


**Night School 27:  
Fundamentals of  
Welding and Bolting**

Thank you for joining our live webinar. We will begin shortly. Please standby.

**AISC Night School**



**Session 3 – Special Welding Applications**  
October 18, 2021 | Duane K. Miller




**Smarter.  
Stronger.  
Steel.**

**AISC Night School**

Today's audio will be broadcast through the internet. Please be sure to turn up the volume on your speakers.

Please type any questions or comments in the Q&A window.




**AISC Night School**

**Today's live webinar will begin shortly. Please stand by.**

Today's audio will be broadcast through the internet. Please be sure to turn up the volume on your speakers.

Please type any questions or comments in the Q&A window.




**AISC Night School**

**AIA Credit**

AISC is a Registered Provider with The American Institute of Architects Continuing Education Systems (AIA/CES). Credit(s) earned on completion of this program will be reported to AIA/CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This program has been submitted for AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.





### Copyright Materials

This presentation is protected by US and International Copyright laws. Reproduction, distribution, display and use of the presentation without written permission of AISC is prohibited.

© The American Institute of Steel Construction 2021

The information presented herein is based on recognized engineering principles and is for general information only. While it is believed to be accurate, this information should not be applied to any specific application without competent professional examination and verification by a licensed professional engineer. Anyone making use of this information assumes all liability arising from such use.



### Course Description

#### Special Welding Applications October 18, 2021

This session covers atypical welding applications for buildings. The live webinar presents practical, straightforward solutions to challenging situations including: welding of steel headed stud anchors, welding on coated steels, welding AESS, welding on existing structures, welding heavy sections, welding under high restraint, field welding, heat shrinking, cold temperature applications and more.



### Learning Objectives

1. Describe tolerance issues that may affect welded connections in AESS structures.
2. Identify welded HSS connections where member configurations could prevent proper welding, inspection or assembly.
3. List considerations for welded connections on rolled heavy shapes.
4. List consideration for welded connections in cold temperature applications.



## Night School 27: Fundamentals of Welding and Bolting



Curtis L. Decker, PhD,  
PE, SE, The Lincoln  
Electric Company



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



Chad Larson, LeJeune  
Bolt Company



Smarter.  
Stronger.  
Steel.

## Night School 27: Fundamentals of Welding and Bolting

Welding Part 3: Special Welding Applications  
October 18, 2021

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



### SPECIAL WELDING APPLICATIONS

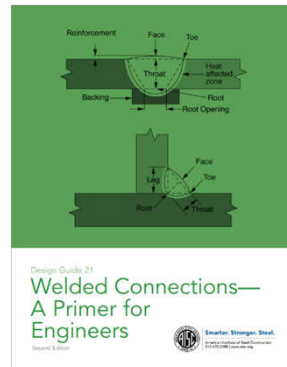


10

### AISC Design Guide 21, 2<sup>nd</sup> Edition

Welded Connections—  
A Primer for Engineers

### Chapter 14 Special Welding Applications



11

### SPECIAL WELDING APPLICATIONS



### Chapter 14 Special Welding Applications



- 14.1 Welding of Steel Headed Stud Anchors
- 14.2 Welding on Galvanized Steels
- 14.3 Welding on Primed and Painted Steel
- 14.4 Welding on Heavy Shapes
- 14.5 Welding on Highly Restrained Members
- 14.6 Welding HSS



12

**SPECIAL WELDING APPLICATIONS**



- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.10 Welds and Mechanical Fasteners
- 14.11 Welding on Members to be Hot-Dip Galvanized
- 14.12 Cold Temperature Applications
- 14.13 Deck Welding



13

**SPECIAL WELDING APPLICATIONS**

- 14.14 Welding on In-Place Embed Plates
- 14.15 Heat Shrinking
- 14.16 Buttering



14

**SPECIAL WELDING APPLICATIONS**

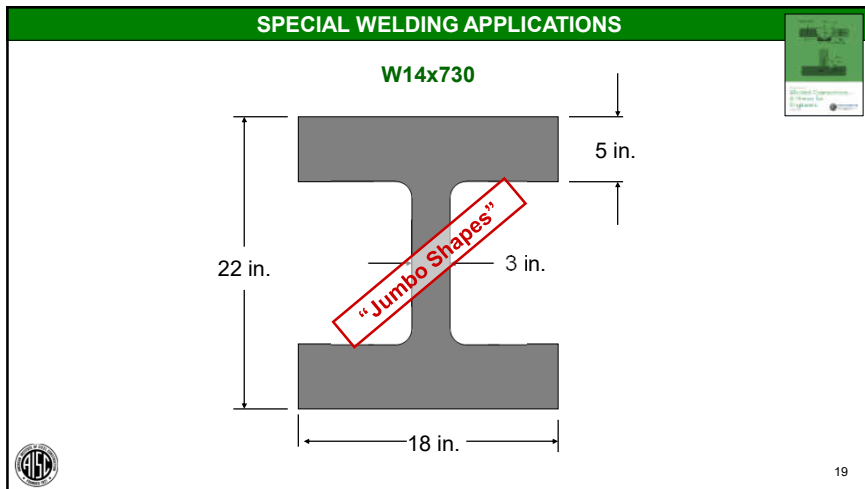
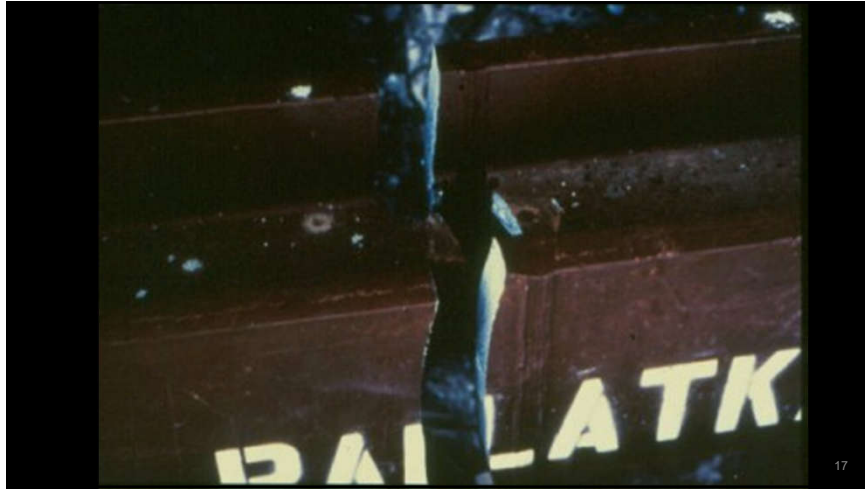
**Today's Webinar**

