Night School 27: Fundamentals of Welding and Bolting

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Session 4 – Problems and Fixes

October 25, 2021 | Duane K. Miller

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Course Description

Problems and Fixes
October 25, 2021

This session covers problems associated with structural steel construction and provides solutions to many issues. Topics such as repairs to base metal, out-of-tolerance weld joints, repairs to welds, welding on anchor rods including extending rods that are too short, repairing lamellar tears and more are addressed in this session. In all cases, the session provides practical solutions to these common problems.

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Learning Objectives

- Describe all considerations for making repairs to base metal.
- List weldability concerns with extending anchor rods.
- Describe tolerance issues that may affect welded joints.
- Describe how to address a weld performed without proper inspection.

Night School 27: Fundamentals of Welding and Bolting

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Chad Larson, LeJeune Bolt Company

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Night School 27: Fundamentals of Welding and Bolting

Welding Part 4: Problems and Fixes
October 25, 2021

Duane K. Miller, PE, ScD, The Lincoln Electric Company

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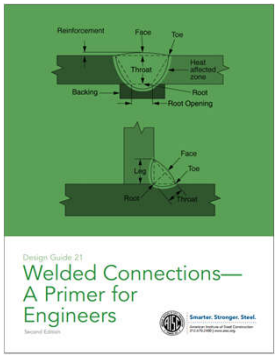
PROBLEMS AND FIXES

AISC Design Guide 21, 2nd Edition

Welded Connections – A Primer for Engineers

Chapter 15: Problems and Fixes



AWS D1.1

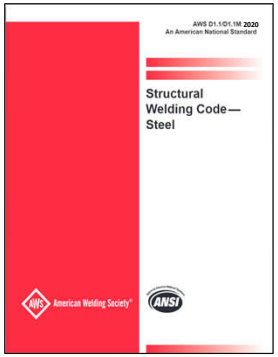
Structural Welding Code – Steel

"…with the approval of the Engineer…"

"…when approved by the Engineer…"

"…Engineer approval shall be required…"

"…discretion of the Engineer…"



AWS D1.1:2020 Structural Welding Code--Steel

7.25.3 Engineer's Approval.

Prior approval of the Engineer shall be obtained for repairs to base metal (other than those required by 7.14), repair of major or delayed cracks, repairs to ESW and EGW with internal defects, or for a revised design to compensate for deficiencies. The Engineer shall be notified before welded members are cut apart.

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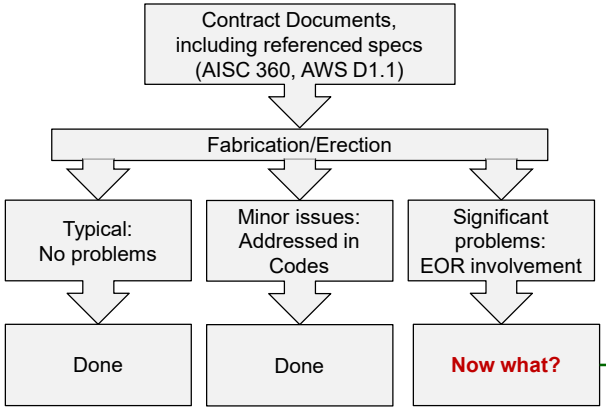
PROBLEMS AND FIXES



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PROBLEMS AND FIXES

Chapter 15: Problems and Fixes

15.1 Repairs to Base Metal
15.2 Repairs to Cut Edges
15.3 Butt Joint Alignment
15.4 Out-of-Tolerance Weld Joints
15.5 Fixing Members that are Cut Short
15.6 Repair of Mislocated Holes
15.7 Use of Plug Welds in Lieu of Bolts
15.8 Repairs to Welds

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PROBLEMS AND FIXES

Chapter 15: Problems and Fixes

15.9 Heat Shrinking of Q&T Steel
15.10 Unspecified Welds
15.11 Welds Made Without Inspection
15.12 Welding on Anchor Rods
15.13 Welding Anchor Rod-to-Base Plates
15.14 Removing and Reinstalling Column Base Plates
15.15 Repairing Lamellar Tears

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PROBLEMS AND FIXES

Chapter 15: Problems and Fixes

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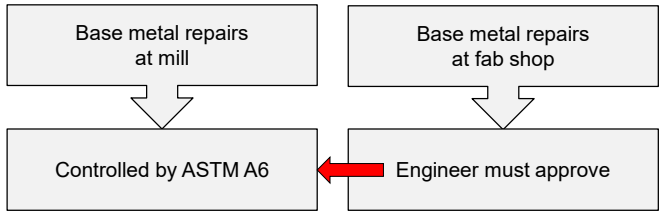
PROBLEMS AND FIXES



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PROBLEMS AND FIXES

15.1.2 Repair of Mill-Induced Discontinuities

Table 15-1. Limits on Imperfection Repaired by Grinding

Material Thickness, in. (mm)	Maximum Removal Depth, in. (mm)
< 3/8 (10)	1/32 (1)
3/8 (10) – 2 (50)	1/16 (2)
> 2 (50)	1/8 (3)

This table was adapted from ASTM A6, Section 9.2.

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PROBLEMS AND FIXES

15.1.2 Repair of Mill-Induced Discontinuities

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3/8 (10) – 2 (50)	1/16 (2)
> 2 (50)	1/8 (3)

This table was adapted from ASTM A6, Section 9.2.

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ASTM A6 (summary)

- The total area of ground material must not exceed 2% of the total surface area of that piece.
- The reduction in thickness by grinding must not exceed 30% of the nominal thickness of the material at the location of the imperfection, nor exceed 1-1/4 in. (31 mm).
- For defects that require deeper removal depths than those shown in Table 15-1, repair by welding is permitted.

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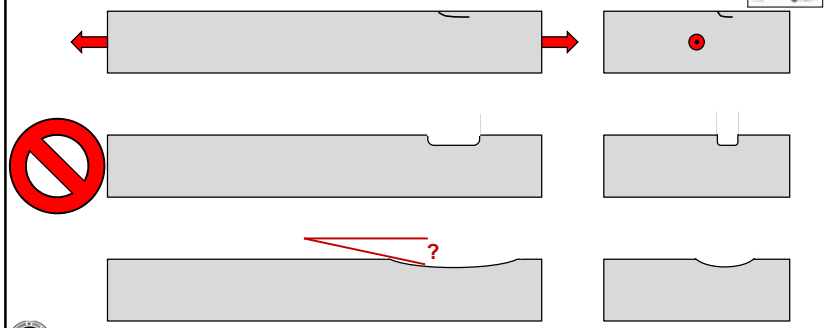
PROBLEMS AND FIXES



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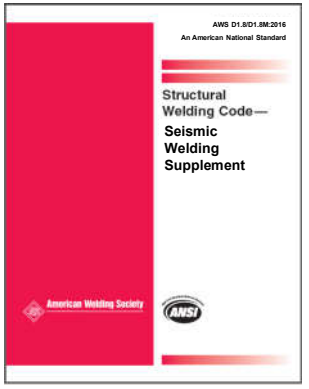
AWS D1.8/D1.8M:2016

**Structural Welding Code-
Seismic Welding Supplement**



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AWS D1.8:2016 Seismic Welding Supplement

6.18.5 Repair of Gouges and Notches.

Gouges and notches in the Protected Zone shall be repaired as follows:

6.18.5.1 Grinding.

When gouges and notches are repaired by grinding, the ground area shall provide a gradual taper to the surface of the base metal. In the direction parallel to the member axis, the taper shall not be greater than 1:5. In the direction transverse to the member axis, the taper shall not be greater than 1:2.5.

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PROBLEMS AND FIXES

Repairs to Base Metal: Summary

- EOR involvement needed for repairs made in the base metal in the shop, but not in the mill
- DG21 recommendation: apply ASTM A6 criteria to shop repairs
- DG21 recommendation: for slope: D1.8 provides a conservative criteria
- For welded repairs, location of repair should be considered

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PROBLEMS AND FIXES

Chapter 15: Problems and Fixes

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PROBLEMS AND FIXES

15.2 Repairs to Cut Edges

- Repairs to mill-induced discontinuities
- Repairs to contractor-induced discontinuities

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7.25.3 Engineer's Approval.

Prior approval of the Engineer shall be obtained for repairs to base metal (other than those required by 7.14), repair of major or delayed cracks, repairs to ESW and EGW with internal defects, or for a revised design to compensate for deficiencies. The Engineer shall be notified before welded members are cut apart.

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7.14.5 Mill-Induced Discontinuities.

The limits of acceptability and the repair of visually observed cut surface discontinuities shall be in conformance with Table 7.4, in which the length of discontinuity is the visible long dimension on the cut surface of material and the depth is the distance that the discontinuity extends into the material from the cut surface. All welded repairs shall be in conformance with this code. Removal of the discontinuity may be done from either surface of the base metal. The aggregate length of welding shall not exceed 20% of the length of the plate surface being repaired except with approval

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(4) If the area of the discontinuity W, X, Y, or Z exceeds the allowable in 5.14.5.1(2), the cut material or subcomponent shall be rejected and replaced, or repaired at the discretion of the Engineer.

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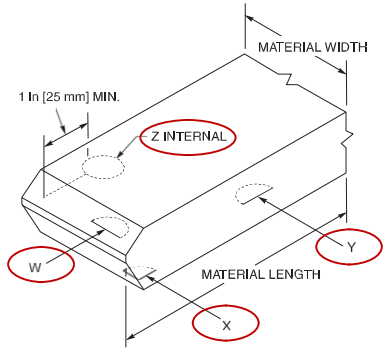

Figure 7.1—Edge Discontinuities in Cut Material

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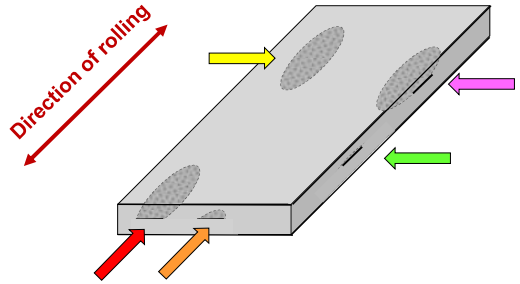
PROBLEMS AND FIXES



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PROBLEMS AND FIXES

Limits on Acceptability and Repair of Mill Induced Laminar Discontinuities in Cut Surfaces

Discontinuity		Repair
Length (L)	Depth	
≤ 1 in [25 mm]	any	None, need not be explored
> 1 in [25 mm]	≤ 1/8 in [3 mm]	None, but determine depth
	> 1/8 in [3mm] ≤ 1/4 in [6 mm]	Remove, need not weld
	>1/4 in [6 mm] ≤ 1 in [25 mm]	Remove and weld
	>1 in [25 mm]	See 7.14.5.1

Adapted from AWS D1.1, Table 7.4.

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PROBLEMS AND FIXES

Limits on Acceptability and Repair of Mill Induced Laminar Discontinuities in Cut Surfaces

Discontinuity		Repair
Length (L)	Depth	
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	>1/4 in [6 mm] ≤ 1 in [25 mm]	Remove and weld
	>1 in [25 mm]	See 7.14.5.1

Adapted from AWS D1.1, Table 7.4.

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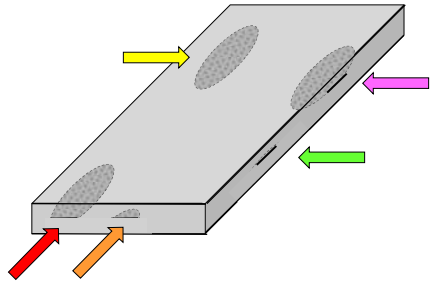
PROBLEMS AND FIXES

All are acceptable if the visible dimension is ≤ 1 in. [25 mm].



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PROBLEMS AND FIXES

Limits on Acceptability and Repair of Mill Induced Laminar Discontinuities in Cut Surfaces

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> 1 in [25 mm]	≤ 1/8 in [3 mm]	None, but determine depth
	> 1/8 in [3mm] ≤ 1/4 in [6 mm]	Remove, need not weld
	>1/4 in [6 mm] ≤ 1 in [25 mm]	Remove and weld
	> 1 in [25 mm]	See 7.14.5.1

Adapted from AWS D1.1, Table 7.4.

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PROBLEMS AND FIXES

Limits on Acceptability and Repair of Mill Induced Laminar Discontinuities in Cut Surfaces

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	> 1/8 in [3mm] ≤ 1/4 in [6 mm]	Remove, need not weld
	>1/4 in [6 mm] ≤ 1 in [25 mm]	Remove and weld
	> 1 in [25 mm]	See 7.14.5.1

Adapted from AWS D1.1, Table 7.4.

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PROBLEMS AND FIXES

Limits on Acceptability and Repair of Mill Induced Laminar Discontinuities in Cut Surfaces

Discontinuity		Repair
Length (L)	Depth	
≤ 1 in [25 mm]	any	None, need not be explored
> 1 in [25 mm]	≤ 1/8 in [3 mm]	None, but determine depth
	> 1/8 in [3mm] ≤ 1/4 in [6 mm]	Remove, need not weld
	>1/4 in [6 mm] ≤ 1 in [25 mm]	Remove and weld
	> 1 in [25 mm]	See 7.14.5.1

Adapted from AWS D1.1, Table 7.4.

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AWS D1.1:2020 Structural Welding Code--Steel

Note to AWS D1.1 Table 7.4:

A spot check of 10% of the discontinuities on the cut surface in question should be explored by grinding to determine depth. If the depth of any one of the discontinuities explored exceeds 1/8 in [3 mm], then all of the discontinuities over 1 in [25 mm] in length remaining on that cut surface shall be explored by grinding to determine depth. If none of the discontinuities explored in the 10% spot check have a depth exceeding 1/8 in [3 mm], then the remainder of the discontinuities on that cut surface need not be explored.

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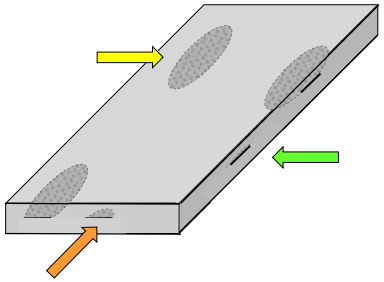
PROBLEMS AND FIXES

These are acceptable if the visible dimension is > 1 in. [25 mm], and depth is less than 1/8 in. [3 mm].



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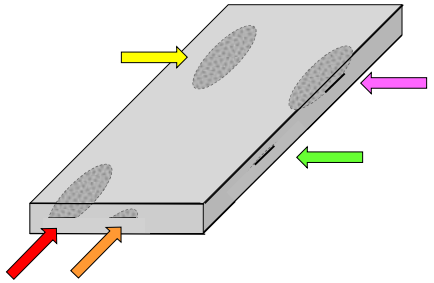
PROBLEMS AND FIXES

These are acceptable if the visible dimension is > 1 in. [25 mm], and depth is less than 1/8 in. [3 mm] if not found in the 10% check.



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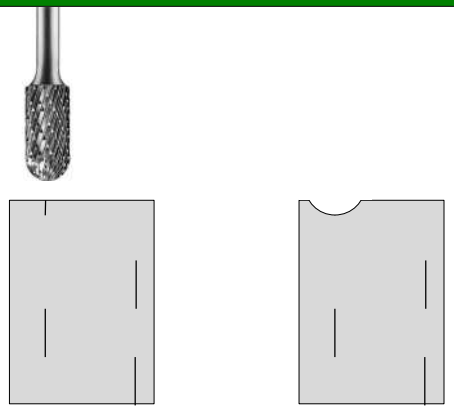

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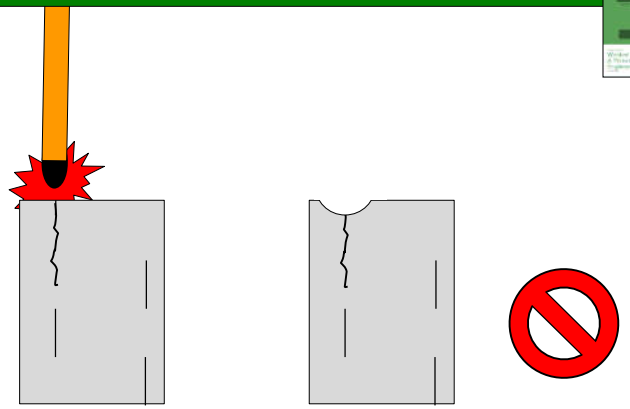

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PROBLEMS AND FIXES

Limits on Acceptability and Repair of Mill Induced Laminar Discontinuities in Cut Surfaces

Discontinuity		Repair
Length (L)	Depth	
≤ 1 in [25 mm]	any	None, need not be explored
> 1 in [25 mm]	≤ 1/8 in [3 mm]	None, but determine depth
	> 1/8 in [3mm] ≤ 1/4 in [6 mm]	Remove, need not weld
	>1/4 in [6 mm] ≤ 1 in [25 mm]	Remove and weld
	> 1 in [25 mm]	See 7.14.5.1

Adapted from AWS D1.1, Table 7.4.

