

# USDI Welding Procedures and PHMSA Welding Updates

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Presented by USDI  
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# Overview

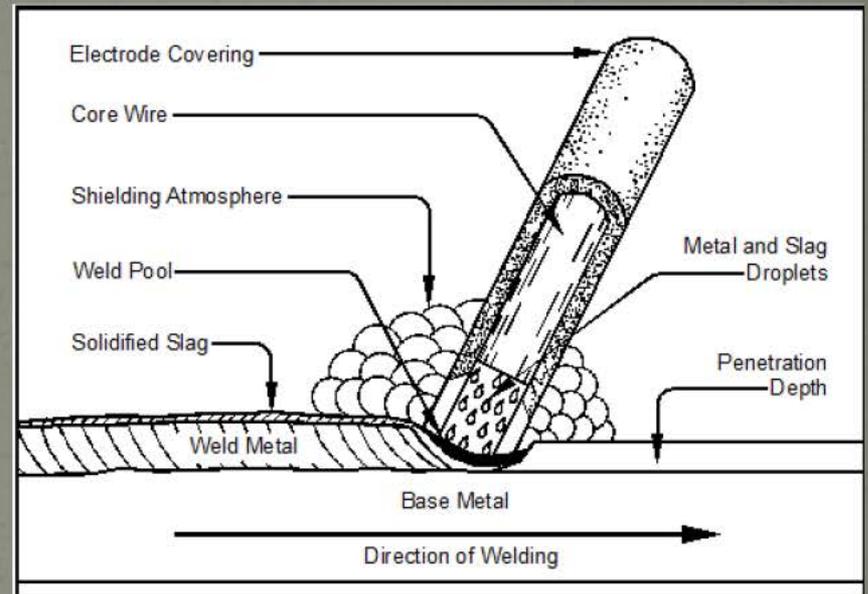
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- Shield Metal Arc Welding (SMAW)
- AWS Electrode Classification
- Visual Inspection – Examples of Defects
- Welding Safety and Useful Information
- 49 CFR 192.225 – Welding Procedures
- New X60 Welding Procedure Spec. No.'s A-7 & A-8
- 49 CFR 192.227 – Qualification of Welders
- 49 CFR 192 (Ref. Section 6 API 1104) vs. Appendix C
- Maintaining Weld Qualification
- Proposed Ruling – Reference to Appendix B
- New In-Service Welding Procedures

# Shielded Metal Arc Welding (SMAW)

- Shielded Metal Arc Welding is also referred to as 'stick' welding.
- Manual arc welding process that uses a consumable electrode covered with a flux to lay the weld.
- Electric current in the form of AC or DC current is used to form an electric arc between the electrode and the metals to be joined.

# Shielded Metal Arc Welding (SMAW)



# SMAW Electrodes

<b>E</b>	<b>60</b>	<b>1</b>	<b>0</b>
Electrode	Tensile Strength	Position	Type of Coating and Current

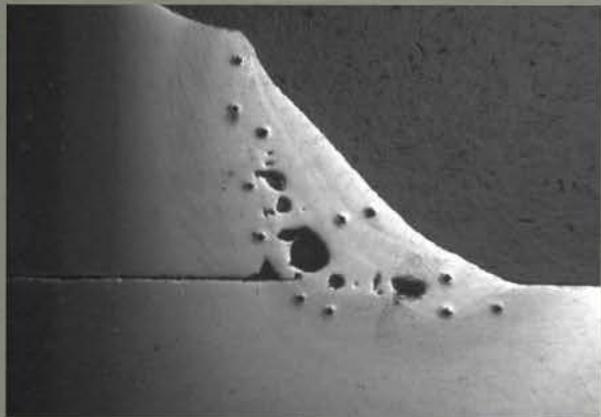


0	High cellulose sodium	DC+
1	High cellulose potassium	AC, DC+ or DC-
2	High titania sodium	AC, DC-
3	High titania potassium	AC, DC+
4	Iron powder, titania	AC, DC+ or DC-
5	Low hydrogen sodium	DC+
6	Low hydrogen potassium	AC, DC+
7	High iron oxide, iron powder	AC, DC+ or DC-
8	Low hydrogen potassium, iron powder	AC, DC+ or DC-