- ➔ 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- 14.16 Buttering



15






**AISC 360-16 SPECIFICATION**

**Commentary A3**

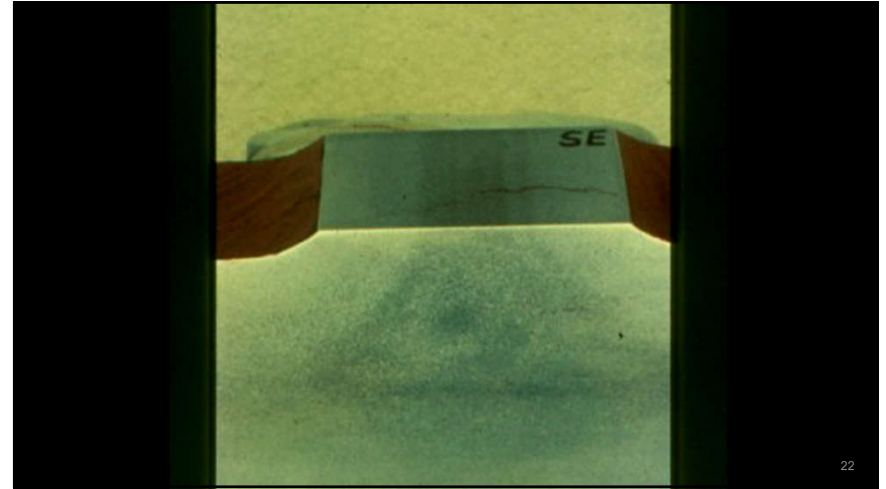
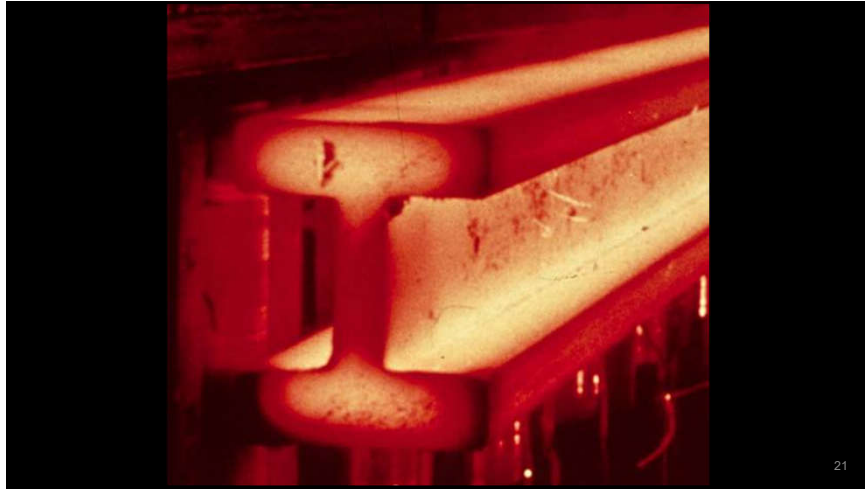
**1c. Rolled Heavy Shapes**

The web-to-flange intersection and the web center of heavy hot-rolled shapes, as well as the interior portions of heavy plates, may contain a more coarse grain structure and/or lower notch toughness material than other areas of these products.

**Segregation**      **Reduced Rolling**      **Slower Cooling**



20




AISC 360-16 Specification for Structural Steel Buildings

Commentary A3

**1c. Rolled Heavy Shapes**

This characteristic is not detrimental to suitability for compression members or for non-welded members. However, when heavy cross sections are joined by splices or connections using complete-joint-penetration groove welds that extend through the coarser and/or low notch-tough interior portions, tensile strains induced by welding may result in cracking.



23


AISC 360-16 Specification for Structural Steel Buildings

Commentary A3

**1a. ASTM Designations**

Rolled Steel is anisotropic, especially insofar as ductility is concerned; therefore, weld contraction strain in the region of highly restrained welded connections may exceed the strength of the material if special attention is not given to material selection, details, workmanship and inspection.

Material      Details      Workmanship      Inspection



24

**AISC 360-16 Specification for Structural Steel Buildings**

**Material**

**CHAPTER A  
GENERAL PROVISIONS**

**A3. MATERIAL**

1c. Rolled Heavy Shapes

ASTM A6/A6M hot-rolled shapes with a flange thickness exceeding 2 in. (50 mm) are considered to be rolled heavy shapes. Rolled heavy shapes used as members subject to primary (computed) tensile forces due to tension or flexure and spliced or connected using complete-joint-penetration groove welds that fuse through the thickness of the flange or the flange and the web, shall be specified as follows. The structural design documents shall require that such shapes be supplied with Charpy V-notch (CVN) impact test results in

25

**AISC 360-16 Specification for Structural Steel Buildings**

**Material**

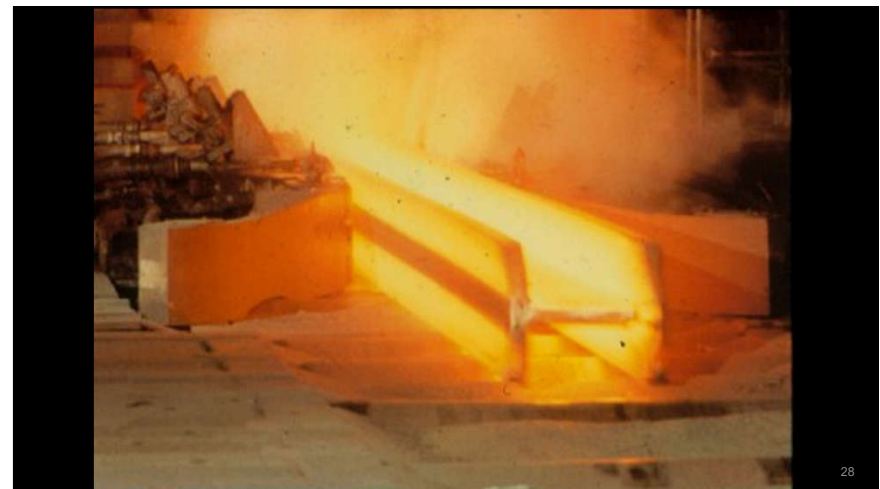
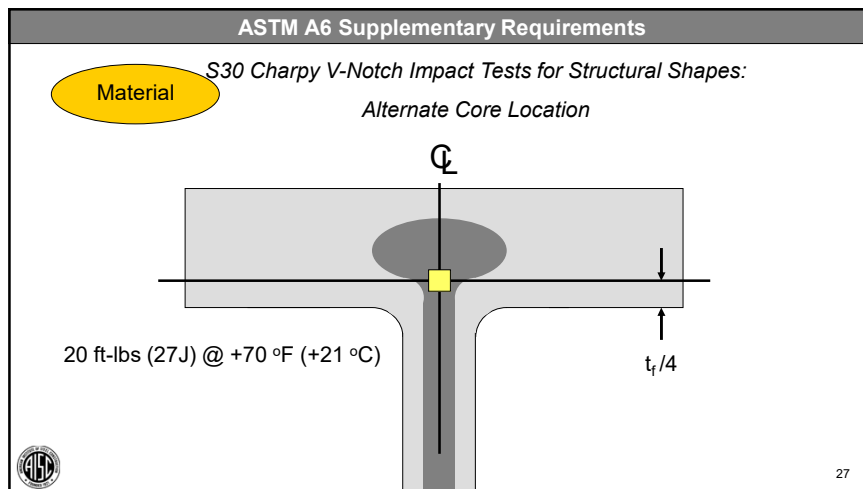
**CHAPTER A  
GENERAL PROVISIONS**