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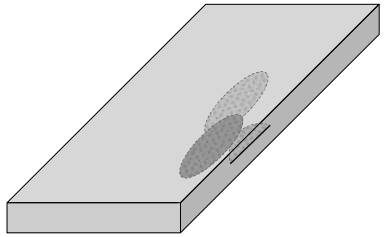
PROBLEMS AND FIXES

Shallow grinding of a small inclusion may reveal another inclusion, and then another.



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PROBLEMS AND FIXES

Limits on Acceptability and Repair of Mill Induced Laminar Discontinuities in Cut Surfaces

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Length (L)	Depth	
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> 1 in [25 mm]	≤ 1/8 in [3 mm]	None, but determine depth
	> 1/8 in [3mm] ≤ 1/4 in [6 mm]	Remove, need not weld
	>1/4 in [6 mm] ≤ 1 in [25 mm]	Remove and weld
	> 1 in [25 mm]	See 7.14.5.1

Adapted from AWS D1.1, Table 7.4.

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PROBLEMS AND FIXES

Limits on Acceptability and Repair of Mill Induced Laminar Discontinuities in Cut Surfaces

Discontinuity		Repair
Length (L)	Depth	
≤ 1 in [25 mm]	any	None, need not be explored
> 1 in [25 mm]	≤ 1/8 in [3 mm]	None, but determine depth
	> 1/8 in [3mm] ≤ 1/4 in [6 mm]	Remove, need not weld
	>1/4 in [6 mm] ≤ 1 in [25 mm]	Remove and weld
	> 1 in [25 mm]	See 7.14.5.1

Adapted from AWS D1.1, Table 7.4.

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7.14.5.1 Acceptance Criteria.

For discontinuities greater than 1 in [25 mm] in length and depth discovered on cut surfaces, the following procedures shall be observed.

(1) Where discontinuities such as W, X, or Y in Figure 7.1 are observed prior to completing the joint, the size and shape of the discontinuity shall be determined by UT. …

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One purpose of 7.14.5.1 is to find this:

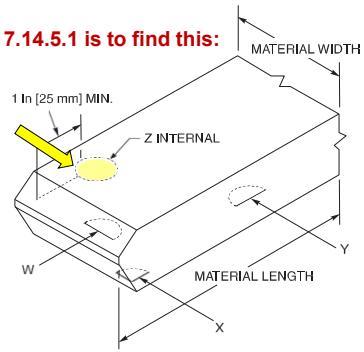

Figure 7.1—Edge Discontinuities in Cut Material

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(4) If the area of the discontinuity W, X, Y, or Z exceeds the allowable in 7.14.5.1(2), the cut material or subcomponent shall be rejected and replaced, or repaired at the discretion of the Engineer.

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AWS D1.1:2020 Structural Welding Code--Steel

7.14.5.2 Repair.

In the repair and determination of limits of mill induced discontinuities visually observed on cut surfaces, the amount of metal removed shall be the minimum necessary to remove the discontinuity or to determine the limits of Table 7.4 are not exceeded. …

NOTE: The requirements of 7.14.5.2 may not be adequate in cases of tensile load applied through the thickness of the material.

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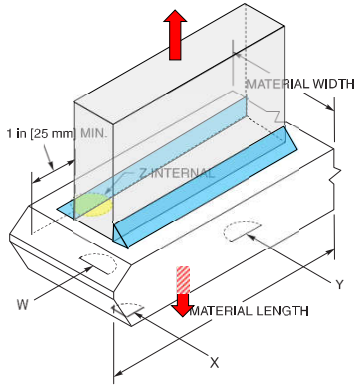
PROBLEMS AND FIXES



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PROBLEMS AND FIXES

Repairs to Cut Edges (Mill Induced): Summary

- Length and depth determine acceptability and permitted repairs
- Explore by grinding, not AAG
- Excessive inclusions may render the steel unacceptable

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PROBLEMS AND FIXES

Chapter 15: Problems and Fixes

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7.21.3 Butt Joint Alignment.

Parts to be joined at butt joints shall be carefully aligned. Where the parts are effectively restrained against bending due to eccentricity in alignment, the offset from the theoretical alignment shall not exceed 10% of the thickness of the thinner part joined, or 1/8 in [3 mm], whichever is smaller. In correcting misalignment in such cases, the parts shall not be drawn in to a greater slope than 1/2 in [12 mm] in 12 in [300 mm]. Measurement of offset shall be based upon the centerline of parts unless otherwise shown on the drawings.

1/2 in 12 = 1 in 24

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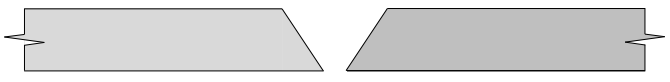

Ideal

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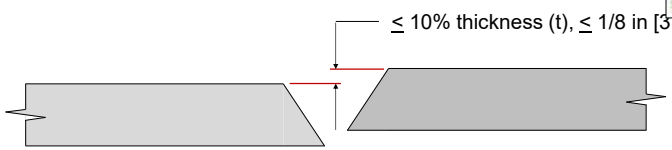

Acceptable

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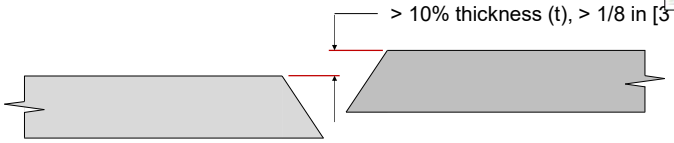

Now what?

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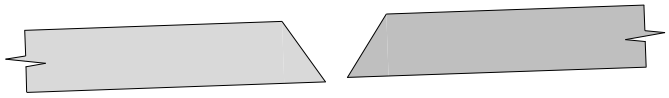

Acceptable

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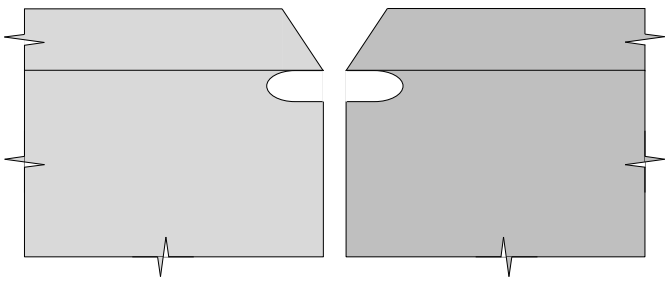

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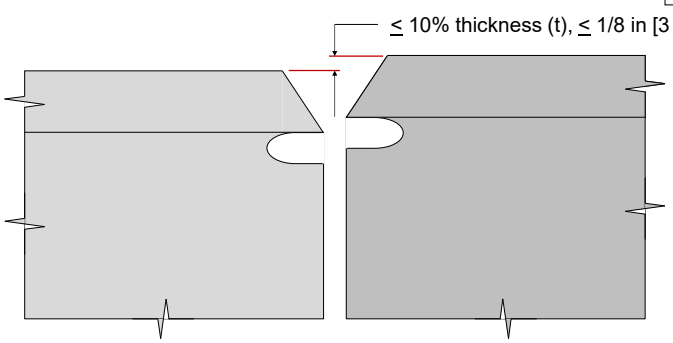

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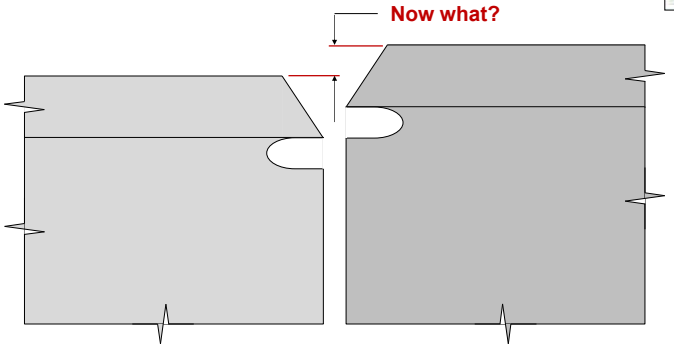
PROBLEMS AND FIXES



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AWS D1.1:2020 Structural Welding Code--Steel

8.8 Engineer's Approval for Alternate Acceptance Criteria

The fundamental premise of the code is to provide general stipulations applicable to most situations. Acceptance criteria for production welds different from those described in the code may be used for a particular application, provided they are suitably documented by the proposer and approved by the Engineer.

These alternate acceptance criteria may be based upon evaluation of suitability for service using past experience, experimental evidence or engineering analysis considering material type, service load effects, and environmental factors.

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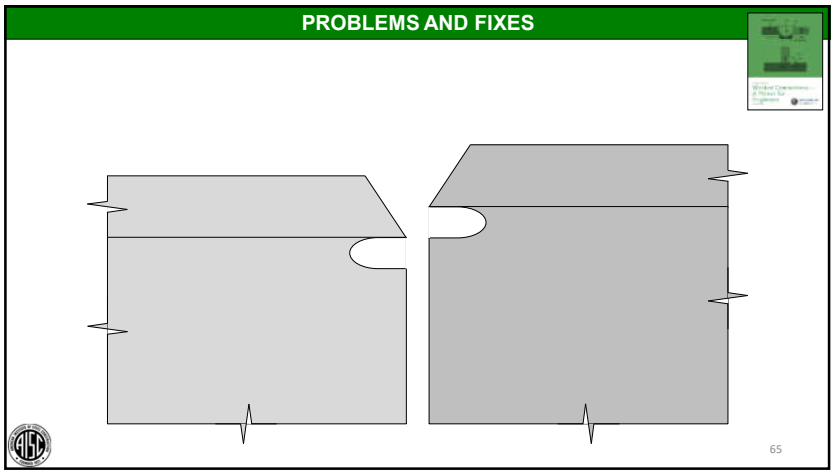
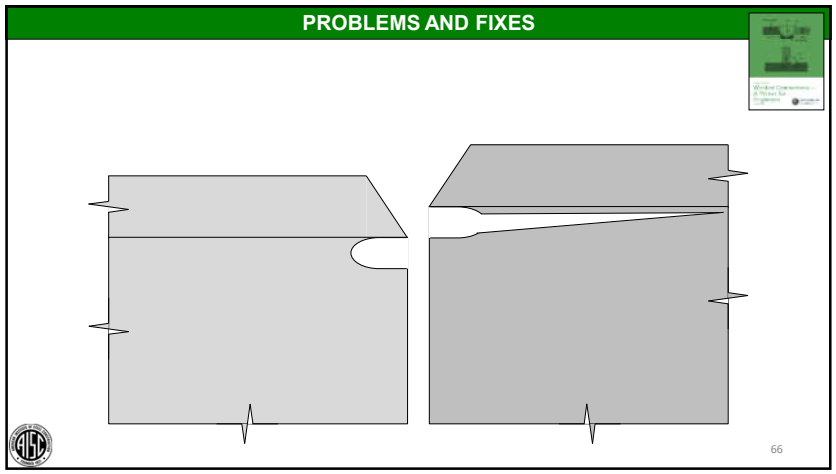
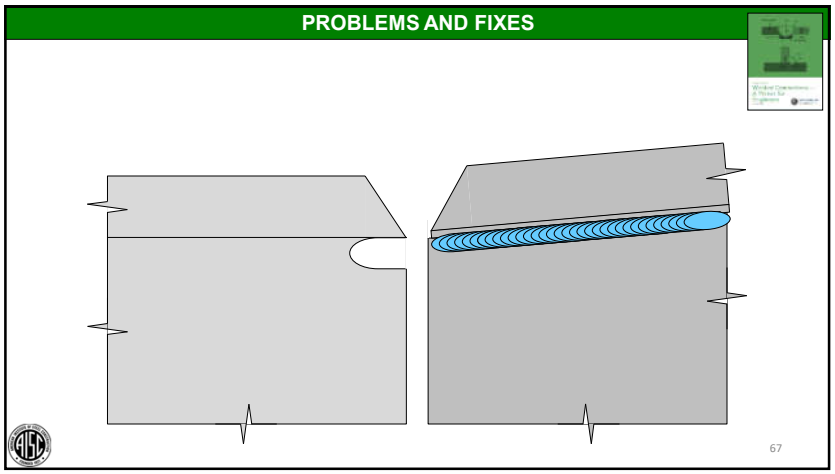
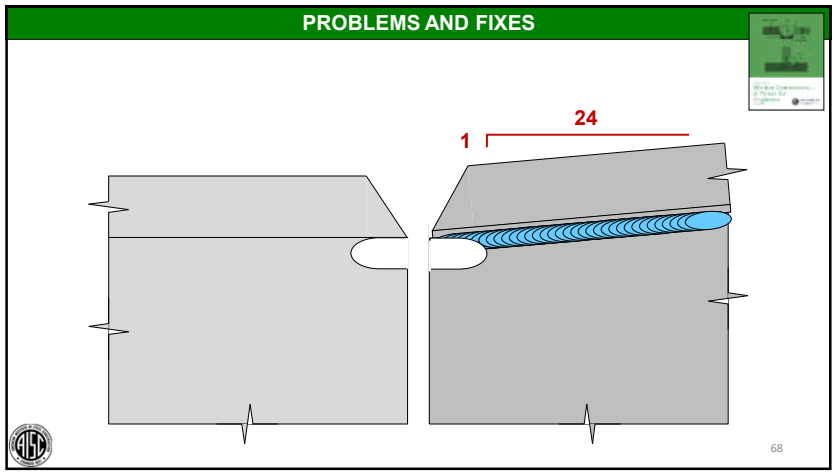
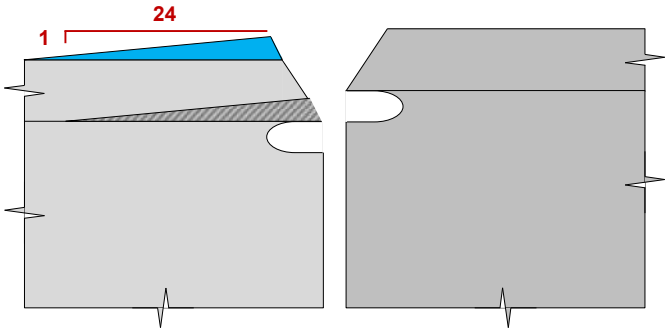








PROBLEMS AND FIXES



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PROBLEMS AND FIXES

1 in 24 ratio

Offset	Length
1/4 in (6 mm)	6 in (150 mm)
1/2 in (12 mm)	12 in (300 mm)
3/4 in (18 mm)	18 in (450 mm)
1 in (25 mm)	24 in (600 mm)

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7.21.3 Butt Joint Alignment.

Parts to be joined at butt joints shall be carefully aligned. Where the parts are effectively restrained against bending due to eccentricity in alignment, the offset from the theoretical alignment shall not exceed 10% of the thickness of the thinner part joined, or 1/8 in [3 mm], whichever is smaller. In correcting misalignment in such cases, the parts shall not be drawn in to a greater slope than 1/2 in [12 mm] in 12 in [300 mm]. Measurement of offset shall be based upon the centerline of parts unless otherwise shown on the drawings.

1/2 in 12 = 1 in 24

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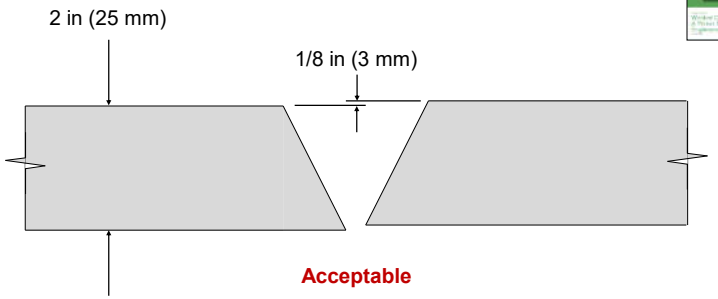
PROBLEMS AND FIXES



Acceptable

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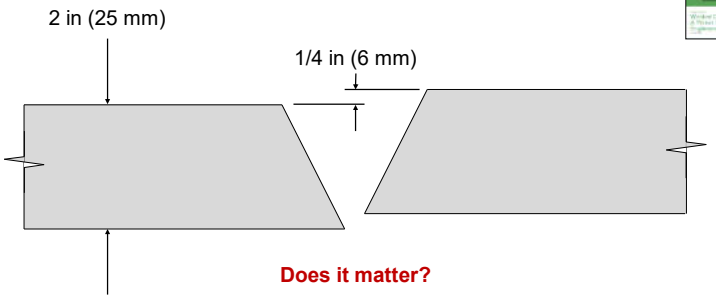
PROBLEMS AND FIXES



Does it matter?