# Visual Inspection Defects

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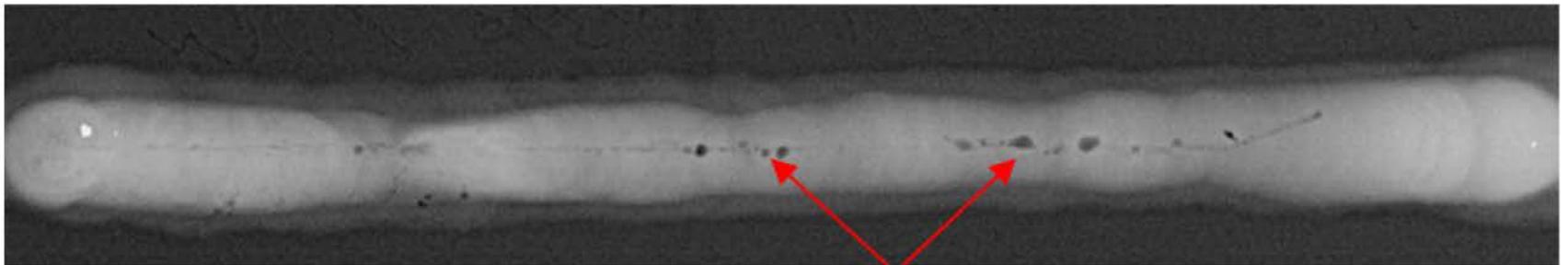
- Porosity
  - Holes/Voids caused by moisture in the flux (changed to steam) and trapped gas pockets



# Visual Inspection Defects

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- Slag Inclusion
  - Weld not properly cleaned prior to start of next bead, or inadequate overlap between two weld beads

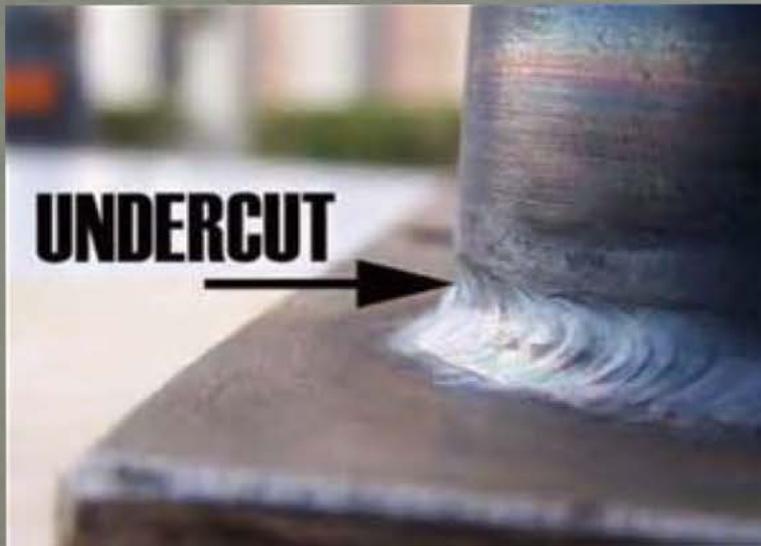


Slag inclusion

# Visual Inspection Defects

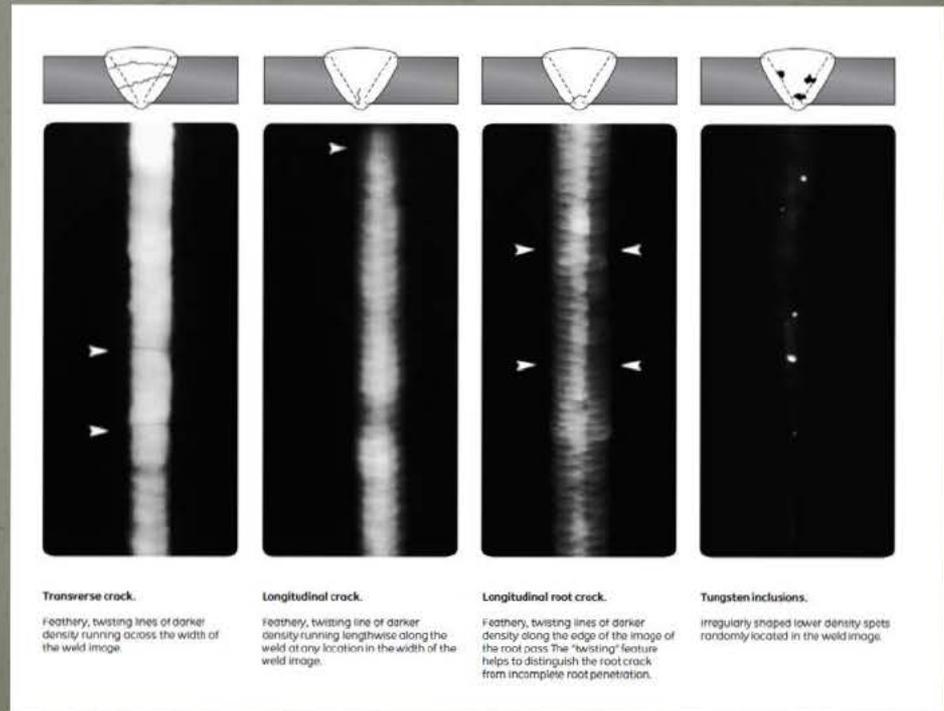
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- Undercut
  - Base metal cut into/penetrated by electric arc without leaving any filler metal.