**A3. MATERIAL**

1c. Rolled Heavy Shapes (cont'd)

The structural design documents shall require that such shapes be supplied with Charpy V-notch (CVN) impact test results in accordance with ASTM A6/A6M, Supplementary Requirement S30, Charpy V-Notch Impact Test for Structural Shapes—Alternate Core Location. The impact test shall meet a minimum average value of 20 ft-lb (27 J) absorbed energy at a maximum temperature of +70°F (+21°C).

26



**AISC 360-16 Specification for Structural Steel Buildings**

**Material**      **CHAPTER A**  
**GENERAL PROVISIONS**

**A3 MATERIAL**

1d. Built-Up Heavy Shapes

Built-up cross sections consisting of plates with a thickness exceeding 2 in. (50 mm) are considered built-up heavy shapes. Built-up heavy shapes used as members subject to primary (computed) tensile forces due to tension or flexure and spliced or connected to other members using complete-joint-penetration groove welds that fuse through the thickness of the plates, shall be specified as follows. The structural design documents shall require that the steel be supplied with Charpy V-notch impact test results in accordance with ASTM A6/A6M,

29

**AISC 360-16 Specification for Structural Steel Buildings**

**Material**      **CHAPTER A**  
**GENERAL PROVISIONS**

**A3 MATERIAL**

1d. Built-Up Heavy Shapes (cont'd)

The structural design documents shall require that the steel be supplied with Charpy V-notch impact test results in accordance with ASTM A6/A6M, Supplementary Requirement S5, Charpy V-Notch Impact Test. The impact test shall be conducted in accordance with ASTM A673/A673M, Frequency P, and shall meet a minimum average value of 20 ft-lb (27 J) absorbed energy at a maximum temperature of +70°F (+21°C).

30

**ASTM A6 Supplementary Requirements**

**Material**      **S5 Charpy V-Notch Impact Test**

20 ft-lbs (27 J) @ +70 °F (+21 °C)

For built-up cross sections

31

**AISC 360-16 Specification for Structural Steel Buildings**

**Material**      **CHAPTER J**  
**DESIGN OF CONNECTIONS**

**J2. 6. Filler Metal Requirements**

Filler metal with a specified minimum Charpy V-notch toughness of 20 ft-lb (27 J) at 40°F (4°C) or lower shall be used in the following joints:

(a) CJP groove welded T- and corner joints with steel backing left in place, subject to tension normal to the effective area, unless the joints are designed using the nominal strength and resistance factor or safety factor, as applicable, for a PJP groove weld

(b) CJP groove welded splices subject to tension normal to the effective area in heavy sections, as defined in Sections A3.1c and A3.1d


32

AISC 360-16 Specification for Structural Steel Buildings

Material

**J2.6 Filler Metal Requirements**

20 ft-lbs (27 J) @ +40 °F (+4 °C)




33

AISC 360-16 Specification for Structural Steel Buildings

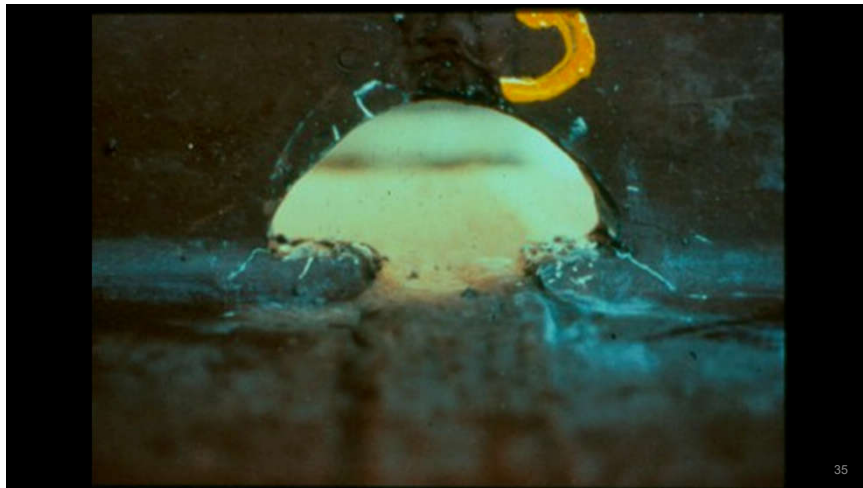
**Commentary A3**

**1c. Rolled Heavy Shapes**

To minimize the potential for fracture, the notch toughness requirements of Section A3.1c must be used in conjunction with good design and fabrication procedures. Specific requirements are given in Sections J1.5, J1.6, J2.6 and J2.7.



34



**AISC 360-16 Specification for Structural Steel Buildings**

Details

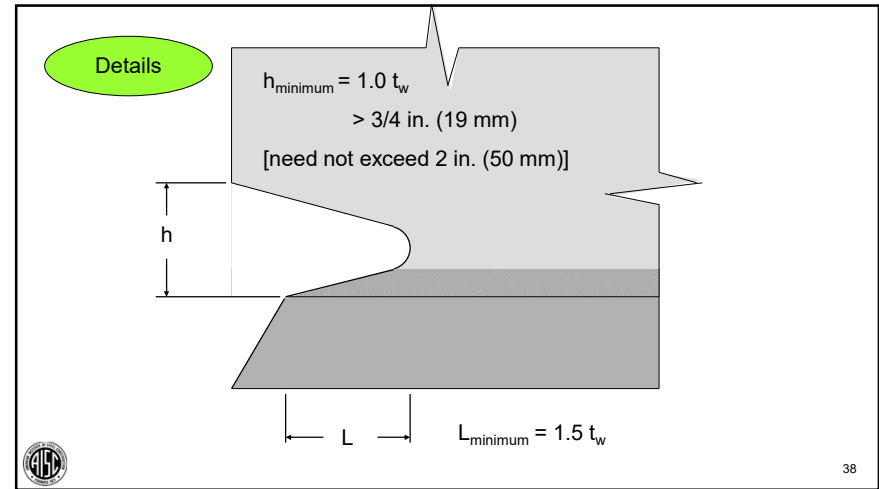
**CHAPTER J**

**DESIGN OF CONNECTIONS**

**J1.6. Weld Access Holes**

Weld access holes shall meet the following requirements:

- (a) All weld access holes required to facilitate welding operations shall be detailed to provide room for weld backing as needed.
- (b) The access hole shall have a length from the toe of the weld preparation not less than 1-1/2 times the thickness of the material in which the hole is made, nor less than 1-1/2 in. (38 mm).
- (c) The access hole shall have a height not less than the thickness of the material with the access hole, nor less than 3/4 in. (19 mm), nor does it need to...