73

PROBLEMS AND FIXES

15.3 Butt Joint Alignment: Summary

- Code provides limits: smaller of 10% thickness or 1/8 in (3 mm)
- For restrained members, 1: 24 slope
- EOR could permit alternative criteria

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PROBLEMS AND FIXES

Chapter 15: Problems and Fixes

15.1 Repairs to Base Metal
15.2 Repairs to Cut Edges
15.3 Butt Joint Alignment
→ 15.4 Out-of-Tolerance Weld Joints
15.5 Fixing Members that are Cut Short
15.6 Repair of Mislocated Holes
15.7 Use of Plug Welds in Lieu of Bolts
15.8 Repairs to Welds

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PROBLEMS AND FIXES

15.4 Out-of-tolerance Weld Joints

15.4.1 Sources of Fit-Up Variation
→ 15.4.2 Fit-Up Problems with Fillet Welded Joints
15.4.3 Fit-Up Problems with CJP Groove Welded Joints
15.4.4 Fit-Up Problems with PJP Groove Welded Joints
15.4.5 Fit-Up Problems with Plug and Slot Welded Joints

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7.21.1 Fillet Weld Assembly.

The parts to be joined by fillet welds shall be brought into as close contact as practicable. The root opening shall not exceed 3/16 in [5 mm] except in cases involving either shapes or plates 3 in [75 mm] or greater in thickness if, after straightening and in assembly, the root opening cannot be closed sufficiently to meet this tolerance…a maximum root opening of 5/16 in [8 mm] may be used, provided suitable backing is used.

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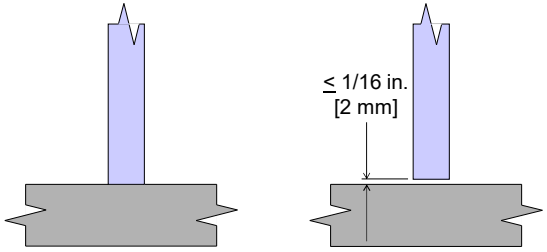
PROBLEMS AND FIXES

Ideal

Permitted without correction



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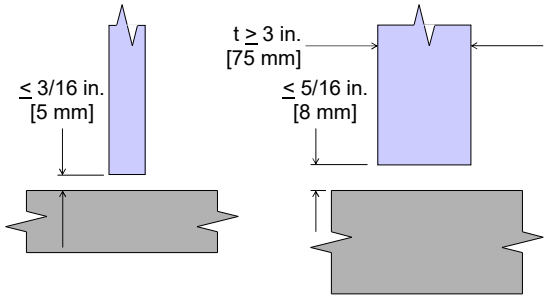
PROBLEMS AND FIXES

Permitted with correction



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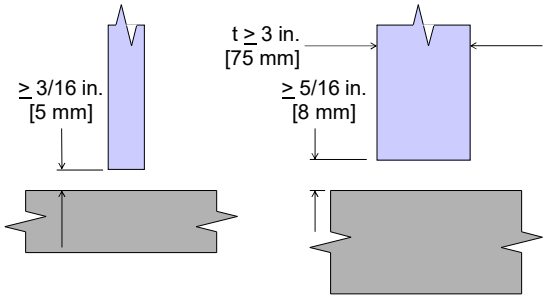
PROBLEMS AND FIXES

Now what?



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AWS D1.1:2020 Structural Welding Code--Steel

8.8 Engineer's Approval for Alternate Acceptance Criteria

The fundamental premise of the code is to provide general stipulations applicable to most situations. Acceptance criteria for production welds different from those described in the code may be used for a particular application, provided they are suitably documented by the proposer and approved by the Engineer.

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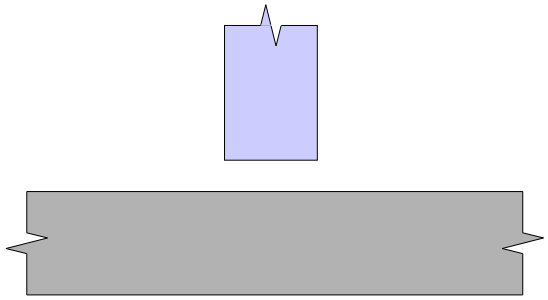
PROBLEMS AND FIXES

Design Guide Option 1: Buttering



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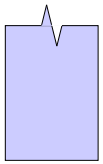
PROBLEMS AND FIXES

Design Guide Option 1: Buttering



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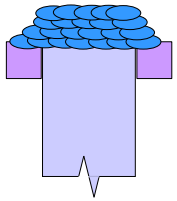
PROBLEMS AND FIXES

Design Guide Option 1: Buttering



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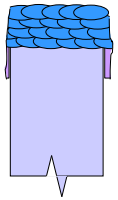
PROBLEMS AND FIXES

Design Guide Option 1: Buttering



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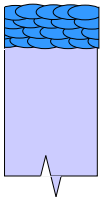
PROBLEMS AND FIXES

Design Guide Option 1: Buttering



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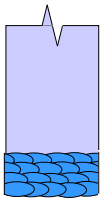
PROBLEMS AND FIXES

Design Guide Option 1: Buttering



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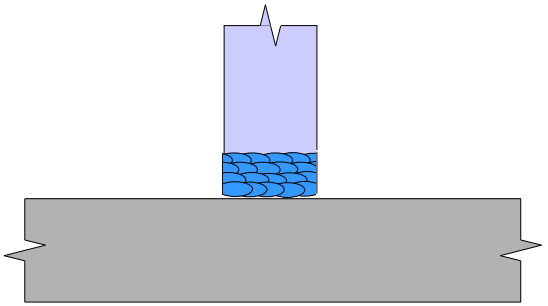
PROBLEMS AND FIXES

Design Guide Option 1: Buttering



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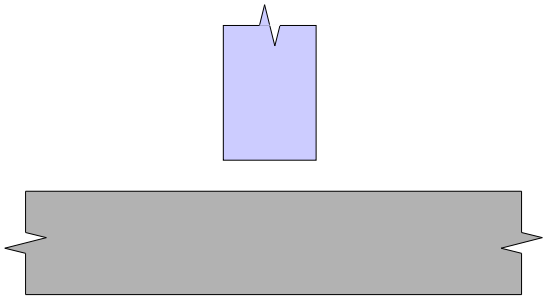
PROBLEMS AND FIXES

Design Guide Option 2: Change to CJP groove weld



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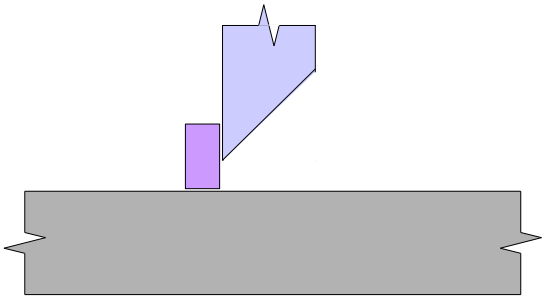
PROBLEMS AND FIXES

Design Guide Option 2: Change to CJP groove weld



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PROBLEMS AND FIXES

15.4 Out-of-tolerance Weld Joints

15.4.1 Sources of Fit-Up Variation
15.4.2 Fit-Up Problems with Fillet Welded Joints
15.4.3 Fit-Up Problems with CJP Groove Welded Joints
15.4.4 Fit-Up Problems with PJP Groove Welded Joints
15.4.5 Fit-Up Problems with Plug and Slot Welded Joints

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PROBLEMS AND FIXES

15.4 Out-of-tolerance Weld Joints

15.4.3 Fit-up Problems with CJP Groove Welded Joints

Prequalified Joint Details		Fitup Problem	
		Too Tight	Too Loose
Backing	Yes	X	X
	No	X	X

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PROBLEMS AND FIXES

15.4 Out-of-tolerance Weld Joints

15.4.3 Fit-up Problems with CJP Groove Welded Joints

Prequalified Joint Details		Fitup Problem	
		Too Tight	Too Loose
Backing	Yes	X	X
	No	X	X

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PROBLEMS AND FIXES

15.4 Out-of-tolerance Weld Joints

15.4.3 Fit-up Problems with CJP Groove Welded Joints

Prequalified Joint Details		Fitup Problem	
		Too Tight	Too Loose
Backing	Yes	X	X
	No	X	X

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PROBLEMS AND FIXES

15.4 Out-of-tolerance Weld Joints

15.4.3 Fit-up Problems with CJP Groove Welded Joints

Prequalified Joint Details		Fitup Problem	
		Too Tight	Too Loose
Backing	Yes	X	**X**
	No	X	X

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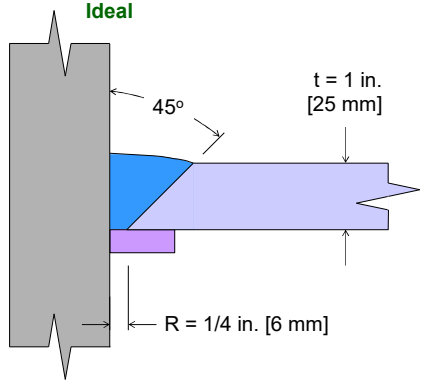
PROBLEMS AND FIXES

Ideal

Weld volume:
3.08 lb/ft
[4.58 kg/m]

V = 1.0



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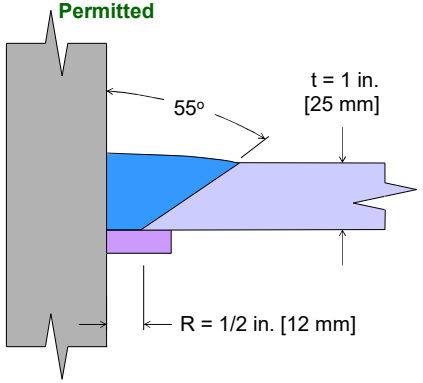
PROBLEMS AND FIXES

Permitted

Weld volume:

V = 1.6



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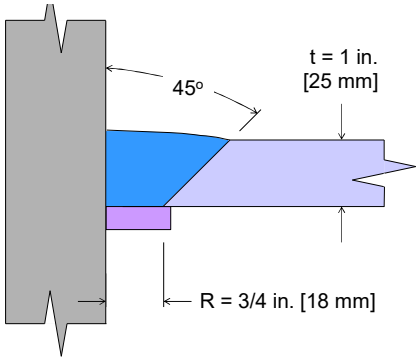
PROBLEMS AND FIXES

Outside Limits

Weld volume:

V = 1.57



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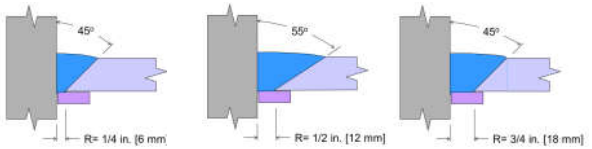
PROBLEMS AND FIXES



Ideal	**Permitted**	**Outside Limits**
$\alpha = 45°$	$\alpha = 55°$	$\alpha = 45°$
R = 1/4 in.	R = 1/2 in.	R = 3/4 in.
V/L = 1.0	V/L = 1.60	V/L = 1.57

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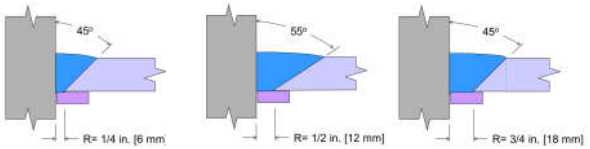
PROBLEMS AND FIXES



DG 21 Suggestion:

If the volume of weld metal required to weld the joint that is outside limits is less that what is permitted for similar joints with allowed tolerances, the EOR can approve welding of the joint without correction.

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7.21.4.2 Correction.

Root openings greater than those allowed in 7.21.4.1, but not greater than twice the thickness of the thinner part or 3/4 in [20 mm], whichever is less, may be corrected by welding to acceptable dimensions prior to joining the parts by welding.

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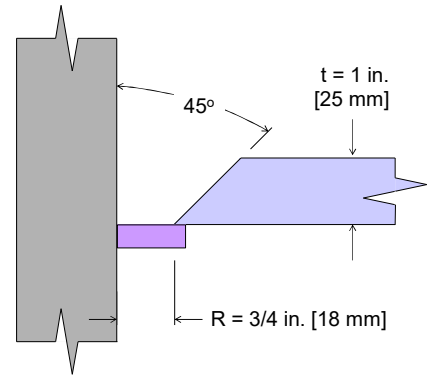
PROBLEMS AND FIXES

Outside general limits, within clause 5.21.4.2



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PROBLEMS AND FIXES

Outside general limits, within clause 5.21.4.2

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PROBLEMS AND FIXES

Outside general limits, within clause 5.21.4.2

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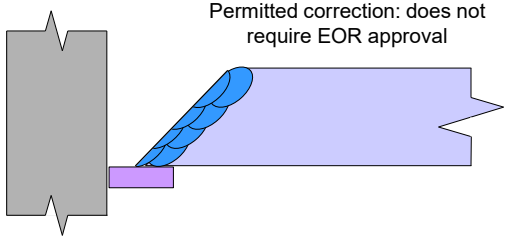
PROBLEMS AND FIXES

Outside general limits, within clause 5.21.4.2

Permitted correction: does not require EOR approval



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7.21.4.3 Engineer's Approval.

Root openings greater than allowed by 7.21.4.2 may be corrected by welding only with the approval of the Engineer.

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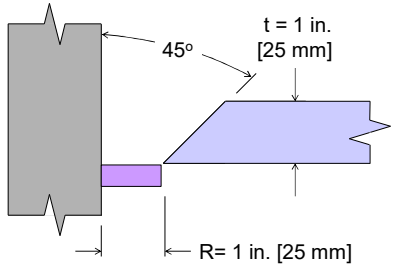
PROBLEMS AND FIXES

Outside general limits, outside limits of clause 5.21.4.2



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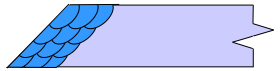
PROBLEMS AND FIXES

Outside general limits, outside limits of clause 5.21.4.2



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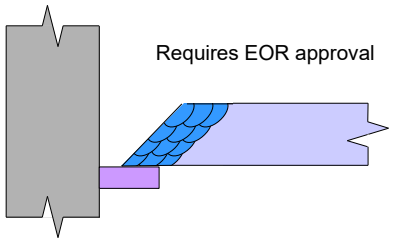
PROBLEMS AND FIXES

Outside general limits, outside limits of clause 5.21.4.2



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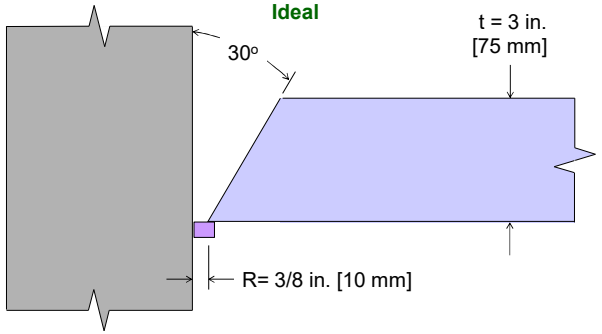
PROBLEMS AND FIXES

Ideal



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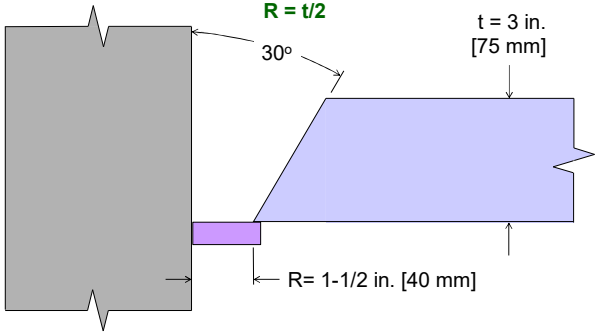
PROBLEMS AND FIXES

R = t/2



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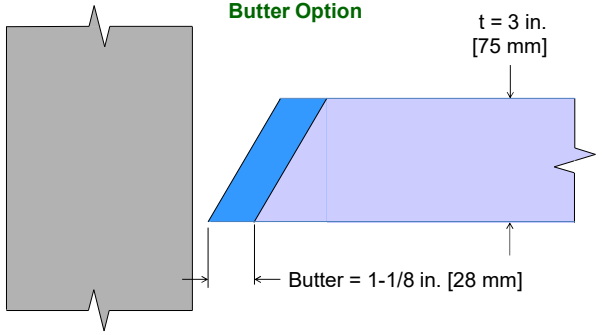
PROBLEMS AND FIXES

Butter Option



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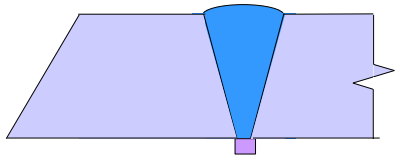
PROBLEMS AND FIXES

Splice Option



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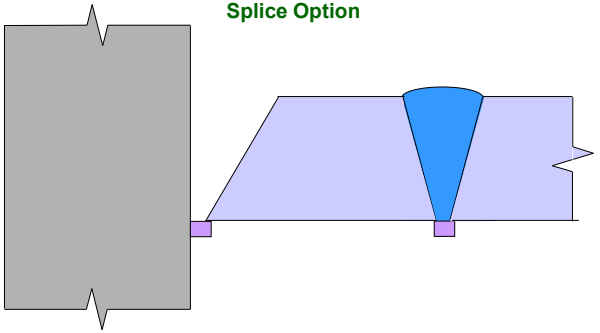
PROBLEMS AND FIXES