# Visual Inspection Defects

- Cracking
  - Residual stresses, base material shrinkage, quenching of the weld
  - Mostly applies to full encirclement fittings/sleeves



# Visual Inspection Defects

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- Surface Defect
  - Chipping hammer damage – Caused by excessive force of hammer while removing slag.
  - Typically the use of a power grinder with a wire wheel is preferred over a chipping hammer.



# Visual Inspection Defects

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- All of the above.....



# Welding Safety & Useful Tips

- Wear proper PPE and clothing when welding
  - Welding Mask
  - Leather Gloves and Sleeves

Welding produces UV rays that are harmful to the eyes, hands, and skin.



# Welding Safety & Useful Tips



# Welding Safety & Useful Tips

- Pipeline Cutting Video - Stress on Pipeline

<https://www.youtube.com/watch?v=oz3FmgzTeK8>

# Welding Safety & Useful Tips

- Use Ultrasonic Thickness (UT) gauge to measure the wall thickness of the main/pipeline prior to welding
  - Confirms wall thickness is what you expect.
  - Can prevent serious accident (burn through, etc.)
  - Record wall thickness of existing pipeline – able to obtain data you might not have.....





# Welding Safety & Useful Tips

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# 49 CFR PART 192

## Subpart E – Welding of Steel in Pipelines

- 192.225 Welding Procedures
  - (A) Welding must be performed by a qualified welder in accordance with welding procedures qualified under Section 5 of API 1104 to produce welds meeting the requirements of this subpart. The quality of the test welds used to qualify welding procedures shall be determined by destructive testing in accordance with the applicable welding standard(s)
  - (B) Each welding procedure must be recorded in detail, including the results of the qualifying tests. This record must be retained and followed whenever the procedure is used.

# Procedure Qualification Report (PQR)



**JANX INTEGRITY GROUP**  
Coupon Test Report



Customer: Utility Safety & Design, Inc. Project: Procedure Qualification Record (PQR)-50  
 Process: SMAW WPQR: USCI Standard Procedure specification A7  
 Material: API 5L - X60M (NorthWest - H# B400643) Weather: Inside Shop (Avg 1.4 F / 1.1 C) (s)  
 Pipe Diameter: 12.75" OD Welding of: Pipe-to-Pipe  
 Joint Design: Single V-Groove - Butt Wall Thickness: 2.50"  
 Filler Metal: E6010 (Root), E7010 (Remainder) Direction Of Welding: Downhill  
 Electrical Characteristics: DCRP Time Lapse Between Passes: <5 Min Root-to-Root  
 Position: 5G - Fixed Preheat / Interpass Heat: Nil, 250° F  
 Number of Welders: 1 Welding Machine: Vantage300 Size: 300 Amp  
 Cleaning and / or Grinding: Grind/Brush Welding Time: 45 Min.  
 Type of Incup clamps: None Wind Break Used: Yes  
 Welder Name: Jordan Cummins - 6622 AWS - CWI: Dale Bell - Spection, LLC  
 Specification/Acceptance Criteria: API 1104 - 20th Edition  
 Comments: Welding parameter ranges during test were intentionally expanded to better document procedure  
 Lincoln Electrodes Q1 Lots - 1/8" 6P+ 13766031, 1/8" HYP+ 14195537, 5/32" HYP+ 14179506