**AISC 360-16 Specification for Structural Steel Buildings**

Workmanship

**CHAPTER M**

**FABRICATION AND ERECTION**

**M2.2. Thermal Cutting**

For beam copes and weld access holes in which the curved part of the access hole is thermally cut in ASTM A6/A6M hot-rolled shapes with a flange thickness exceeding 2 in. (50 mm) and welded built-up shapes with material thickness greater than 2 in. (50 mm), a preheat temperature of not less than 150°F (66°C) shall be applied prior to thermal cutting. The thermally cut surface of access holes in ASTM A6/A6M hot-rolled shapes with a flange thickness exceeding 2 in. (50 mm) and built-up shapes with a material thickness greater than 2 in. (50 mm) shall be ground.

**AWS D1.1:2020 STRUCTURAL WELDING CODE**

Table 5.8 (Continued)  
 Prequalified Minimum Preheat and Interpass Temperature (see 6.7)

Table 5.8  
**Prequalified Minimum  
 Preheat/Interpass Temperatures**

C A T E G O R Y	Steel Specification	Welding Process	Thickness of Thickened Part or Root of Weld		Minimum Preheat Temperature	Minimum Interpass Temperature
			in	mm		
A	ASTM A709	Grade A, Class 2	SMAW	1/8 to 3/4	3 to 20	32*
	ASTM A847	Grade 45 Class 1				
	ASTM A891	Grade 50 Class 1				
	ASTM A992	Grade 50				
	ASTM A1008 HSLAS	Grade 45 Class 1				
	ASTM A1008 HSLAS	Grade 45 Class 2				
	ASTM A1008 HSLAS-F	Grade 50				
	ASTM A1011 HSLAS	Grade 45 Class 1				
	ASTM A1011 HSLAS	Grade 45 Class 2				
	ASTM A1011 HSLAS	Grade 50				
B (Cont'd)	ASTM A1008 HSLAS-F	Grade 50	SMAW with low-hydrogen electrodes, SAW, GMAW, FCAW	1/8 to 3/4	3 to 20	32*
	ASTM A1011 HSLAS	Grade 45 Class 1				
	ASTM A1011 HSLAS	Grade 45 Class 2				
	ASTM A1011 HSLAS	Grade 50 Class 1				
	ASTM A1011 HSLAS	Grade 50 Class 2				
	ASTM A1011 HSLAS	Grade 55 Class 1				
	ASTM A1011 HSLAS	Grade 55 Class 2				
	ASTM A1011 HSLAS	Grade 50 Class 1				
	ASTM A1011 HSLAS	Grade 50 Class 2				
	ASTM A1011 HSLAS	Grade 55 Class 1				
B (cont'd)	ASTM A1011 HSLAS	Grade 55 Class 2	SMAW with low-hydrogen electrodes, SAW, GMAW, FCAW	1/8 to 3/4	3 to 20	32*
	ASTM A1011 HSLAS	Grade 45 Class 1				
	ASTM A1011 HSLAS	Grade 45 Class 2				
	ASTM A1011 HSLAS	Grade 50 Class 1				
	ASTM A1011 HSLAS	Grade 50 Class 2				
	ASTM A1011 HSLAS	Grade 55 Class 1				
	ASTM A1011 HSLAS	Grade 55 Class 2				
	ASTM A1011 HSLAS	Grade 50 Class 1				
	ASTM A1011 HSLAS	Grade 50 Class 2				
	ASTM A1011 HSLAS	Grade 55 Class 1				

41

**AWS D1.1:2020 STRUCTURAL WELDING CODE**

C A T E G O R Y	Steel Specification	Welding Process	Thickness of Thickened Part or Root of Weld		Minimum Preheat Temperature	Minimum Interpass Temperature
			in	mm		
B (Cont'd)	ASTM A808	Grade 50	SMAW with low-hydrogen electrodes, SAW, GMAW, FCAW	1/8 to 3/4	3 to 20	32*
	ASTM A913	Grade 45 Class 1				
	ASTM A992	Grade 45 Class 2				
	ASTM A1008 HSLAS	Grade 50 Class 1				
	ASTM A1008 HSLAS	Grade 50 Class 2				
	ASTM A1008 HSLAS	Grade 55 Class 1				
	ASTM A1008 HSLAS	Grade 55 Class 2				
	ASTM A1008 HSLAS-F	Grade 50				
	ASTM A1011 HSLAS	Grade 45 Class 1				
	ASTM A1011 HSLAS	Grade 45 Class 2				
B (Cont'd)	ASTM A1008 HSLAS-F	Grade 50	SMAW with low-hydrogen electrodes, SAW, GMAW, FCAW	1/8 to 3/4	3 to 20	32*
	ASTM A1011 HSLAS	Grade 45 Class 1				
	ASTM A1011 HSLAS	Grade 45 Class 2				
	ASTM A1011 HSLAS	Grade 50 Class 1				
	ASTM A1011 HSLAS	Grade 50 Class 2				
	ASTM A1011 HSLAS	Grade 55 Class 1				
	ASTM A1011 HSLAS	Grade 55 Class 2				
	ASTM A1011 HSLAS-F	Grade 50				
	ASTM A1018 HSLAS	Grade 45 Class 1				
	ASTM A1018 HSLAS	Grade 45 Class 2				
B (cont'd)	ASTM A1018 HSLAS	Grade 50 Class 1	SMAW with low-hydrogen electrodes, SAW, GMAW, FCAW	1/8 to 3/4	3 to 20	32*
	ASTM A1018 HSLAS	Grade 50 Class 2				
	ASTM A1018 HSLAS	Grade 55 Class 1				
	ASTM A1018 HSLAS	Grade 55 Class 2				
	ASTM A1018 HSLAS	Grade 50 Class 1				
	ASTM A1018 HSLAS	Grade 50 Class 2				
	ASTM A1018 HSLAS	Grade 55 Class 1				
	ASTM A1018 HSLAS	Grade 55 Class 2				
	ASTM A1018 HSLAS	Grade 50 Class 1				
	ASTM A1018 HSLAS	Grade 50 Class 2				

42

**AISC 360-16 Specification for Structural Steel Buildings**

Inspection

Commentary J1

**J1.5. Splices in Heavy Sections**

Previous editions of this Specification required magnetic particle or dye-penetrant inspection of thermally cut weld access holes for splices in heavy sections. This requirement was deliberately removed as anecdotal evidence suggested this inspection was not necessary because cracks from thermal cutting rarely occurred when the other Specification requirements were met. The previously prescribed magnetic particle testing or penetrant testing was replaced with a requirement for visual inspection of weld access holes after welding (see Table N5.4-3).