Splice Option



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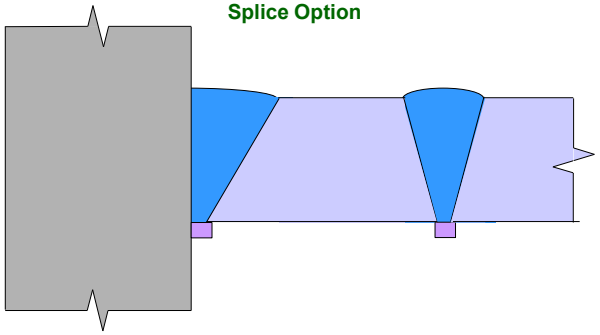
PROBLEMS AND FIXES

Splice Option



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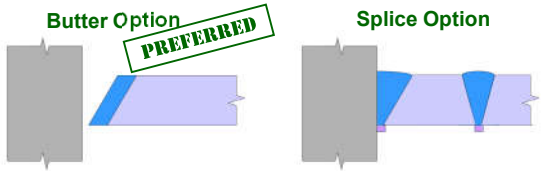
PROBLEMS AND FIXES

Butter Option

PREFERRED

Splice Option



- Both require EOR approval
- Both require similar amounts of welding
- Buttering is a simpler solution

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PROBLEMS AND FIXES

15.4 Out-of-tolerance Weld Joints

15.4.3 Fit-up Problems with CJP Groove Welded Joints

Prequalified Joint Details		Fitup Problem	
		Too Tight	Too Loose
Backing	Yes	X	X
	No	X	**X**

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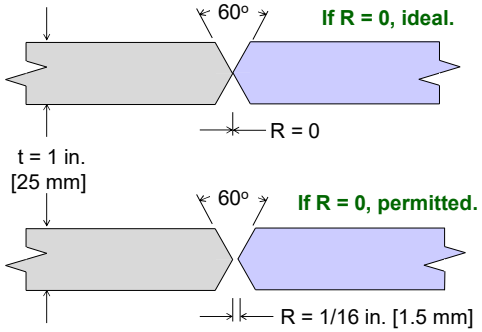
PROBLEMS AND FIXES



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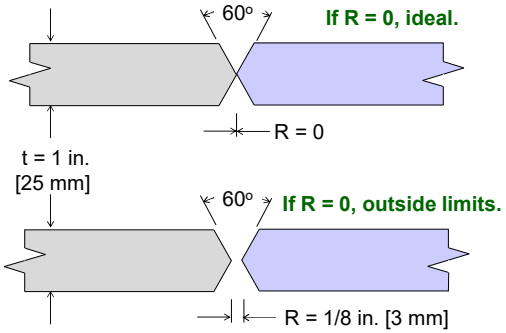
PROBLEMS AND FIXES



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AWS D1.1:2020 Structural Welding Code--Steel

7.21.4.2 Correction.

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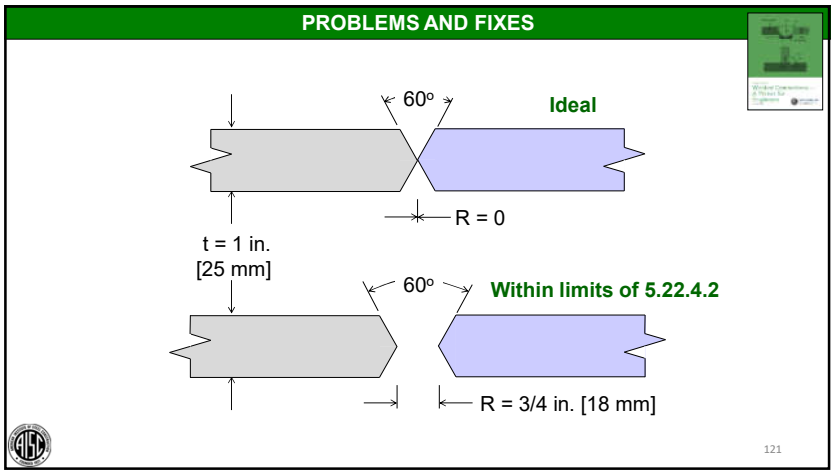
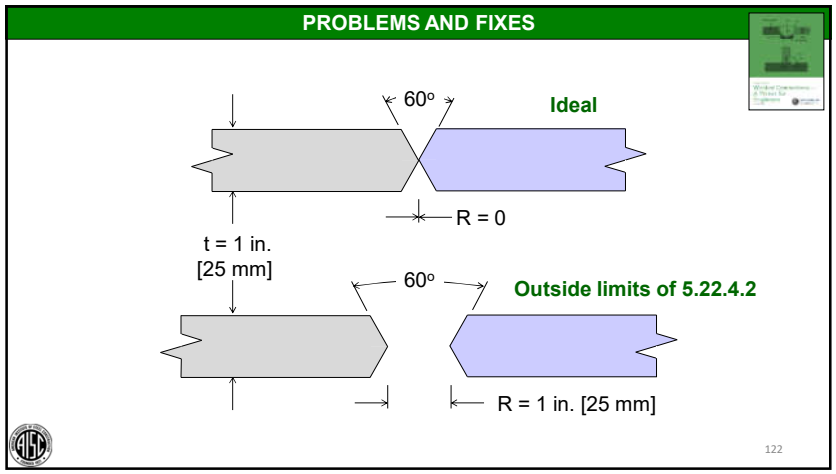
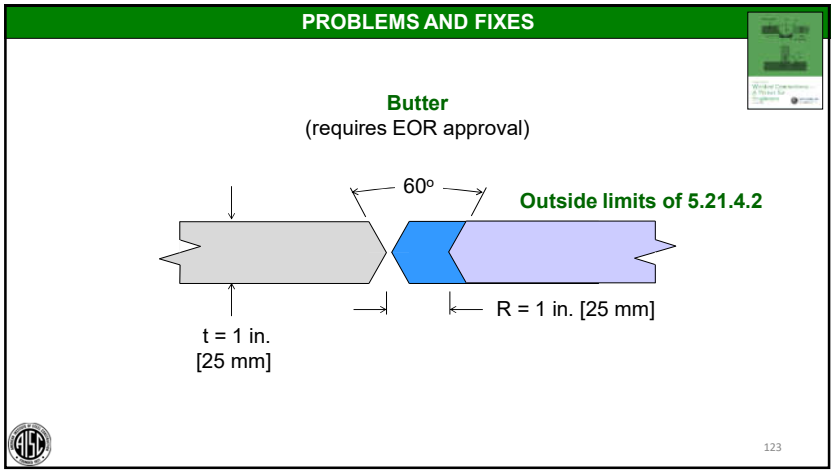
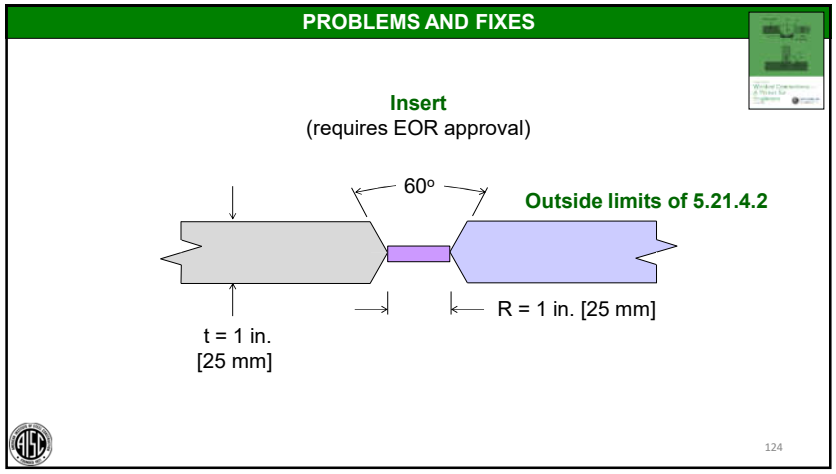
120



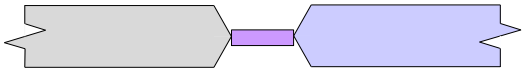






PROBLEMS AND FIXES

Insert
(requires EOR approval)



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PROBLEMS AND FIXES

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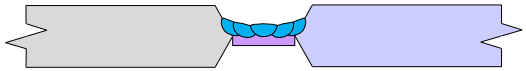

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PROBLEMS AND FIXES

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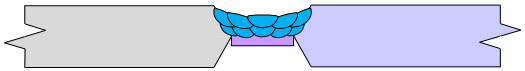
(requires EOR approval)



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PROBLEMS AND FIXES

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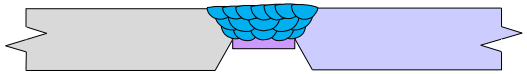

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PROBLEMS AND FIXES

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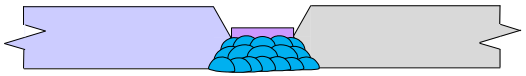

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PROBLEMS AND FIXES

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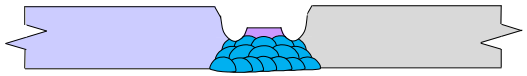
(requires EOR approval)



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PROBLEMS AND FIXES

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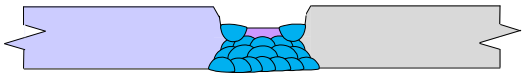
(requires EOR approval)



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PROBLEMS AND FIXES

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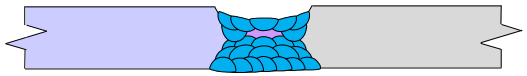
(requires EOR approval)



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PROBLEMS AND FIXES

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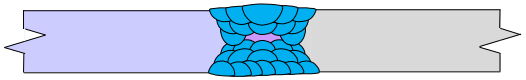
(requires EOR approval)



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PROBLEMS AND FIXES

15.4 Out-of-Tolerance Weld Joints: Summary

- The code provides limits, primarily based on workmanship
- The code provides solutions for problems, within limits
- The EOR can extend those limits
- DG21 provides alternatives the EOR can consider

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PROBLEMS AND FIXES

Chapter 15: Problems and Fixes

15.1 Repairs to Base Metal
15.2 Repairs to Cut Edges
15.3 Butt Joint Alignment
15.4 Out-of-Tolerance Weld Joints
→ 15.5 Fixing Members that are Cut Short
15.6 Repair of Mislocated Holes
15.7 Use of Plug Welds in Lieu of Bolts
15.8 Repairs to Welds

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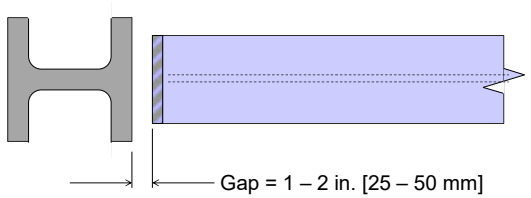
PROBLEMS AND FIXES

15.5 Fixing Members That Are Cut Short

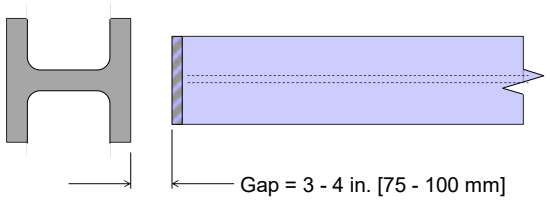


Buttering may be a good solution

136

PROBLEMS AND FIXES

15.5 Fixing Members That Are Cut Short

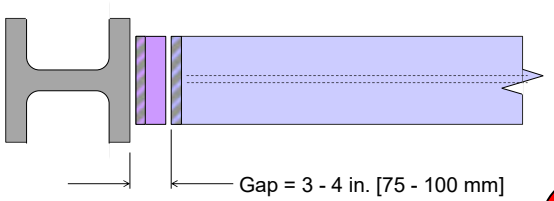


Buttering probably not a good solution

137

PROBLEMS AND FIXES

15.5 Fixing Members That Are Cut Short

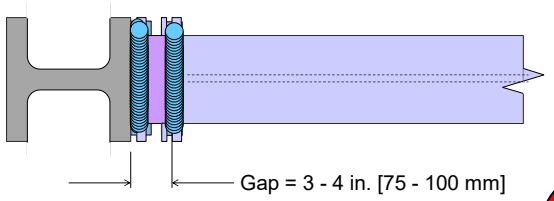


Use an insert?

138

PROBLEMS AND FIXES

15.5 Fixing Members That Are Cut Short

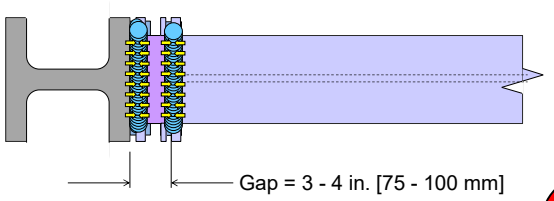


Use an insert?

139

PROBLEMS AND FIXES

15.5 Fixing Members That Are Cut Short

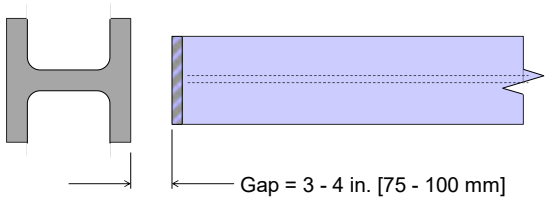


Use an insert?

140

PROBLEMS AND FIXES

15.5 Fixing Members That Are Cut Short

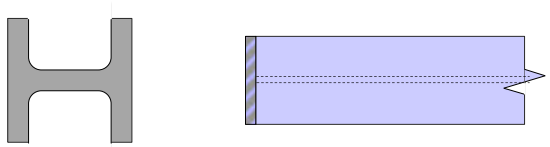


Install a larger insert

141

PROBLEMS AND FIXES

15.5 Fixing Members That Are Cut Short

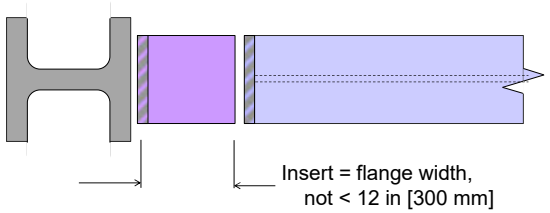


DG suggestion: install a larger insert

142

PROBLEMS AND FIXES

15.5 Fixing Members That Are Cut Short



DG suggestion: install a larger insert

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AWS D1.1:2020 Structural Welding Code--Steel

7.12 Conformance with Design

The sizes and lengths of welds shall be no less than those specified by design requirements and detail drawings, except as allowed in Table 8.1 or Table 10.16. The location of welds shall not be changed without approval of the Engineer.

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PROBLEMS AND FIXES

15.5 Fixing Members that are Cut Short

- Buttering may be an option (EOR must approve)
- Using an insert may be an option (EOR must approve)
- DG21 advise: make insert flange width or 12 in [300 mm] minimum to separate the two parallel welds

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PROBLEMS AND FIXES

Chapter 15: Problems and Fixes

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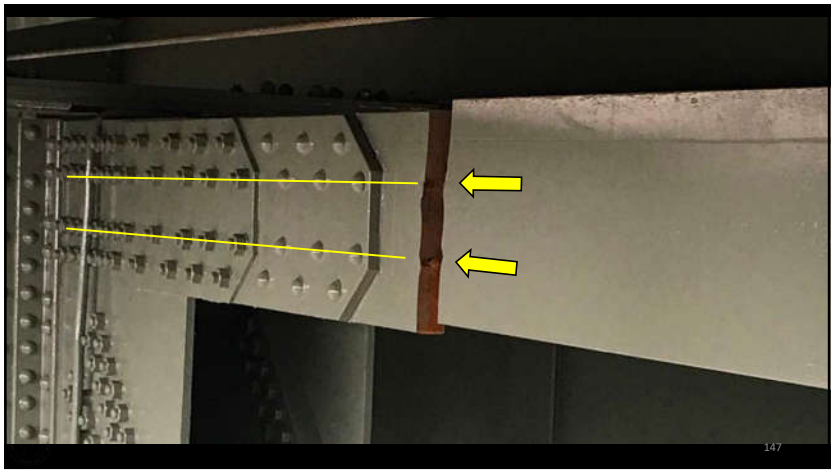

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AWS D1.1:2020 Structural Welding Code--Steel

7.25.5 Welded Restoration of Base Metal with Mislocated Holes.

Mislocated holes may be left open or filled with bolts except when welding is necessary to fulfill contract requirements or when require by the engineer. Base metal with mislocated holes may be restored by welding provided the Contractor prepares and follows a qualified or prequalified WPS and meeting the requirements of (1) through (4) below. The geometry shall be considered prequalified.

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AWS D1.1:2020 Structural Welding Code--Steel

C-7.25.5 Welded Restoration of Base Metal with Mislocated Holes.