Bead Number	Electrode Type	Electrode Size	Voltage	Amperage	Speed of Travel (ipm)
1-Root	E6010	1/8"	24-27	94-110	6-14
2-Fill	E7010	1/8"	24-28	92-120	7-15
3-Fill	E7010	5/32"	24-30	114-146	6-13
4-Cap	E7010	5/32"	26-29	110-138	5-10

Coupon	Remarks	Original Dimensions(in)	Original Area(in <sup>2</sup> )	Min Load (lbs)	Tensile Strength(psi)	Pass/Fail
1-TB	Break in Pipe	2530x1.0565	0.2678	24,994	93,331	Pass
2-NB						Pass
3-RB	C <1/8"					Pass
4-FB						Pass
5-TB	Break in HAZ	2515x1.0565	0.26068	24,676	94,637	Pass
6-NB						Pass
7-RB						Pass
8-FB						Pass

Procedure Qualification:  Qualified  Disqualified

Welder Qualification:  Qualified  Disqualified

USCI Shop - Olney, IL  
Test Location

Dale Bell - Spection, LLC  
Tested by

25-Jun-2015  
Test Date




- Procedure Qualification Report (PQR) is the record showing a procedure is qualified.

# Section 5 API 1104

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- Procedure Specification

- Process (SMAW)
- Pipe and Fitting Materials (Grade B, X42, ETC)
- Diameters and Wall Thicknesses (Varies)
- Joint Design (Butt, Fillet, Etc.)
- Filler Metal and Number of Beads (Electrode)
- Electrical Characteristics (Amps, Volts)
- Position (Roll/Fixed)
- Direction of Welding (Uphill/Downhill)
- Time Between Passes (5 Min.)
- Type and Removal of Lineup Clamp (Internal/External/Not Required)
- Cleaning and/or Grinding (Power or Hand Tools)
- Pre- and Post-Heat Treatment (Methods, Temp. Control, Etc.)
- Speed of Travel (In/Min.)

# Section 5 API 1104

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- Essential Variables

- Base Material
- Joint Design
- Position
- Wall Thickness/Pipe Diameter
- Filler Metal
- Electrical Characteristics
- Time Between Passes
- Direction of Welding
- Speed of Travel
- Pre-Heat
- Post-Weld Heat Treatment



A CHANGE TO ANY ONE OF  
THESE REQUIRES  
REQUALIFICATION OF THE  
WELD PROCEDURE

# USDI X60 Welding Procedure

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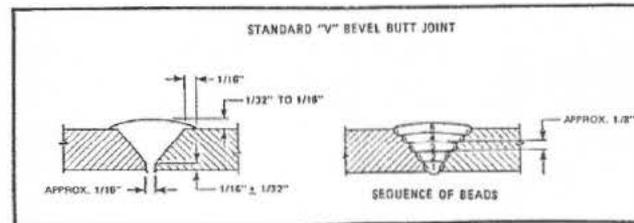
- American Petroleum Institute (API) provides standards for line pipe manufacturers to follow.
  - Many have been adopted into state and federal regulations.
- In the past API-5L Spec allowed dual and quad stenciling of line pipe.
- The latest edition (45<sup>th</sup>) of API-5L only allows single stenciling.
- Almost all pipe 2" and larger is X52 now. (52,000 psi)
- Until recently USDI's welding procedures were only qualified up to X42 line pipe (42,000 psi)
- Changing Material Groups is an ESSENTIAL VARIABLE change per API 1104
  - Group 1 – SMYS  $\leq$  42,000 psi (X42 and under)
  - Group 2 – SMYS  $>$  42,000,  $<$  65,000 psi (X45-X60)
  - Group 3 – SMYS  $>$  65,000 psi (X65 and up)

# X60 Weld Procedure – Standard Procedure Specification No. A-7

## STANDARD PROCEDURE SPECIFICATION NO. A-7

For Arc Welding of Steel Pipe and Fittings  
 2-3/8" Pipe Diameters and Larger and 0.188" thru 0.750" Wall Thickness  
 (Nominal Pipe Sizes 2" and Larger)