43

**SPECIAL WELDING APPLICATIONS**

**Welding Heavy Sections: Summary**

- Material notch toughness requirements ( $\geq 2$  in [50 mm])
- Weld access hole geometry
- Preheat for thermal cutting, grinding
- MT and PT no longer required, but good visual needed
- Preheat for welding
- Follow other "good practices" for welding on highly restrained members

Material      Details      Workmanship      Inspection

44

**SPECIAL WELDING APPLICATIONS**

**Today's Webinar**

- 14.4 Welding on Heavy Shapes
- ➔ 14.6 Welding HSS
- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- 14.16 Buttering





45

**SPECIAL WELDING APPLICATIONS**

**14.6 Welding HSS**

- ➔ • Connections and HSS member size
- Overall configuration
- Cutting and preparing HSS


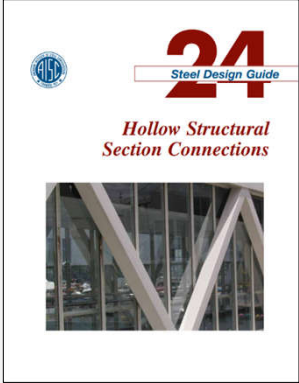


46

Design Guide 24

**Hollow Structural Section Connections**

by  
Packer, Sherman, Lecce





47

**Design Guide 24 Hollow Structural Section Connections**

**Chapter 1  
Introduction**

“Connections usually have been the challenging aspect for the designer of structures that involve HSS....Note that, in many cases, the local strength of the HSS at the connection is an integral part—and perhaps a limitation—of the design.”

**HSS member size may need to be increased to accommodate connection design.**




48

**Design Guide 24 Hollow Structural Section Connections**

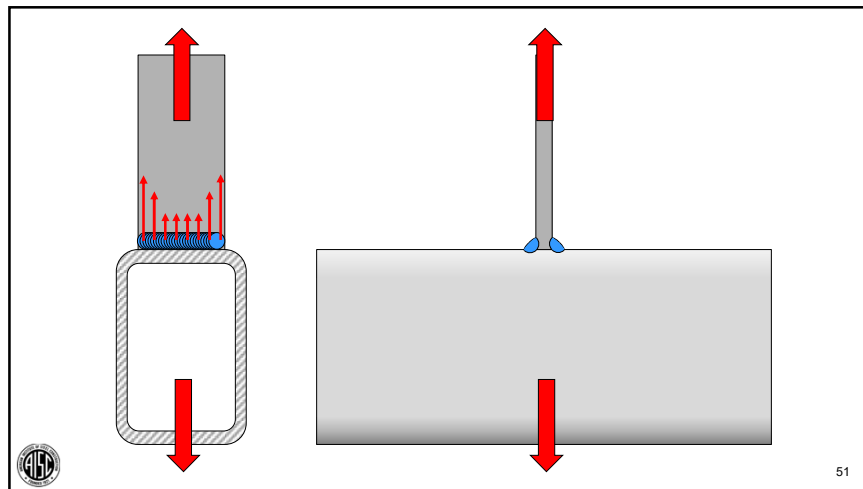
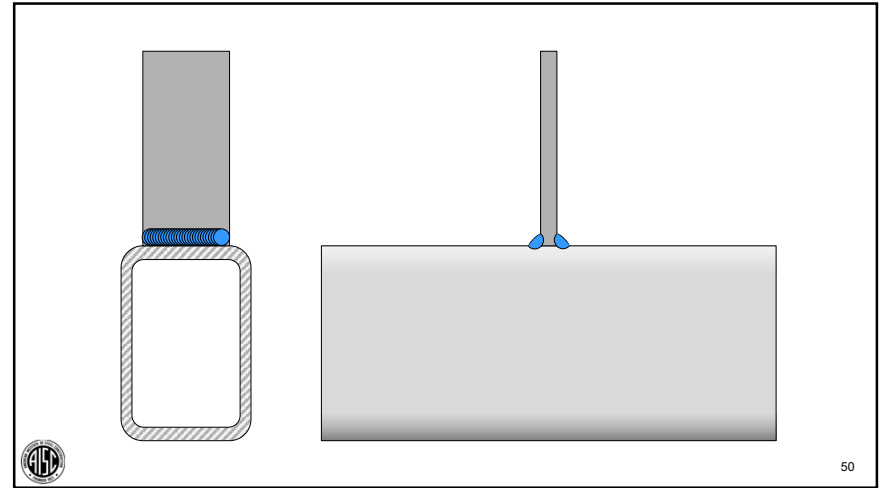
**Chapter 2  
Welding**

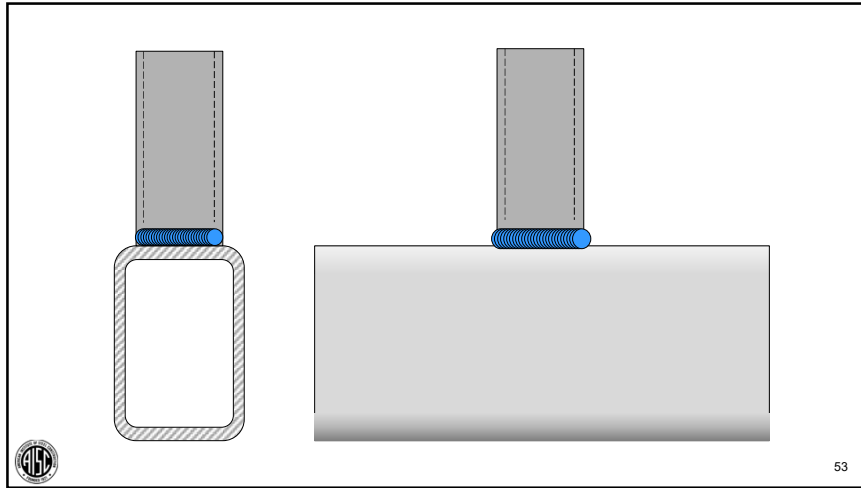
**2.4 EFFECTIVE WELD LENGTH**

Due to the variation in flexural stiffness of the wall across the width of a rectangular HSS, a force transmitted through a weld is often not uniformly distributed. This can be accounted for in design using an effective weld length approach. This reduced effective length applies both to the weld and to the force in the connected element.