The following may be found useful when addressing mislocated holes:

(two approaches follow)

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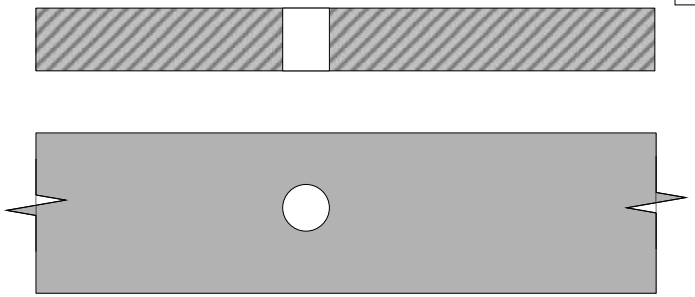
PROBLEMS AND FIXES

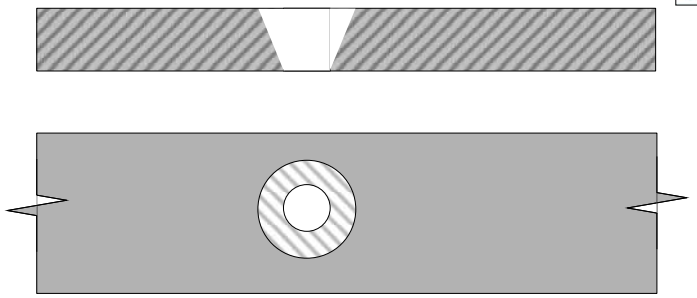
First approach



150

PROBLEMS AND FIXES

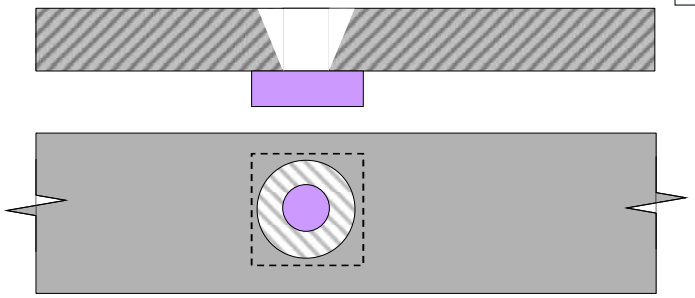
First approach



151

PROBLEMS AND FIXES

First approach



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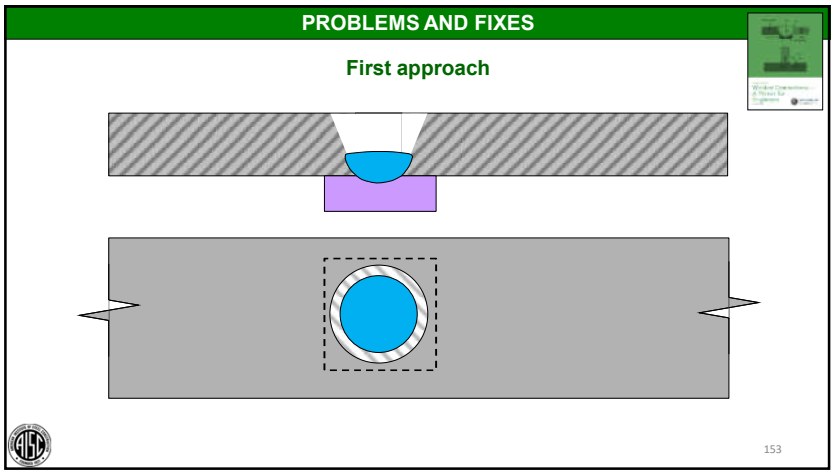
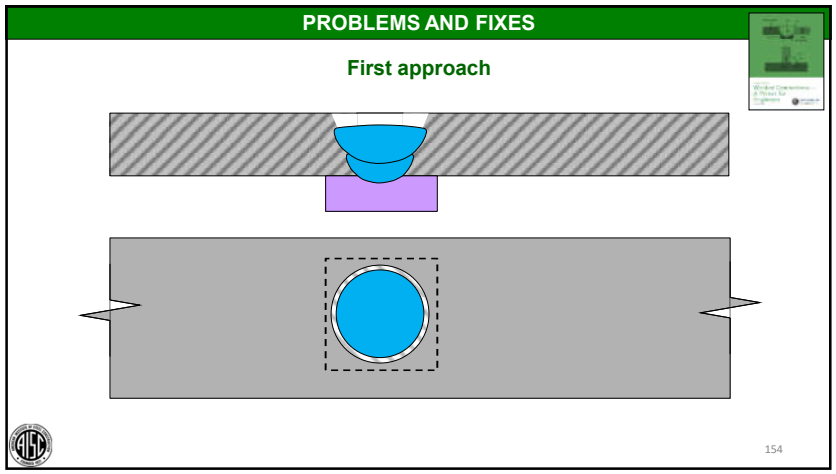
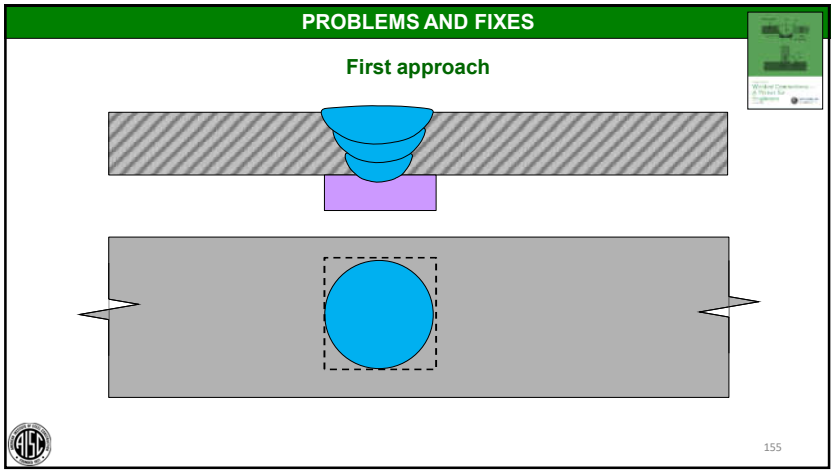
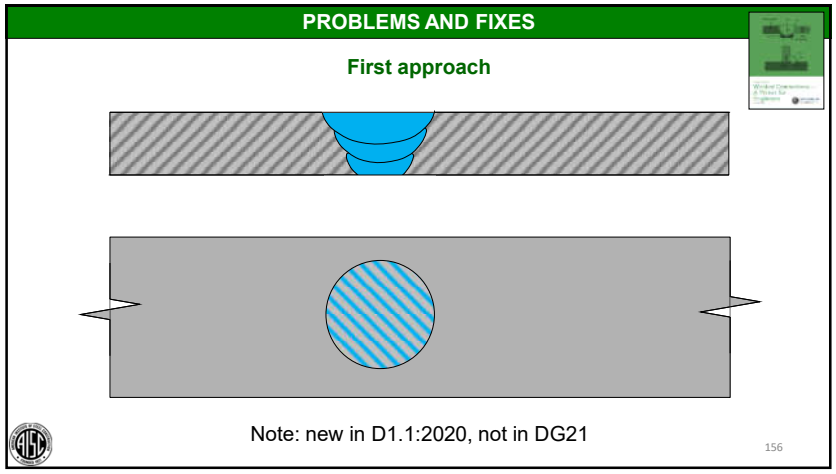


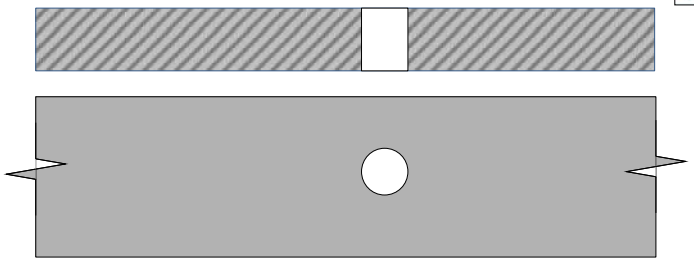






PROBLEMS AND FIXES

Second approach



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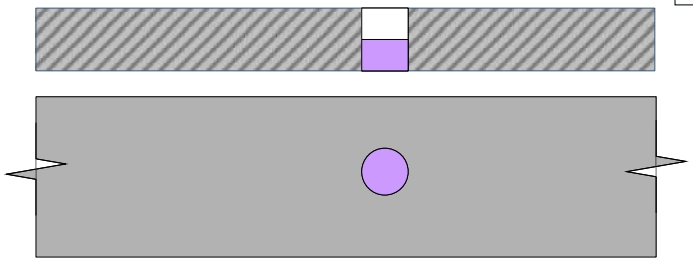
PROBLEMS AND FIXES

Second approach



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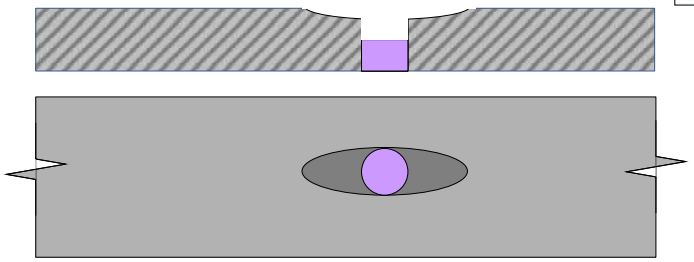
PROBLEMS AND FIXES

Second approach



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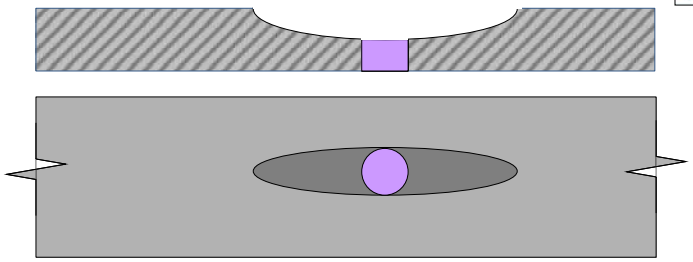
PROBLEMS AND FIXES

Second approach



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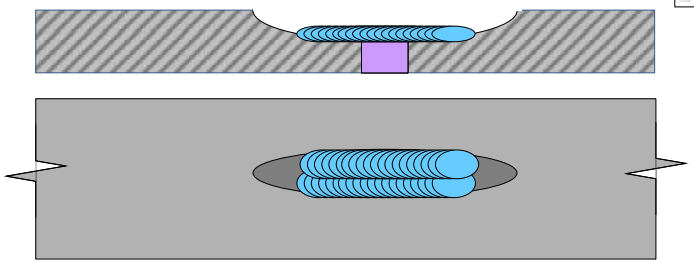
PROBLEMS AND FIXES

Second approach



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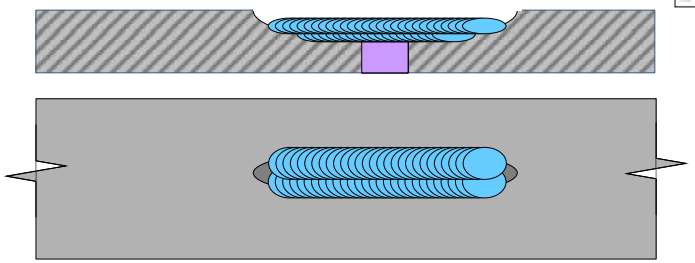
PROBLEMS AND FIXES

Second approach



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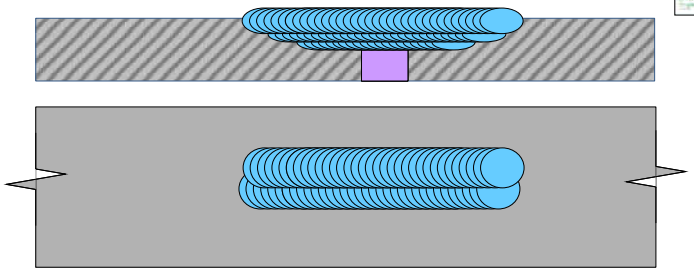
PROBLEMS AND FIXES

Second approach



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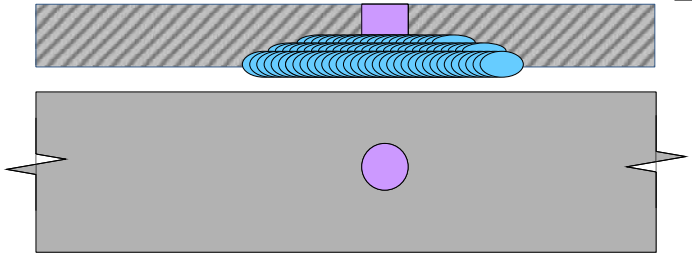
PROBLEMS AND FIXES

Second approach



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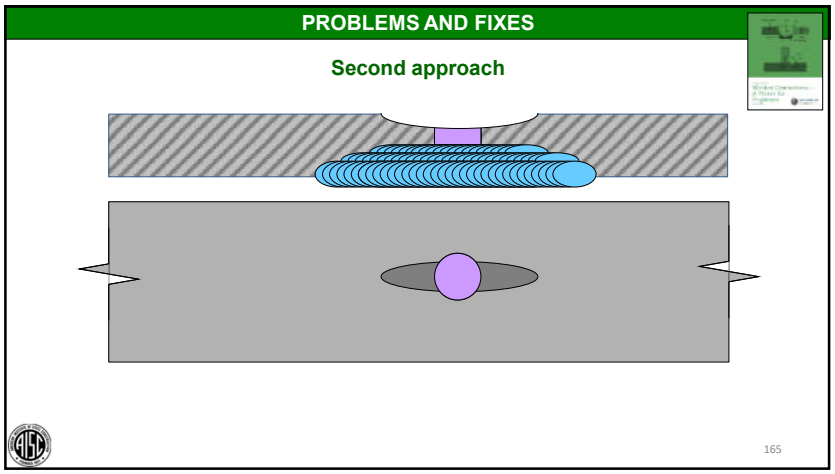

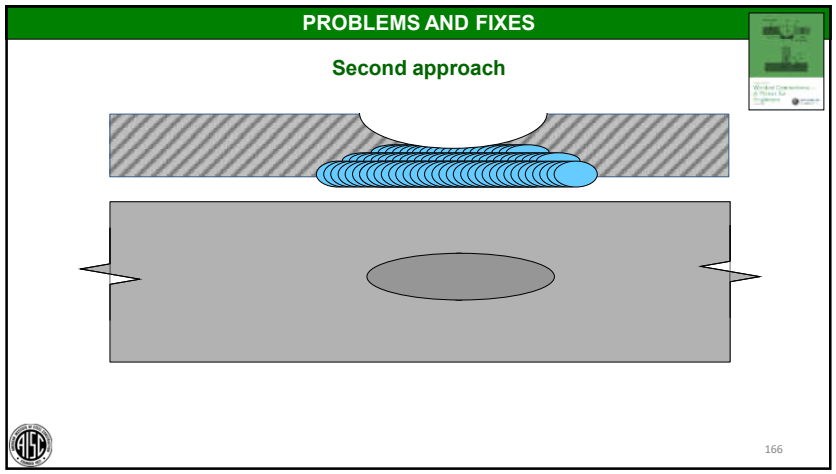

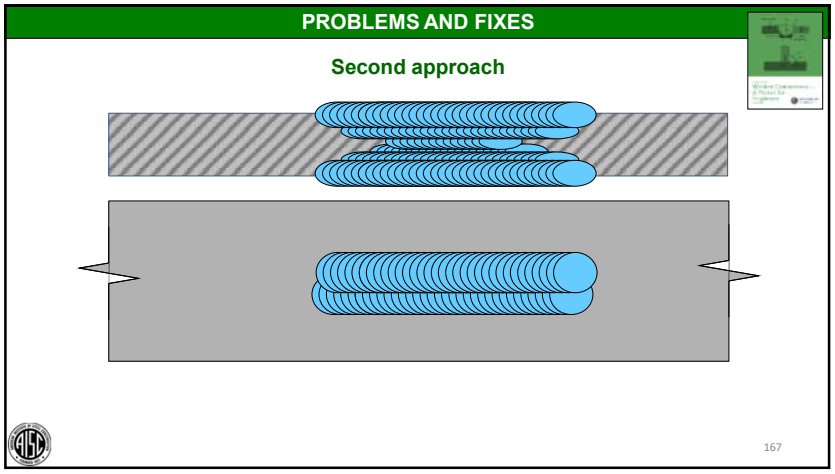

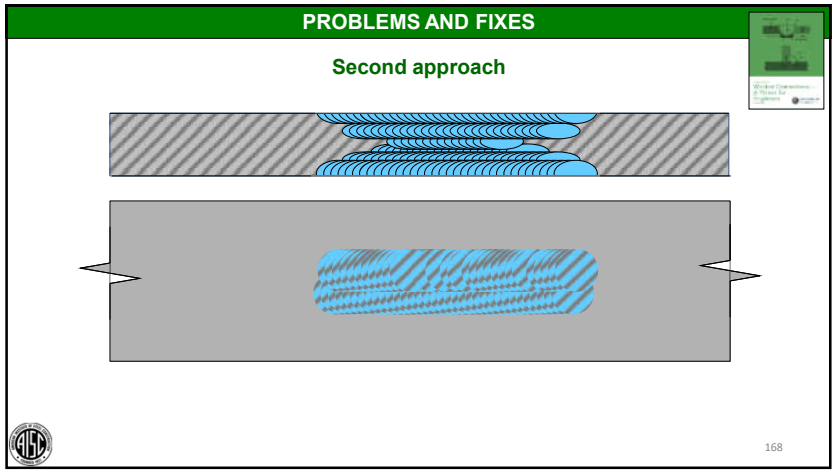

AWS D1.1:2020 Structural Welding Code--Steel

7.25.5 Welded Restoration of Base Metal with Mislocated Holes.

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PROBLEMS AND FIXES

15.6 Repair of Mislocated Holes: Summary

- Caution: improperly repaired holes have been a problem, particularly for cyclically loaded structures
- Leaving the hole unfilled, or inserting a bolt, are good options
- If a weld repair is required, carefully follow code requirements and commentary recommendations