- A. Process: manual shielded metal arc weld (SMAW)
- B. Material Specification: API Specification 5L grades greater than X42 thru X60 or specifications having similar mechanical and chemical properties. Fitting material shall conform to greater than ASTM Grade Y-42/F-42 thru Y-60/F-60.
- C. Diameter and Wall Thickness: All pipes with outside diameters of 2-3/8 inches and larger. Applies to pipes with wall thicknesses of 0.188-inch to and including 0.750-inch.
- D. Joint Design: Single "V" groove, 60° included angle (30° bevel + 5° 0°). See Figure Below



- E. Filler Metal and Number of Beads: Electrodes E6010, E7010, or other Group 1 filler metals per API 1104, Table 1, AWS Specification A5.1 or 5.5. All root passes shall conform to AWS classification E6010. The remaining passes shall conform to AWS classification E7010.

WALL THICKNESS	ROD SIZE				MIN. NO. OF BEADS
	3/32"	1/8"	5/32"	3/16"	
.188 - .249	ANY PASS		FILL OR CAP ONLY		3
.250 - .343	ANY PASS		FILL OR CAP ONLY		4
.344 - .436	ANY PASS		FILL OR CAP ONLY		5
.437 - .561	ANY PASS		FILL OR CAP ONLY		6
.562 - .687	ANY PASS		FILL OR CAP ONLY		7
.688 - .750	ANY PASS		FILL OR CAP ONLY		8

# X60 Weld Procedure – Standard Procedure Specification No. A-7

## STANDARD PROCEDURE SPECIFICATION NO. A-7

Page 2

F. Electrical Characteristics: welding current D.C. reverse polarity. Electrode positive

ROD SIZE	AMPERES/ELECTRODE		VOLTAGE/ELECTRODE	
	E6010	E7010	E6010	E7010
3/32"	40-75	50-90	22-26	22-26
1/8"	90-120	90-120	22-28	22-28
5/32"	110-160	110-160	24-30	24-30
3/16"	140-190	140-190	28-32	28-32

G. Position: Position Welding

H. Direction of Welding: Downhill

I. Number of Welders: Two welders should be used on 16 inches and larger outside diameter pipe.

J. Time Lapse between Passes: The second pass shall follow the root bead within 5 minutes, except when UNAVOIDABLE circumstances prevail which make this requirement impractical. The complete weld should be finished before the end of the day.

K. Type of Line-up Clamp: External

L. Removal of Line-up Clamp: Uniformly spaced root bead segments covering at least 50 percent of the circumference must be completed before removal of the clamp. (See API 1104, section 4.3)

M. Cleaning: All rust, dirt, and foreign matter shall be removed from the bevel surface before welding is started; the bevel surface includes that area on the inside of the pipe in the immediate proximity of the pipe end. Slag shall be removed from the bead surface before the next bead is applied. Power tools may be used. Holes must be cleaned with ice picks or chisels. The finished weld and immediately adjacent pipe surface must be cleaned of all flux, smoke, and weld splatter. No welding shall be done in the rain unless suitable protection is provided.

N. Preheat, Stress Relief: Preheat shall be required when the ambient temperature or metal temperature is below 50° F. The minimum preheat temperature is 250° F for 3" on both sides of the weld. If moisture is present on the parent metal, it shall be driven off by preheating to a temperature at which it will not re-form. Stress Relief is not required.

# X60 Weld Procedure – Standard Procedure Specification No. A-7

## STANDARD PROCEDURE SPECIFICATION NO. A-7

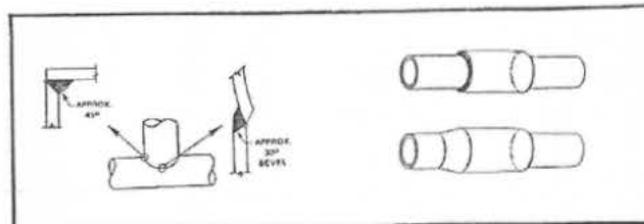
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- O. Shielding Gas and Flow Rate: (N/A)
- P. Shielding Flux: (N/A)
- Q. Speed of Travel: 4 to 15 inches per minute

# X60 Weld Procedure – Standard Procedure Specification No. A-8

**STANDARD PROCEDURE SPECIFICATION NO. A-8**  
**For Arc Fillet Welding of Steel Pipe and Fittings**  
**0.188" thru 0.750" Wall Thickness**