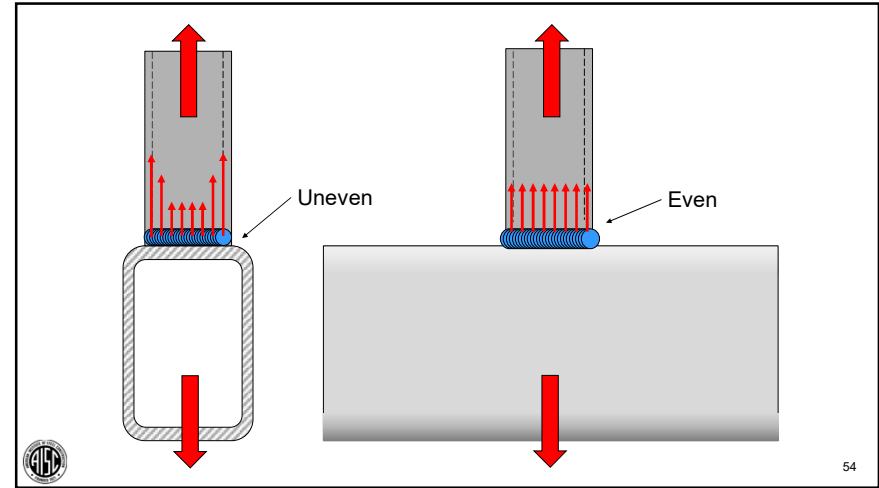


49





53



54

**AISC 360:16 Specification for Structural Steel Buildings**

**TABLE K2.1**  
 Available Strength of Plate-to-Round HSS Connections

Connection Type	Connection Available Strength	Plate Bending
Transverse Plate T- and Cross-Connections	Limit State: HSS Local Yielding	
	Plate Axial Load $R_n = F_y A_g \left( \frac{5.6}{1 - 0.81 \frac{D_o}{D}} \right) Q_t$ (K2-1a) $\phi = 0.90$ (LRFD) $\Omega = 1.67$ (ASD)	In-Plane Out-of-Plane $M_n = 0.56 R_n$ (K2-1b)
Longitudinal Plate T-, Y- and Cross-Connections	Limit State: HSS Plastification	
	Plate Axial Load $R_n = 5.5 F_y t^2 \left( 1 + 0.25 \frac{l_b}{D} \right) Q_t$ (K2-2a) $\phi = 0.90$ (LRFD) $\Omega = 1.67$ (ASD)	In-Plane Out-of-Plane $M_n = 0.8 l_b R_n$ (K2-2b)
Functions		
$Q_t = 1$ for HSS (connecting surface) in tension $= 1.0 - 0.3 U$ ( $U = U$ ) for HSS (connecting surface) in compression (K2-3)		
$U = \frac{P_u}{P_u + P_c}$ $M_u = \frac{M_u}{P_u + P_c}$ (K2-4)		
where $P_u$ and $M_u$ are determined on the side of the joint that has the lower compression stress. $P_u$ and $M_u$ refer to required strengths in the HSS: $P_u = P_u$ for LRFD, and $P_u$ for ASD; $M_u = M_u$ for LRFD, and $M_u$ for ASD.		

55

**AISC 360:16 Specification for Structural Steel Buildings**

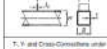


Longitudinal Plate T-, Y- and Cross-Connections

Limit State: <span style="border: 1px solid red; padding: 2px;">HSS Plastification</span>		
Plate Axial Load	In-Plane	Out-of-Plane
$R_n \sin \theta = 5.5 F_y t^2 \left( 1 + 0.25 \frac{l_b}{D} \right) Q_t$ (K2-2a)	$M_n = 0.8 l_b R_n$ (K2-2b)	-
$\phi = 0.90$ (LRFD) $\Omega = 1.67$ (ASD)		

56

**AISC 360:16 Specification for Structural Steel Buildings**

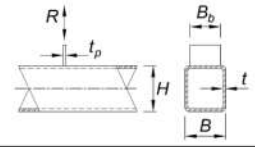
**TABLE K5.1**  
 Effective Weld Properties for  
 Connection to Rectangular HSS

Connection Type	Weld Properties
Transverse Plate T- and Cross-Connections under Plate Axial Load 	Effective Weld Properties $l_e = 2L_e$ (K5-4) where $L_e$ = total effective weld length for welds on both sides of the transverse plate
T-, Y- and Cross-Connections under Branch Axial Load or Moment 	Effective Weld Properties $l_e = 2B_e$ (K5-5) $A_e = \frac{2}{3} \left( \frac{A_w}{A_g} \right) \leq A_g$ (K5-6) $A_w = \frac{2}{3} \left( \frac{A_w}{A_g} \right) \leq A_g$ (K5-7) When $\beta > 0.25$ or $\beta < 0.75$ , $A_e$ shall not exceed $A_g/4$
Gapped Y-Connections under Branch Axial Load 	Effective Weld Properties When $\alpha \leq 30^\circ$ : $l_e = \frac{2B_e(1 + \beta)}{\sin \alpha}$ (K5-8) When $\alpha > 30^\circ$ : $l_e = \frac{2B_e(1 + \beta)}{\sin \alpha}$ (K5-9) When $30^\circ < \alpha < 60^\circ$ , shear interpolation shall be used to determine $l_e$ . When $60^\circ < \alpha < 90^\circ$ , shear interpolation shall be used to determine $l_e$ .

57

**AISC 360:16 Specification for Structural Steel Buildings**

**TABLE K5.1**  
 Effective Weld Properties for  
 Connections to Rectangular HSS

Connection Type	Weld Properties
Transverse Plate T- and Cross-Connections under Plate Axial Load 	<div style="border: 1px solid red; padding: 2px;"><b>Effective Weld Properties</b></div>  $l_e = 2B_e$ (K5-4)  where $l_e$ = total effective weld length for welds on both sides of the transverse plate

58

**SPECIAL WELDING APPLICATIONS**

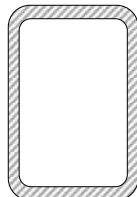
**14.6 Welding HSS**

- Connections and HSS member size
- ➔ • Overall configuration
- Cutting and preparing HSS