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PROBLEMS AND FIXES

Chapter 15: Problems and Fixes

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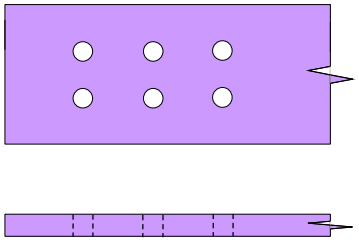
PROBLEMS AND FIXES

15.7 Use Of Plug Welds In Lieu Of Bolts



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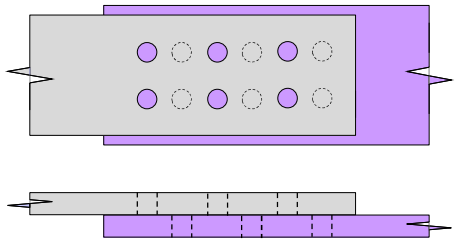
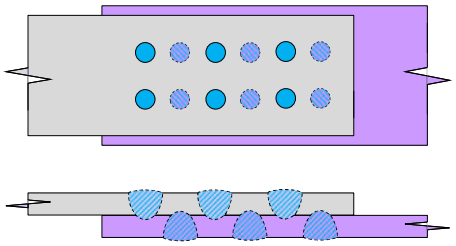
PROBLEMS AND FIXES

15.7 Use Of Plug Welds In Lieu Of Bolts



PROBLEMS AND FIXES

15.7 Use Of Plug Welds In Lieu Of Bolts



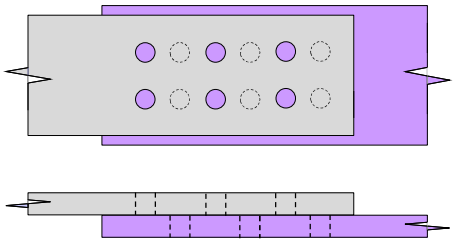
PROBLEMS AND FIXES

Concerns with plug welds

- Original hole was not optimized for plug welding
- Plug weld does not have the capacity of a high strength bolt
- Welding position must be considered; only flat position plug welds are easily made
- For cyclically loaded connections, plug welds have poor fatigue performance (Category E, F)
- Plug welds are assumed to be loaded in shear
- Bolted connection limit states may be different than plug welded connection limit states

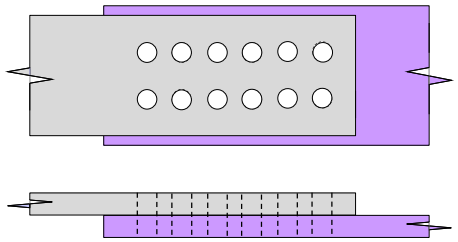
PROBLEMS AND FIXES

Drill new holes and install more bolts



PROBLEMS AND FIXES

Drill new holes and install more bolts



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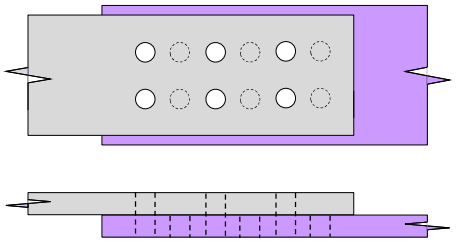
PROBLEMS AND FIXES

Drill new holes and install more bolts



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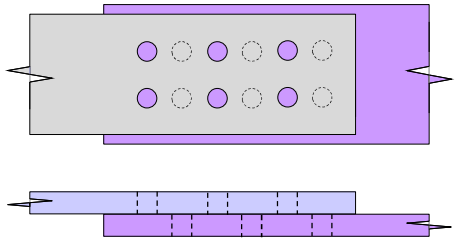
PROBLEMS AND FIXES

Weld hole and re-drill



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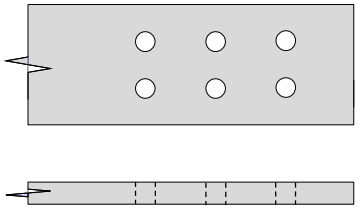
PROBLEMS AND FIXES

Weld hole and re-drill



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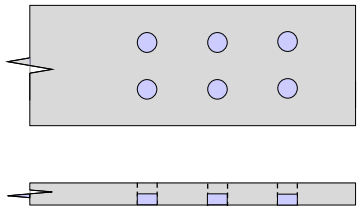
PROBLEMS AND FIXES

Weld hole and re-drill



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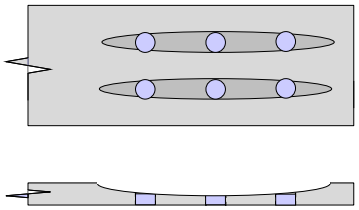
PROBLEMS AND FIXES

Weld hole and re-drill



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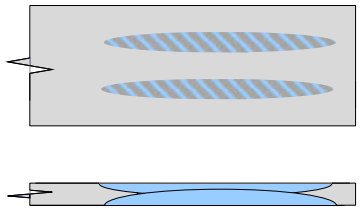
PROBLEMS AND FIXES

Weld hole and re-drill



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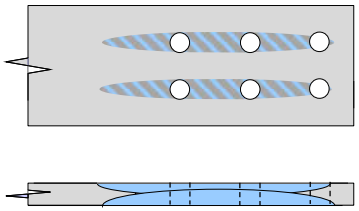
PROBLEMS AND FIXES

Weld hole and re-drill



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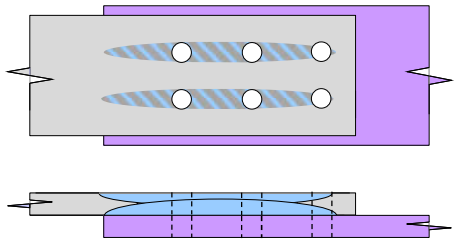
PROBLEMS AND FIXES

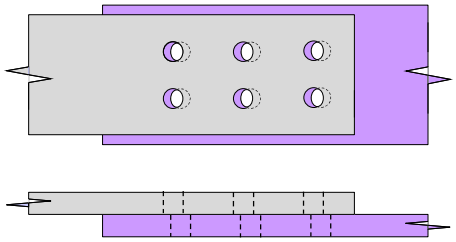
Weld hole and re-drill



185

PROBLEMS AND FIXES

Drill oversized holes and install larger bolts



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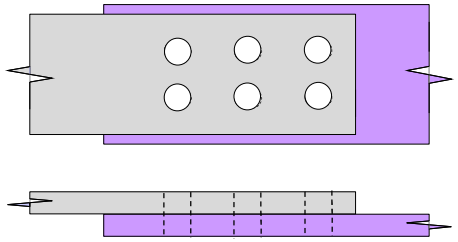
PROBLEMS AND FIXES

Drill oversized holes and install larger bolts



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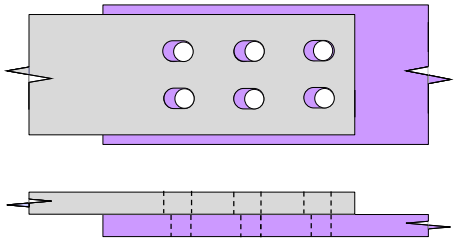
PROBLEMS AND FIXES

Convert holes into slots



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PROBLEMS AND FIXES

15.7 Use of Plug Welds in Lieu of Bolts: Summary

- Plug welds and bolts do not have the same capacity
- Bolt hole sizes are not optimized for plug welding
- Many mechanical options (but, probably more difficult to perform in the field as compared to a plug weld)

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PROBLEMS AND FIXES

15.9 Heat Shrinking of Q&T Steel
15.10 Unspecified Welds
15.11 Welds Made Without Inspection
15.12 Welding on Anchor Rods
15.13 Welding Anchor Rod to Base Plates
15.14 Removing And Reinstalling Column Base Plates
15.15 Repairing Lamellar Tears

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PROBLEMS AND FIXES

15.12 Welding on Anchor Rods

- Extending Anchor Rod
- Welding Anchor Rod to Base Plates

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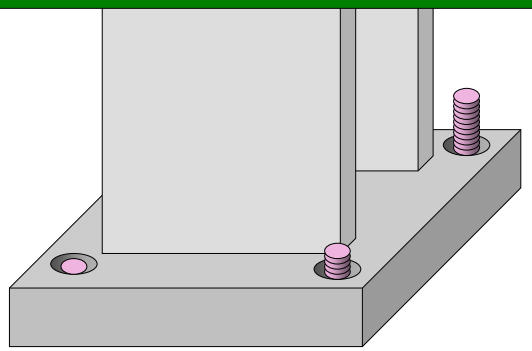
PROBLEMS AND FIXES



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PROBLEMS AND FIXES

Extending Anchor Rods

- Secure the column
- Investigate mechanical options
- Investigate weldability

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AWS STANDARD WELDING TERMS & DEFINITIONS (A3.0:2020)

weldability.

The relative ease with which a material may be welded to meet an applicable standard

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PROBLEMS AND FIXES

Weldability

- Based on composition
- Driven by carbon content
- Compounded by alloy content
- Related to “hardenability”
- “Hot cracking” concerns as well (S, P, others)

Remember: weldability is not <u>whether</u> the material can be welded, but rather <u>how easily</u> can the material be welded.

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PROBLEMS AND FIXES

Weldability Concerns With Anchor Rod Specifications

- High Carbon
- High Alloy
- Undefined Carbon, Alloy
- Heat Treatment (Q&T)

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ASTM A1554-97a

Standard Specification for
Anchor Bolts, Steel, 36, 55, and
105-ksi Yield Strength

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ASTM A1554-97a
Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

Three Grades

4. Classification

4.1 The anchor bolts are furnished in three grades denoting minimum yield strength and two classes denoting thread class as follows:

Grade	Tensile Strength, ksi (MPa)	Description Yield Strength, min, ksi (MPa)	Size Range, in. (mm)
36[A]	58–80 (400–558)	36 (248)	¼ –4 (6.4–102)
55	75–95 (517–655)	55 (380)	¼ –4 (6.4–102)
105	125–150 (862–1034)	105 (724)	¼ –3 (6.4–76)

Class	
1A	anchor bolts with Class 1A threads
2A	anchor bolts with Class 2A threads

[A] When Grade 36 is specified, a weldable Grade 55 may be furnished at the supplier's option.

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ASTM A1554-97a
Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

4.2 Weldable steel for Grade 55 is provided for in Supplementary Requirement S1.

199

ASTM A1554-97a
Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

Substitution option: weldable Grade 55 for Grade 36

4. Classification

4.1 The anchor bolts are furnished in three grades denoting minimum yield strength and two classes denoting thread class as follows:

Grade	Tensile Strength, ksi (MPa)	Description Yield Strength, min, ksi (MPa)	Size Range, in. (mm)
36[A]	58–80 (400–558)	36 (248)	¼ –4 (6.4–102)
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Class	
1A	anchor bolts with Class 1A threads
2A	anchor bolts with Class 2A threads

[A] When Grade 36 is specified, a weldable Grade 55 may be furnished at the supplier's option.

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ASTM A1554-97a
Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

Permitted Options	
Ordered	**Delivered**
Grade 36	Grade 36
	Grade 55 S1
Grade 55	Grade 55
	Grade 55 S1
Grade 55 S1	Grade 55 S1
Grade 105	Grade 105

ASTM A1554-97a
Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

Permitted Options	
Ordered	**Delivered**
Grade 36	Grade 36
	Grade 55 S1
Grade 55	Grade 55
	Grade 55 S1
Grade 55 S1	Grade 55 S1
Grade 105	Grade 105

Four Types to be Considered

ASTM A1554-97a
Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

Grade 36

TABLE 1 Chemical Requirements for Grade 36

Element	Diameter, in. (mm) To ¾ (20), incl	Over ¾ to 1½ (20 to 40), incl	Over 1½ to 4 (40 to 100), incl
Carbon, max, %			
Heat	0.26	27	0.28
Product	0.29	0	0.31
Manganese, %			
Heat	[A]	–0.90	0.60–0.90
Product		0.54–0.98	0.54–0.98
Phosphorus, max, %			
Heat		0.04	0.04
Product		0.05	0.05
Sulfur, max, %			
Heat	0.05	0.05	0.05
Product	0.06	0.06	0.06
Copper, min, % (when specified)			
Heat	0.20	0.20	0.20
Product	0.18	0.18	0.18

[A] Optional with the manufacturer but shall be compatible with weldable steel.

Similar to A36

ASTM A1554-97a
Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

Grade 55
Grade 105

TABLE 2 Chemical Requirements for Grades 55 and 105

Element	Composition, % Heat Analysis	Product Analysis
Phosphorous, max	0.040	0.048
Sulfur, max	0.050	0.058
Copper, min (when Cu is specified)	0.20	0.18

No controls on carbon or alloy content

ASTM A1554-97a
Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

Grade 55 S1

S1. Grade 55 Bars and Anchor Bolts

S1.1 The material described in this section is intended for welding. This supplemental section, by chemical composition restrictions and by a carbon equivalent formula, provides assurance of weldability.

S1.2 Welding technique is of fundamental importance when bolts produced to this supplementary section are welded. It is assumed that suitable welding procedures for the steel being welded and the intended service will be selected.

ASTM A1554-97a
Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

Grade 55 S1

S1.5 *Chemical Composition:*

S1.5.1 Steel shall conform to the following limitations:

	Heat Analysis	Product Analysis
Carbon, max, %	0.30	0.33
Manganese, max, %	1.35	1.41
Phosphorus, max, %	0.040	0.048
Sulfur, max, %	0.050	0.058
Silicon, max, %	0.50	0.55

Cold Cracking Controls

Hot Cracking Controls

ASTM A1554-97a
Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

Grade 55 S1

S1.5.2 *Carbon Equivalent*—In addition to the requirements specified in S1.5.1, the analysis shall be such as to provide a carbon equivalent (CE) meeting the following requirements:

S1.5.2.1 For alloy or low-alloy steel, the carbon equivalent shall not exceed 0.45 % when calculated as follows:

$$CE = \%C + \frac{\%Mn}{6} + \frac{\%Cu}{40} + \frac{\%Ni}{20} + \frac{\%Cr}{10} - \frac{\%Mo}{50} - \frac{\%V}{10}$$

S1.5.2.2 For carbon steel, the carbon equivalent shall not exceed 0.40 % when calculated as follows:

$$CE = \%C + \frac{\%Mn}{4}$$

Weldability of Anchor Rods

Grade 36

- Chemistry is similar to that of ASTM A36
- Deviation on Mn permitted only for smaller rods
- If Grade 55 is substituted, only weldable (S1) material may be used

Weldability should be good.

Weldability of Anchor Rods

Grade 55

- The only chemistry control is on S, P (and Cu, when Cu is specified)
- No weldability promises

Weldability should be investigated on a case-by-case basis.

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Weldability of Anchor Rods

Grade 55 S1

- Chemistry is similar to that of ASTM A36
- Carbon equivalency limits
- "The material described in this section is intended for welding."
- "This supplemental section...provides assurance of weldability."

Weldability should be good.

210

Weldability of Anchor Rods

Grade 105

- The only chemistry control is on S, P (and Cu, when Cu is specified)
- No weldability promises
- High strength (105 ksi yield)
- May be quenched and tempered

Weldability is likely to be poor.

Caveat: poor weldability does not mean unweldable.