- A. Process: manual shielded metal arc weld (SMAW)
- B. **Material Specification: API Specification 5L grades greater than X42 thru X60 or specifications having similar mechanical and chemical properties. Fitting material shall conform to greater than ASTM Grade Y-42/F-42 thru Y-60/F-60.**
- C. Wall Thickness Group: All branch and sleeve diameters with 0.188-inch wall thickness up to and including 0.750-inch.
- D. Joint Design: Fillet, See Figure Below



- E. **Filler Metal and Number of Beads: Electrodes E6010, E7010, or other Group 1 filler metals per API 1104, Table I, AWS Specification A5.1 or 5.5. All root passes shall conform to AWS classification E6010. The remaining passes shall conform to AWS classification E7010.**

WALL THICKNESS	ROD SIZE				MIN. NO. OF BEADS
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.688 - .750	ANY PASS		FILL OR CAP ONLY		8

# X60 Weld Procedure – Standard Procedure Specification No. A-8

## STANDARD PROCEDURE SPECIFICATION NO. A-8

Page 2

F. Electrical Characteristics: Welding current D.C. reverse polarity. Electrode positive

ROD SIZE	AMPERES/ELECTRODE		VOLTAGE/ELECTRODE	
	E6010	E7010	E6010	E7010
3/32"	40-75	50-90	22-26	22-26
1/8"	90-120	90-120	22-28	22-28
5/32"	110-160	110-160	24-30	24-30
3/16"	140-190	140-190	28-32	28-32

G. Position: Position Welding

H. Direction of Welding: Downhill

I. Number of Welders: Two welders should be used on 16 inches and larger outside diameter pipe.

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# X60 Weld Procedure – Standard Procedure Specification No. A-8

## STANDARD PROCEDURE SPECIFICATION NO. A-8

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- O. Shielding Gas and Flow Rate: (N/A)
- P. Shielding Flux: (N/A)
- Q. Speed of Travel: 4 to 15 inches per minute.

# 49 CFR PART 192 – Subpart E – Welding of Steel in Pipelines

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- 192.227 Qualification of Welders
  - Each welder must be qualified in accordance with Section 6 of API 1104 for pipelines that operate at a pressure that produces a hoop stress at or above 20% SMYS. (TRANSMISSION)
  - OR For pipelines that operate at a pressure that produces a hoop stress below 20% SMYS, welders can qualify under the test set forth in Section 1 of Appendix C. IF the welder is to make a welded service line connection to a main must also first perform an acceptable test weld under Section 2 of Appendix C.

# Section 6 – API 1104

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- Single Qualification – Complete 1 Butt Weld
  - Weld must pass x-ray or destructive testing.
  - Only qualified to make production butt welds.
  - Only qualified to weld on pipe up to size tested on.
  - THIS QUALIFICATION IS NOT RECOMMENDED  
WELDER IS VERY LIMITED



Perform Test on 45° Incline  
to be Qualified to Weld in  
All Positions

# Section 6 – API 1104

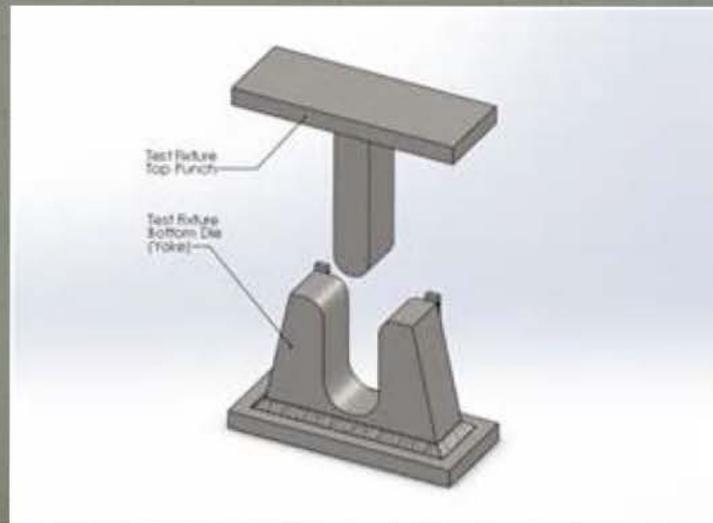
- Multiple Qualifications for Pipe Welding – Branch Weld
  - Pipe size
  - Butt weld
  - Branch
  - Branch
  - Qualification designations less than
  - For test qualification



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will be

# Appendix C – Qualification of Welders for Low Stress Level Pipe

- Section 1 – Basic Test
  - Butt weld to be completed on pipe 12.75”O.D. or less
  - Four coupons subject to root bend test.
  - Three of the four coupons must pass bend test.
  - Cracks must be less than 1/8” long
  - Qualifies welder for all pipe diameters up to 12.75”O.D.