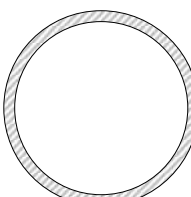
59

**SPECIAL WELDING APPLICATIONS**

**Rectangular**

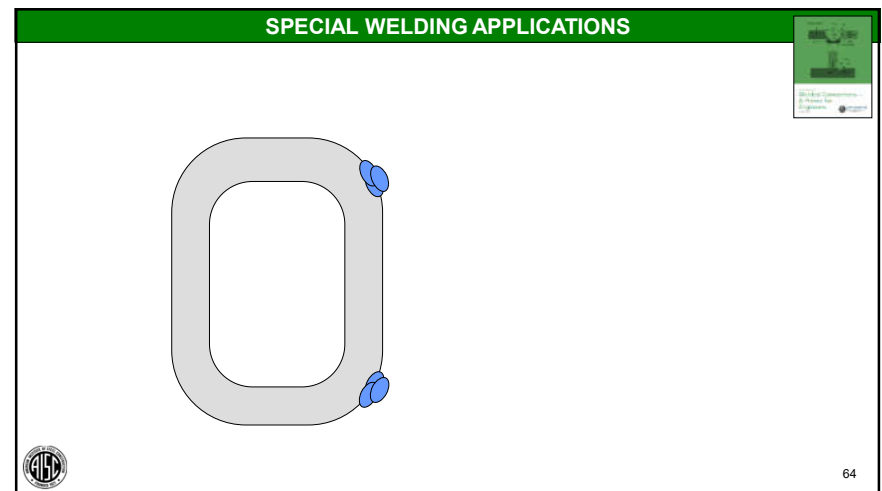
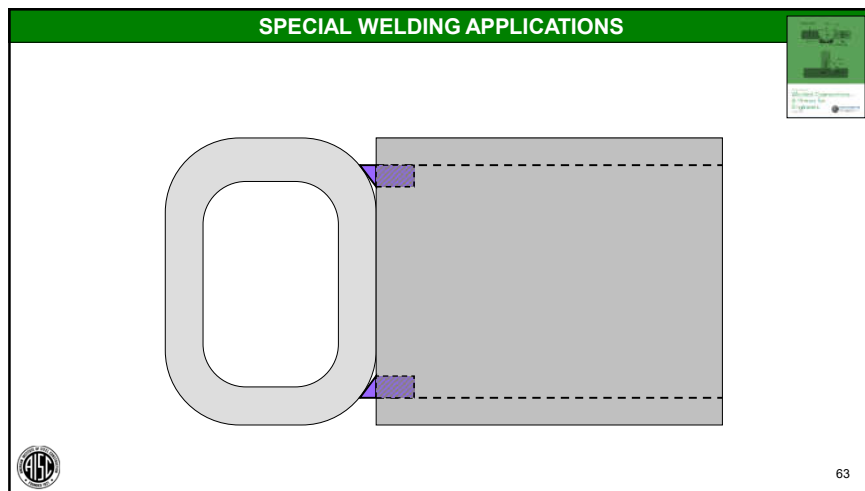
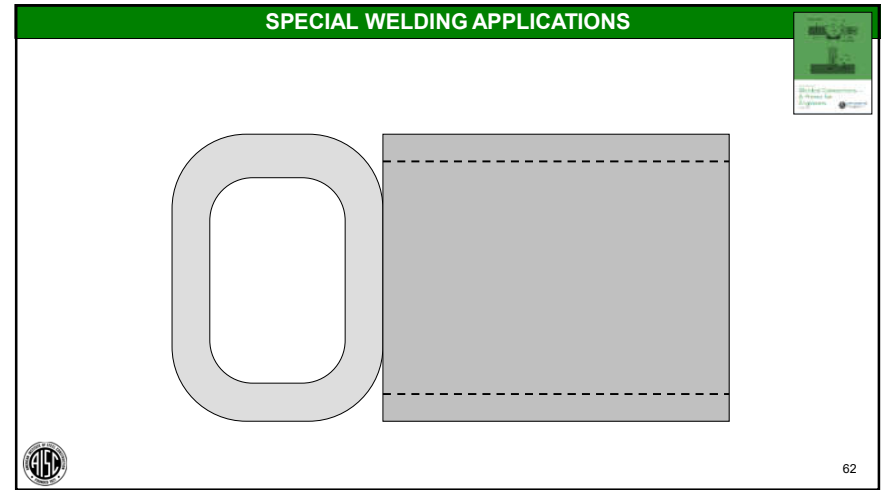
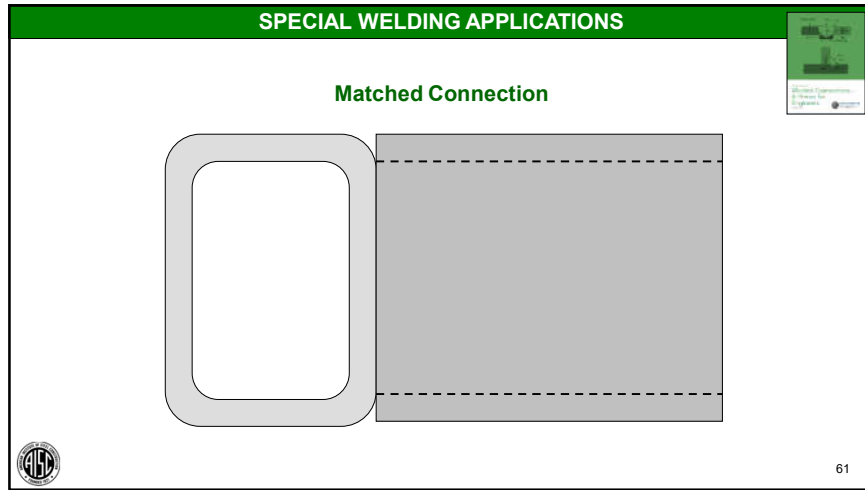