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PROBLEMS AND FIXES

Extending Anchor Rods

- Secure the column
- Investigate mechanical options
- Investigate weldability
- Use an appropriate detail

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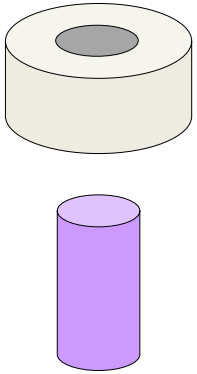
PROBLEMS AND FIXES



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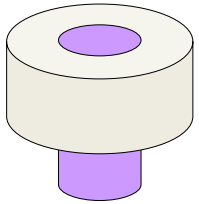
PROBLEMS AND FIXES



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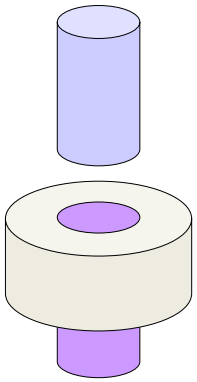
PROBLEMS AND FIXES



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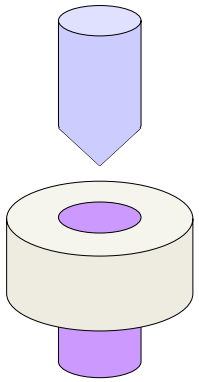
PROBLEMS AND FIXES

Note:

chisel-point,

not pencil-point



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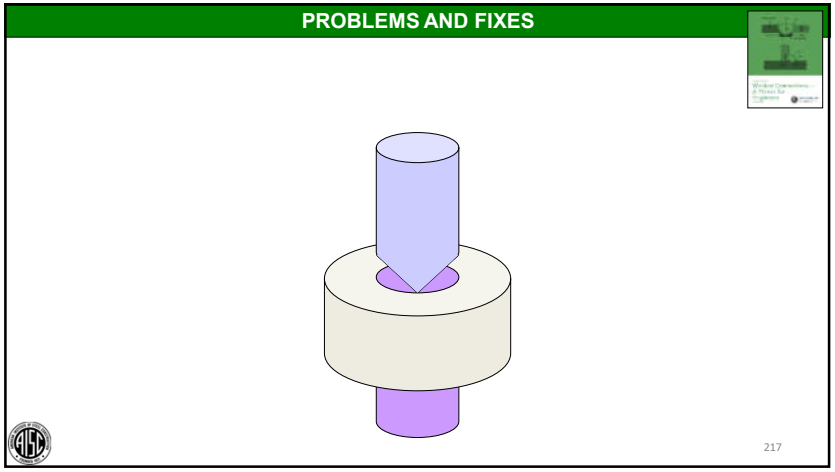

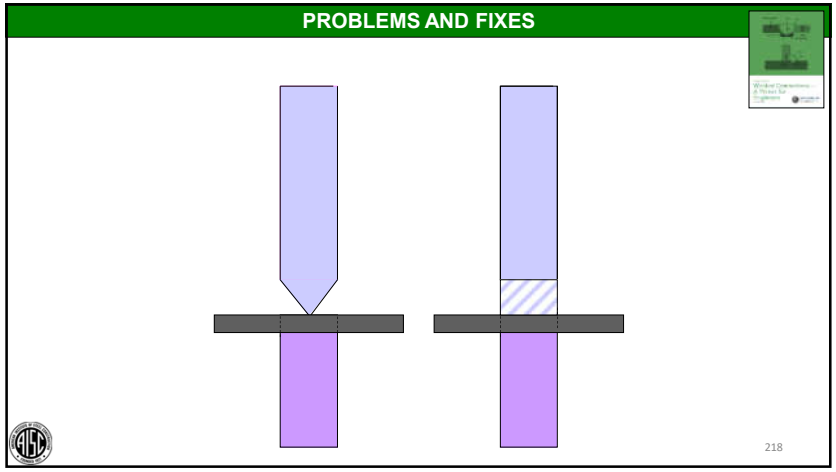

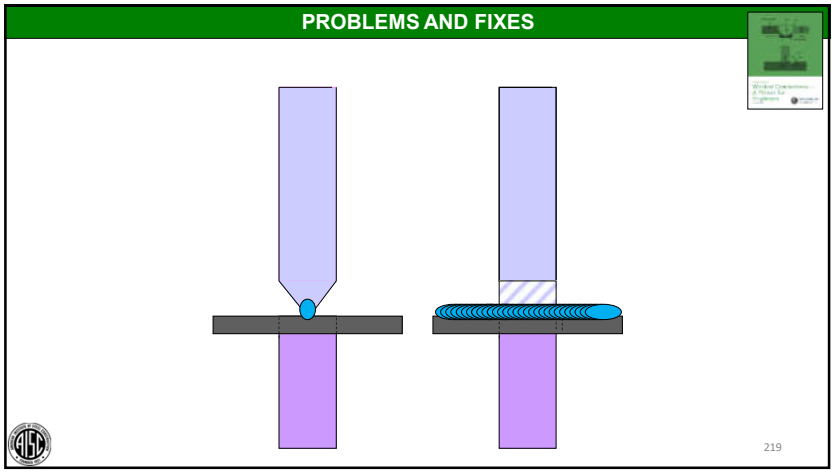

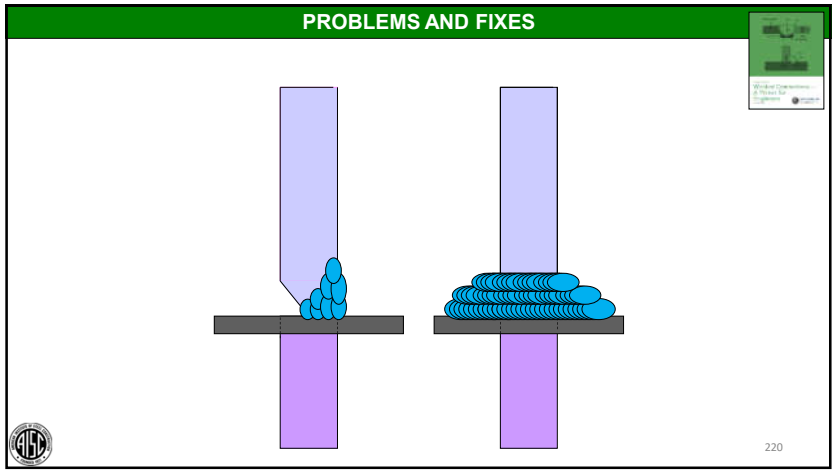

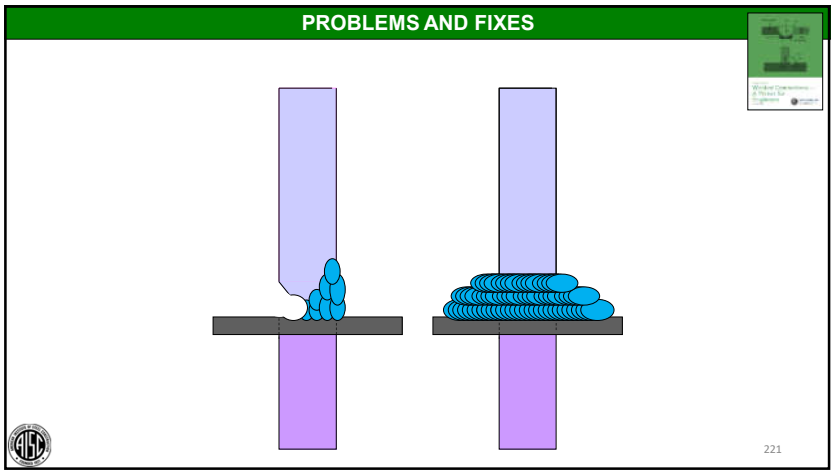

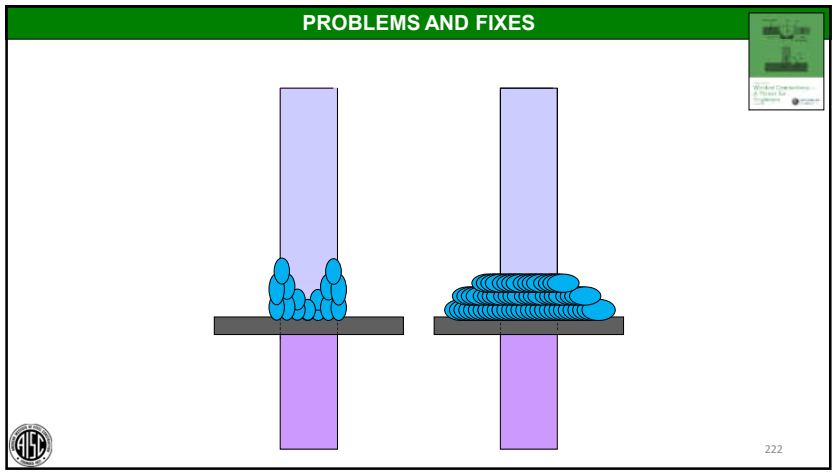

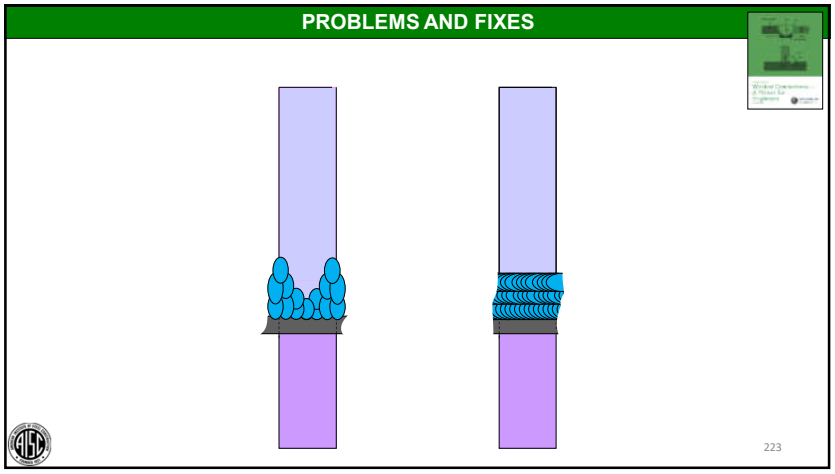

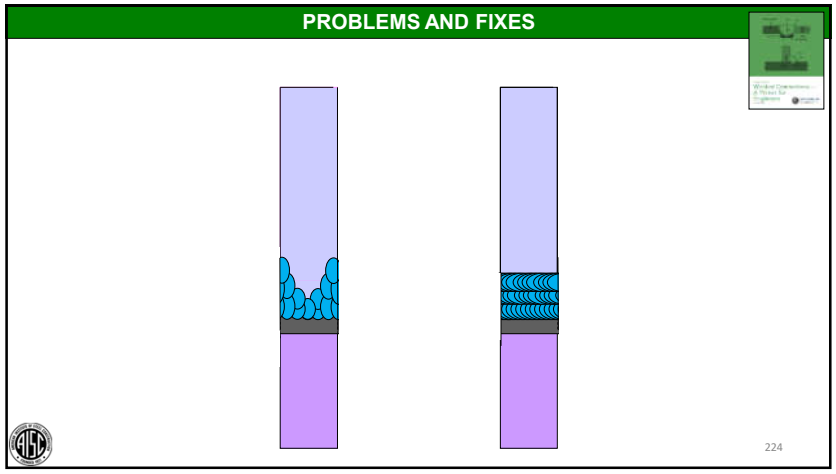

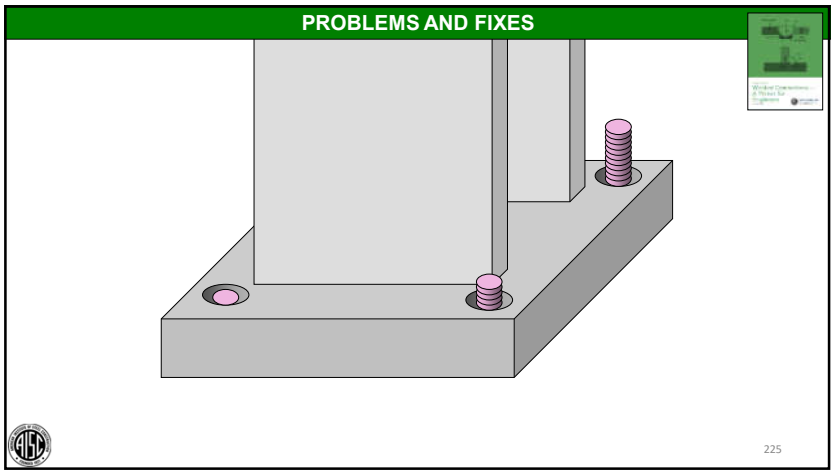

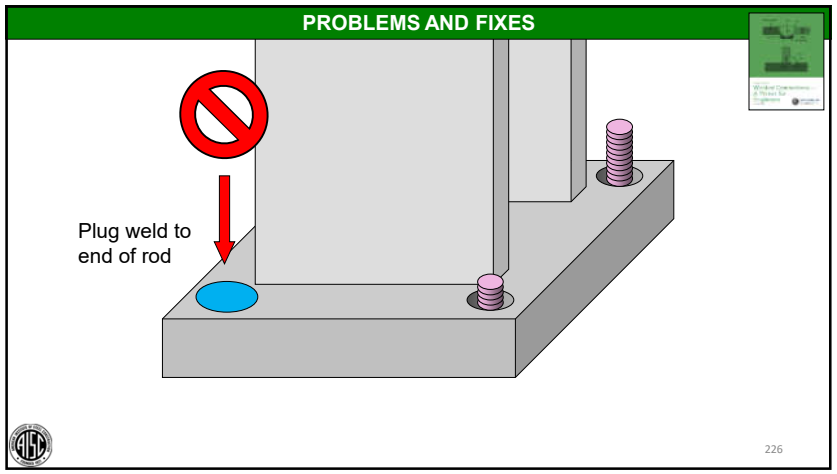

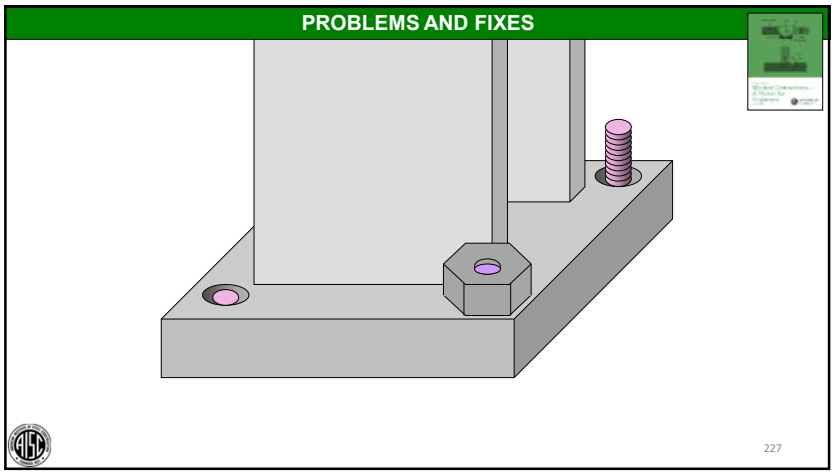

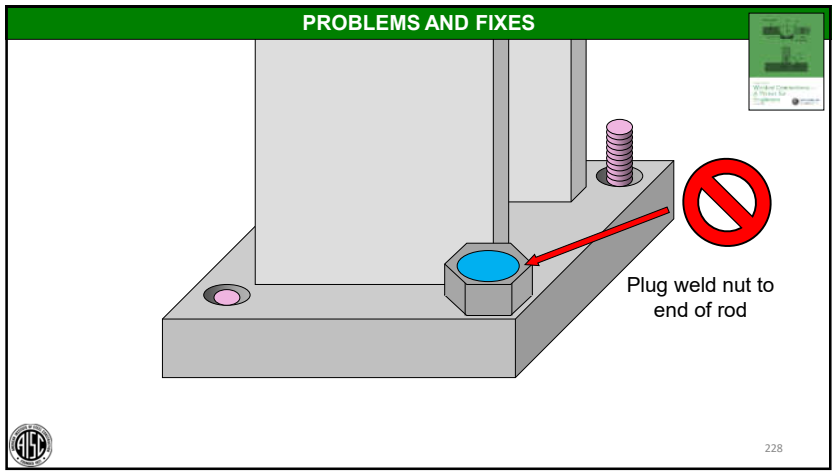

PROBLEMS AND FIXES

15.12 Welding on Anchor Rods

- Extending Anchor Rod
- Welding Anchor Rod to Base Plates

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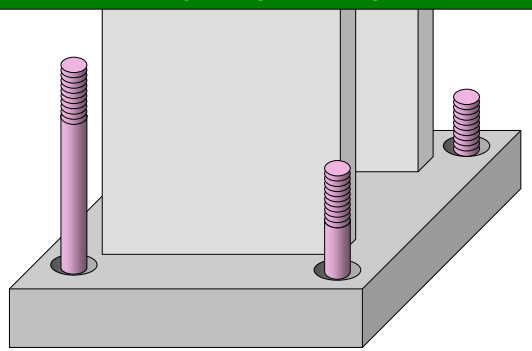
PROBLEMS AND FIXES



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PROBLEMS AND FIXES

Welding Anchor Rod to Base Plates

- Secure the column
- Is there sufficient anchorage?
- Investigate mechanical options

