
PWHT Time:	[39]
GAS	
Shielding Gas:	[40]
Composition:	[41]
Flow:	[42]
Gas Cup Size:	[43]
TECHNIQUE	
Stringer or Weave:	[44]
Method of Cleaning:	[45]
Oscillation:	[46]
Contact Tube to Work Distance:	[47]
Multipass or Single pass per side:	[48]
Number of Electrodes:	[49]
Electrode Spacing:	[50]
Peening:	[51]

VISUAL EXAMINATION: [52]

TENSILE TESTS

Specimen No.	Width mm	Thickness mm	Area mm^2	Ultimate Total Load (kN)	Ultimate Unit Stress (MPa)	Type of Failure & Location
[53]	[54]	[55]	[56]	[57]	[58]	[59]

GUIDED-BEND TESTS

Type	Results	Type	Results
[60]	[61]	[62]	[63]

Welder's Name [64] Stamp or Clock No. [65]

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 the Part B Practical CWI Exam Requirements. It is intended to be used for the CWI Part B Exam only and is not intended to be used for actual production welding or any other use without the written consent of AWS.

Annex IX (Informative)
Welder Qualification Test Record (WQTR)

Welder's Name [1] **ID No.** [2] **Symbol** [3]

Identification of WPS followed: [4]

Specification of base metal(s) welded: [5] **Thickness:** [6]

Testing Variables and Qualification Limits

Welding Variables			Actual Values	Range Qualified
Welding Process(es)			[13]	[31]
Type (i.e.; manual, semi-automatic)			[14]	[32]
Backing (metal, weld metal)	Process 1:	[7]	[15]	[33]
	Process 2:	[8]	[16]	[34]
☐ Plate ☐ Pipe (enter diameter if pipe or tube)			[17]	[35]
Base Metal M-Number to M-Number			[18]	[36]
AWS Filler metal or Electrode Specification(s)			[19]	
Filler metal or electrode classification(s)			[20]	
Filler metal F-Numbers	Process 1:	[9]	[21]	[37]
	Process 2:	[10]	[22]	[38]
Consumable Insert for GTAW			[23]	[39]
Weld deposit thickness for each welding process:				
	Process 1:	[11]	[24]	[40]
	Process 2:	[12]	[25]	[41]
Position Qualified (2G, 6G, etc.)			[26]	[42]
Vertical progression (Uphill or Downhill)			[27]	[43]
Inert gas backing for GTAW or GMAW			[28]	[44]
Transfer Mode (spray/globular or pulse to short circuit-GMAW)			[29]	[45]
GTAW welding current type/polarity (AC, DCEP, DCEN)			[30]	[46]

Results

Visual Examination of Completed Weld : [47]

Guided Bend Test Type: ☐ **Transverse Side** ☐ **Transverse Root & Face**

Specimen No.	Results	Specimen No.	Results
[48]	[49]	[50]	[51]

Alternative radiographic examination results [52]

Fillet Weld – fracture test [53] Length and percent of defects [54] mm

Macro Examination [55] Fillet size (mm) [56] x [57] Concavity/convexity (mm) [58]

Other tests [59]

Film or specimens evaluated by [60] Company [61]

Mechanical tests conducted by [62] Laboratory test no. [63]

Welding supervised by [64]

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Organization [65]

By [66] Date [67]