# Appendix C – Qualification of Welders for Low Stress Level Pipe

- Section 1 – Basic Test
  - Root Bend
  - Failed Specimens



## Appendix C – Qualification of Welders for Low Stress Level Pipe

- Section 2 – Additional Tests for Welders of Service Line Connections to Mains.
  - Service line connection fitting welded to main with diameter of typical main.
    - Unacceptable if it shows serious undercutting or rolled edge
    - Fitting broken from main - unacceptable if it shows incomplete fusion, overlap, or poor penetration at junction of fitting and pipe.



# 49 CFR PART 192 – Subpart E – Welding of Steel in Pipelines

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- 192.229 Limitations on Welders
  - No welder may weld with a particular welding PROCESS unless, within the preceding 6 calendar months, he has engaged in welding with that process.
  - API 1104 Welders –  $\geq$  or  $=$  20%SMYS – Every 6 months a weld tested per Section 6 or 9 API 1104
  - Appendix C – Every 12 months – Section 1 & 2 Tests
    - Cut weld into 4 coupons for destructive testing (Section 1)
    - Make branch connection – destructively tested (Section 2)
    - OR production weld cutout/tested twice a calendar year
  - For welders working on service lines 2” and smaller
    - Two sample welds destructively tested twice a calendar year
    - Guided Bend Test

# Maintaini

# ations



Qualifying Test
Pipe Size
# of Sample
Testing Type
Frequency

Appendix C
2" and Smaller Only
2 Butt Welds
Destructive Test
2x/Calendar Year

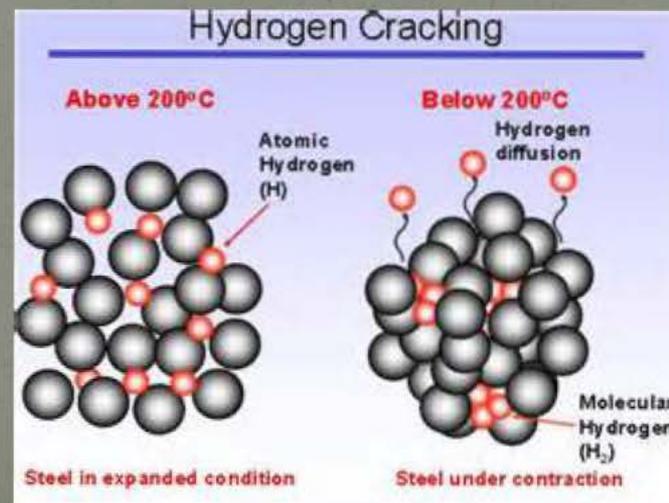


# PHMSA – Proposed Welding Changes

- PHMSA has proposed to revise 49 CFR 192.225 to reference API 1104, Appendix B – In-Service Welding
  - Recommended welding practices for making repairs to or installing appurtenances on pipelines that are IN-SERVICE
  - Also called “Low Hydrogen” Welding
- What does “In-Service” mean?
  - API 1104 Definition - Pipelines or piping systems containing crude petroleum, petroleum products, or fuel gases that may be pressurized and/or flowing

# Appendix B – In-Service Welding

- Two Concerns with In-Service Welding
  - Burn Through – breach of the pipe wall
  - Hydrogen Induced Cracking (HIC)
    - Pipelines with pressurized and/or flowing gas will tend to dissipate heat away from a weld thus “quenching” it.
    - Higher cooling rates trap hydrogen – leads to cracking.