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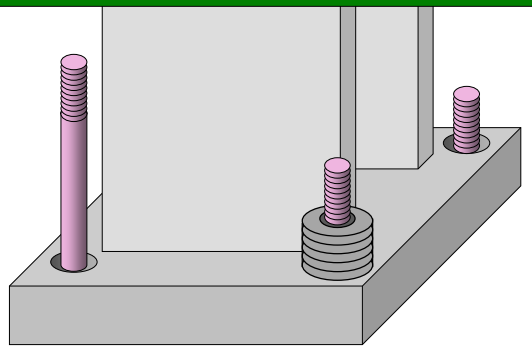
PROBLEMS AND FIXES



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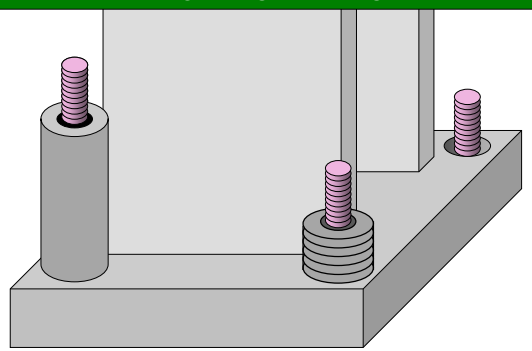
PROBLEMS AND FIXES



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PROBLEMS AND FIXES

Welding Anchor Rod to Base Plates

- Secure the column
- Is there sufficient anchorage?
- Investigate mechanical options
- Investigate weldability
- Use an appropriate detail

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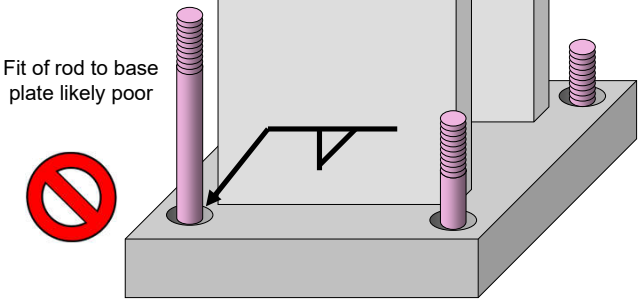
PROBLEMS AND FIXES

Fit of rod to base plate likely poor



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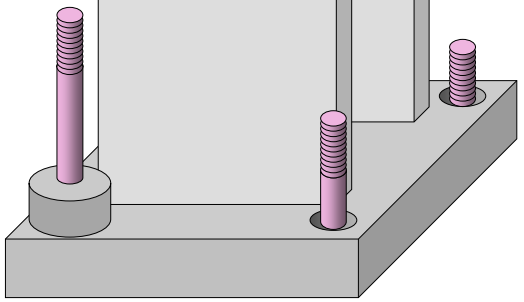
PROBLEMS AND FIXES



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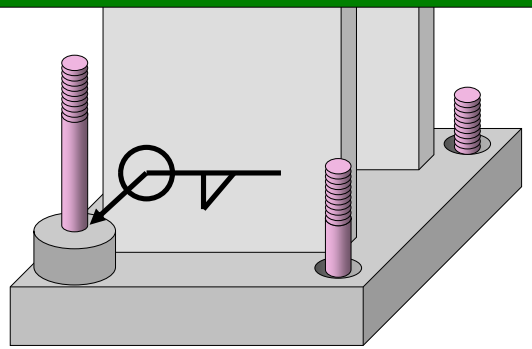
PROBLEMS AND FIXES



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PROBLEMS AND FIXES

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PROBLEMS AND FIXES

Unspecified Welds

Unspecified welds are welds made on a structure that are not identified on contract, shop, or erection drawings.

Tack welds and construction aid welds are separately discussed in AWS D1.1, clause 7.17, with specific provisions for dealing with each type of weld; these are not categorized as unspecified welds.

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AWS D1.1:2020 Structural Welding Code--Steel

8.5 Inspection of Work and Records

8.5.1 Size, Length, and Location of Welds.

The Inspector shall ensure that the size, length, and location of all welds conform to the requirements of this code and to the detail drawings and that no unspecified welds have been added without the approval of the Engineer.

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PROBLEMS AND FIXES

Unspecified Welds

The question to be answered: ***Why?***

"When it rains, it pours"

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PROBLEMS AND FIXES

Unspecified Welds

"Additional caution should be given to unspecified welds when the structure is subjected to cyclic or seismic loading."

"In most cases, problematic unspecified welds can be removed and the localized area repaired by grinding."

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PROBLEMS AND FIXES

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PROBLEMS AND FIXES

Question:
The weld was done without the requisite inspection. Do I have it removed and replaced with the inspector present?

A related theoretical question:
Is it possible for a welder to make a good weld if an inspector is not present?

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AISC 360:16 Specification for Structural Steel Buildings

CHAPTER N

QUALITY CONTROL AND QUALITY ASSURANCE

This chapter addresses minimum requirements for quality control, quality assurance and nondestructive testing for structural steel systems and steel elements of composite members for buildings and other structures.

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AISC 360:16 Specification for Structural Steel Buildings

N5. MINIMUM REQUIREMENTS FOR INSPECTION OF STRUCTURAL STEEL BUILDINGS

4. Inspection of Welding

Observation of welding operations and visual inspection of in-process and completed welds shall be the primary method to confirm that the materials, procedures and workmanship are in conformance with the construction documents.

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AISC 360:16 Specification for Structural Steel Buildings

N5. MINIMUM REQUIREMENTS FOR INSPECTION OF STRUCTURAL STEEL BUILDINGS

4. Inspection of Welding (cont'd)

As a minimum, welding inspection tasks shall be in accordance with Tables N5.4-1, N5.4-2 and N5.4-3. In these tables, the inspection tasks are as follows:

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AISC 360:16 Specification for Structural Steel Buildings

N5. MINIMUM REQUIREMENTS FOR INSPECTION OF STRUCTURAL STEEL BUILDINGS

4. Inspection of Welding (cont'd)

(a) Observe (O): The inspector shall observe these items on a random basis. Operations need not be delayed pending these inspections.

(b) Perform (P): These tasks should be performed for each welded joint or member.

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AISC 360:16 Specification for Structural Steel Buildings

TABLE N5.4-1
Inspection Tasks Prior to Welding

Inspection Tasks Prior to Welding	QC	QA
Welder qualification records and continuity records	P	O
WPS available	P	P
Manufacturer certifications for welding consumables available	P	P
Material identification (type/grade)	O	O
Welder identification system[a]	O	O

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AISC 360:16 Specification for Structural Steel Buildings

TABLE N5.4-2
Inspection Tasks During Welding

Inspection Tasks During Welding	QC	QA
Control and handling of welding consumables • Packaging • Exposure control	O	O
No welding over cracked tack welds	O	O
Environmental conditions • Wind speed within limits • Precipitation and temperature	O	O

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AISC 360:16 Specification for Structural Steel Buildings

TABLE N5.4-3
Inspection Tasks After Welding

Inspection Tasks After Welding	QC	QA
Welds cleaned	O	O
Size, length and location of welds	P	P
Welds meet visual acceptance criteria • Crack prohibition • Weld/base-metal fusion • Crater cross section • Weld profiles • Weld size • Undercut	P	P

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AISC 360:16 Specification for Structural Steel Buildings

TABLE N5.4-3
Inspection Tasks After Welding

Inspection Tasks After Welding	QC	QA
Welds cleaned	O	O
Size, length and location of welds	P	P
Welds meet visual acceptance criteria • Crack prohibition • Weld/base-metal fusion • Crater cross section • Weld profiles • Weld size • Undercut	P	P
Arc strikes	P	
k-area[a]	P	P
Weld access holes in rolled heavy shapes and built-up heavy shapes[b]	P	P
Backing removed and weld tabs removed (if required)	P	P
Repair activities	P	P
Document acceptance or rejection of welded joint or member	P	P
No prohibited welds have been added without the approval of the EOR	O	O

[a] When welding of doubler plates, continuity plates or stiffeners has been performed in the k-area, visually inspect the web k-area for cracks within 3 in. (75 mm) of the weld.
[b] After rolled heavy shapes (see Section A3.1c) and built-up heavy shapes (see Section A3.1d) are welded, visually inspect the weld access hole for cracks.

All of these inspections can still be performed

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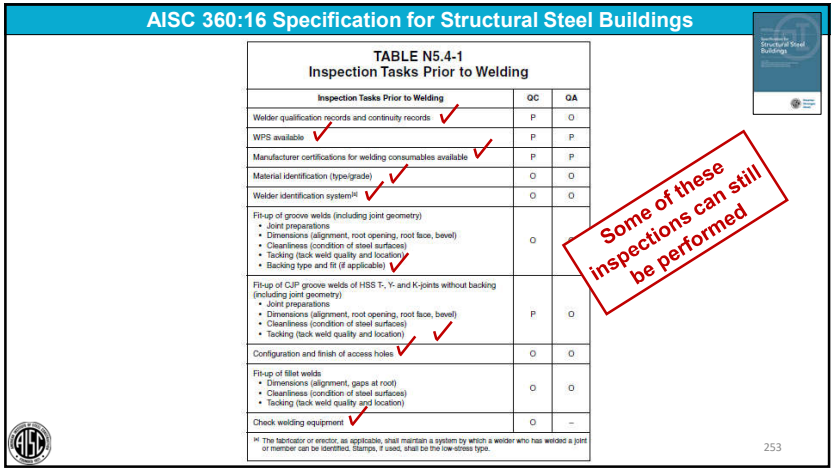

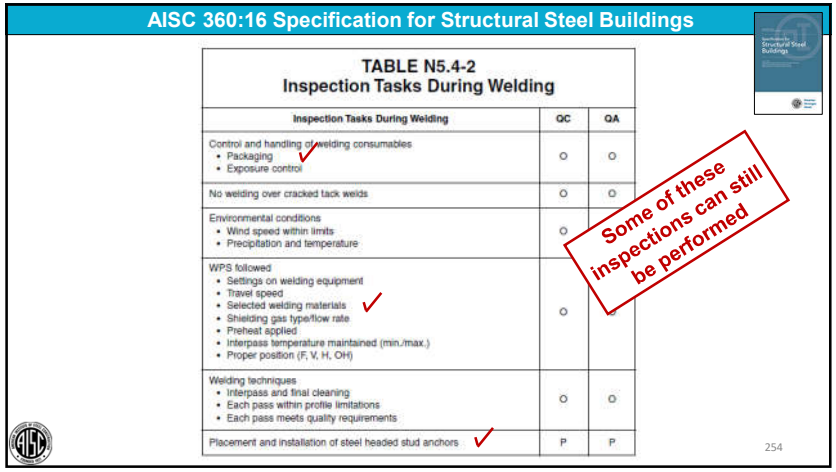

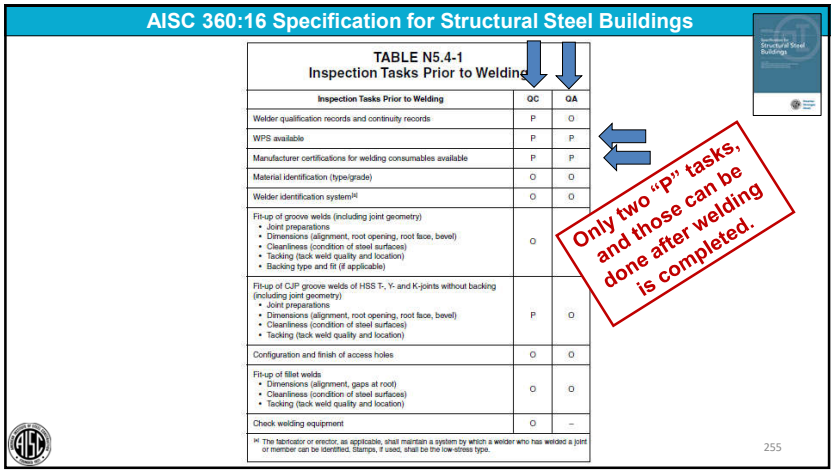

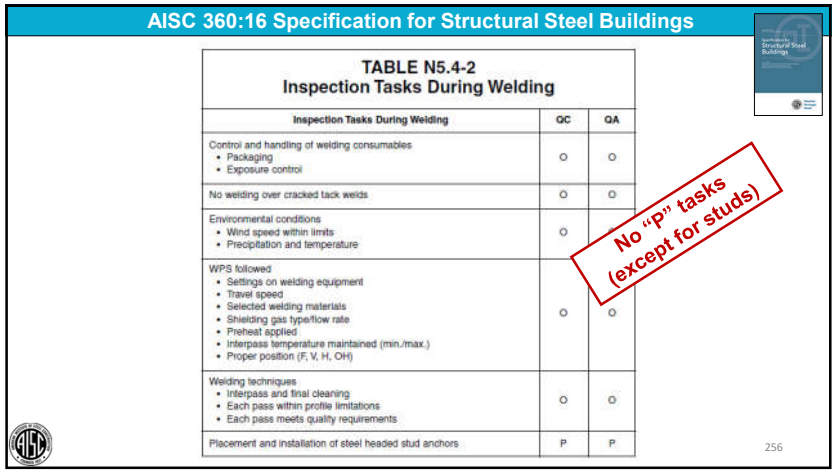

PROBLEMS AND FIXES

Question:

The weld was done without the requisite inspection. Do I have it removed and replaced with the inspector present?

Questions that should be asked?

- Do the welds meet the visual acceptance criteria?
- Has anything changed?
- Does it pass the smell test?

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PROBLEMS AND FIXES

Question:

The weld was done without the requisite inspection. Do I have it removed and replaced with the inspector present?

Possible answers:

No, providing a careful review of the situation reveals no significant non-conformances.

Yes, if the review reveals defective welds.

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PROBLEMS AND FIXES

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Thank you!

AISC | Questions

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Individual Session Registrants

PDH Certificates

- All WFH individuals associated with a group registration will be issued a certificate.
- All individuals attending at your connection: you will receive an email on how to report their attendance from: registration@aisc.org.
  - Be on the lookout: Check your spam filter! Check your junk folder!
  - Completely fill out online form. Don't forget to check the boxes next to each attendee's name!

8-Session Registrants

PDH Certificates

One certificate will be issued at the conclusion of all 8 sessions.

8-Session Registrants

Access to the quiz

Information for accessing the quiz will be emailed to you by Wednesday. It will contain a link to access the quiz. EMAIL COMES FROM NIGHTSCHOOL@AISC.ORG.

Quiz and attendance records

Posted Friday mornings. www.aisc.org/nightschool -- Click on Current Course Details.

Reasons for quiz

- EEU – You must take all quizzes and the final exam to receive EEU.
- PDHs – If you watch a recorded session, you must pass quiz for PDHs.
- REINFORCEMENT – Reinforce what you learn tonight. Get more out of the course.

Note: If you attend the live presentation, you do not have to take the quizzes to receive PDHs

8-Session Registrants

Access to the recording

Information for accessing the recording will be emailed to you by Wednesday. The recording will be available for four weeks. (For 8-session registrants only.) EMAIL COMES FROM NIGHTSCHOOL@AISC.ORG.

PDHs via recording

If you watch a recorded session, you must take *and pass* the quiz for PDHs.

8-Session Registrants

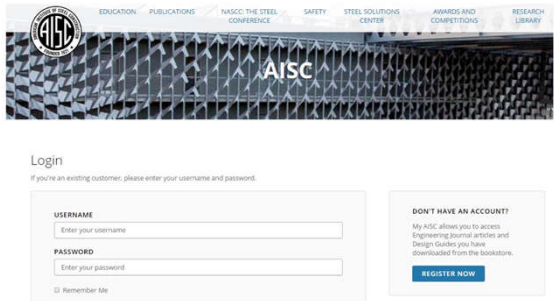
Night School Resources

Find all your handouts, quizzes and quiz scores, recording access, and attendance information all in one place!

8-Session Registrants

Night School Resources

Go to www.aisc.org and sign in.



8-Session Registrants

Night School Resources

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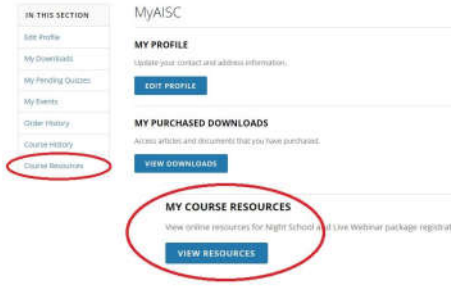

8-Session Registrants

Night School Resources

Course Resources

8-Session Registrants

Night School Resources

Night School 13: Design of Industrial Buildings

8-SESSION PACKAGE RESOURCES

8-Session Registrants

Night School Resources

- Weekly "quiz and recording" email.
- Weekly updates of the master quiz and attendance record, found at www.aisc.org/nightschool27. Scroll down to Quiz and Attendance records.
  - Updated on Friday mornings.

8-Session Registrants

Night School Resources

- Webinar connection information
  - Reminder email sent out Monday mornings
- Links to handouts also found here