# Appendix B – In-Service Welding

- Hydrogen Diffusion Demonstration Video
  - <https://www.youtube.com/watch?v=Wjz8eh3uxkU>

# Appendix B – In-Service Welding

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- Prevent Burn Through
  - Not as likely on pipe with 0.250" w.t.
  - Welding on thin wall pipelines is routine and procedures developed specifically to reduce heat input
- Prevent Hydrogen Cracking
  - Low Hydrogen Electrodes -E7018 electrodes – (E7018)
  - Procedure that uses high heat input
  - Reduce tensile stresses – Proper fit-up

# Appendix B – In-Service Welding

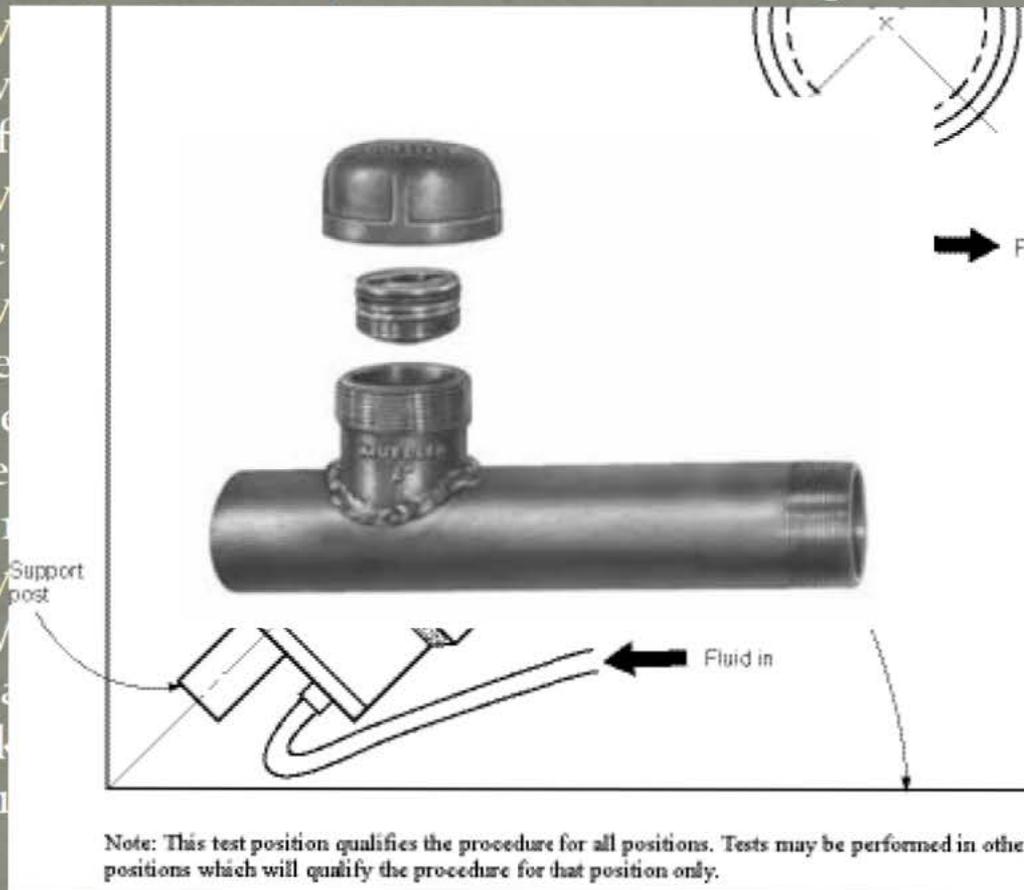
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- Why is In-Service welding needed now?
  - Because PHMSA said so.....
  - Failures in the past on sleeves/line stoppers determined to be cause of hydrogen cracking from high flow rates.
  - Several pipeline companies have been using In-Service welding for years.
  - This proposed ruling ensures proper weld procedures are used in the field.
  - Better quality welds – Better for the customer.

# USDI – In-Service Welding Procedures

- Developed/Qualified 4 In-Service Welding Procedures

- In-Service Welding
  - Service
  - Half
- In-Service Welding
  - Circ
- In-Service Welding
  - Mue
  - Sph
  - Side
  - E60
- In-Service Welding
  - TDV
  - Repa
  - Back
  - E70



- Allows welders more flexibility in the field.

# Appendix B – In-Service Welding

- When do we apply In-Service welding procedures?

- When the

- How do I know

- Measure

- Heat ent

- After 4 m

- If pipe “c

- USE A

- If surfac

- OK to

coated electrodes.



at least 200F

of pipe

FLOW

PROCEDURE

temperature

with cellulose

QUESTIONS?