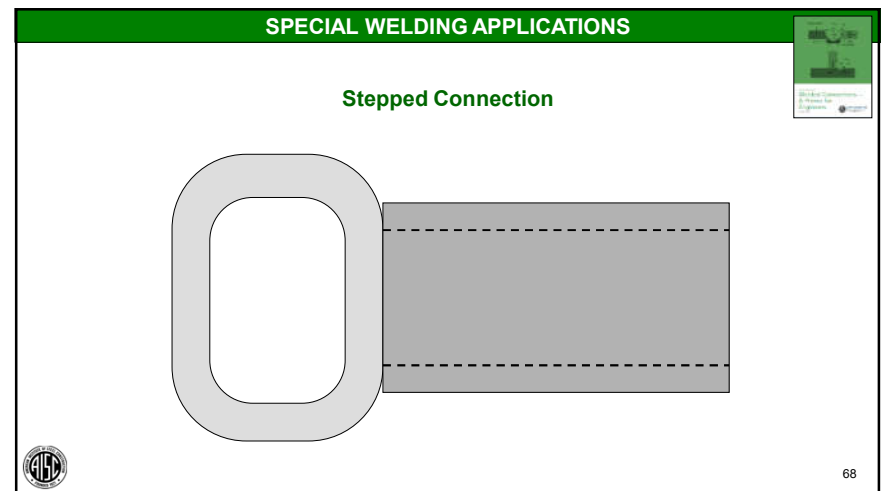
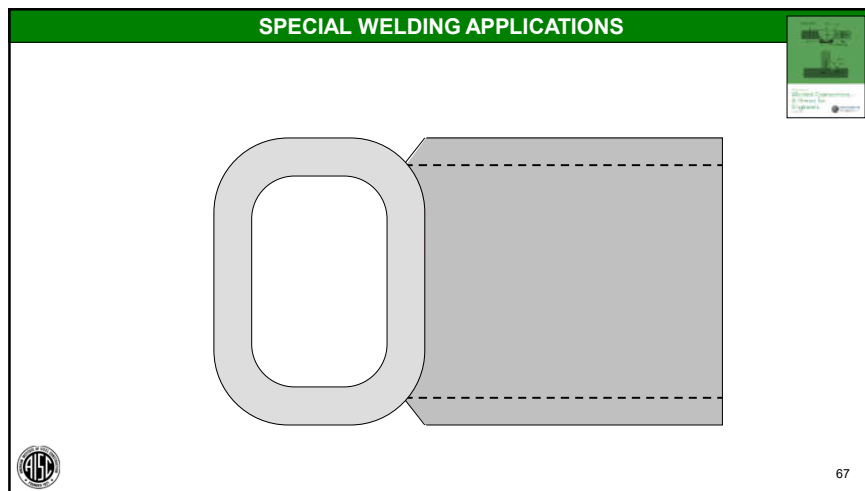
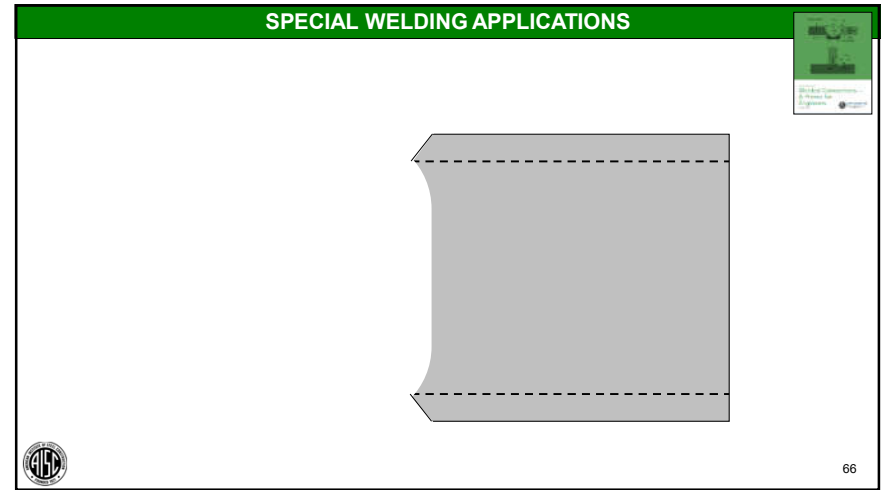
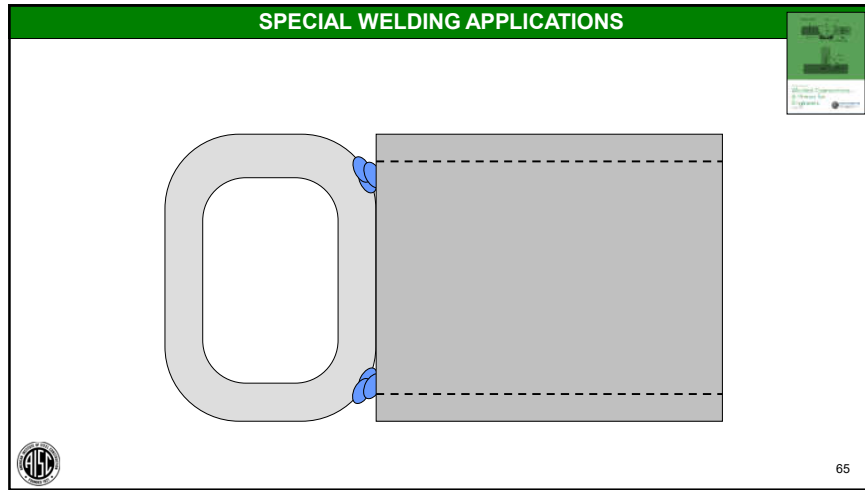
**Round**



Rectangular is nearly always easier to fabricate

60






**SPECIAL WELDING APPLICATIONS**

**14.6 Welding HSS**



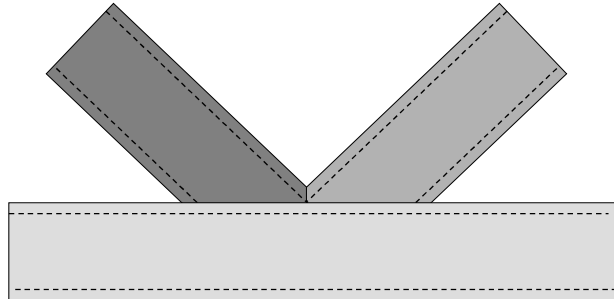
- Connections and HSS member size
- ➔ Overall configuration
- Cutting and preparing HSS



69

**SPECIAL WELDING APPLICATIONS**



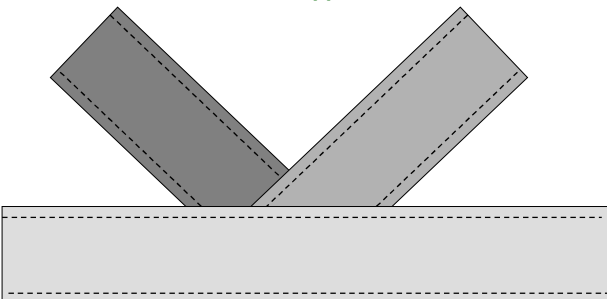
**Overlapped**



70

**SPECIAL WELDING APPLICATIONS**

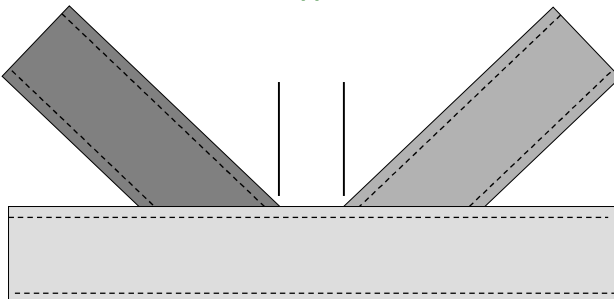
**Overlapped**





71

**SPECIAL WELDING APPLICATIONS**

**Gapped**



**Preferred**

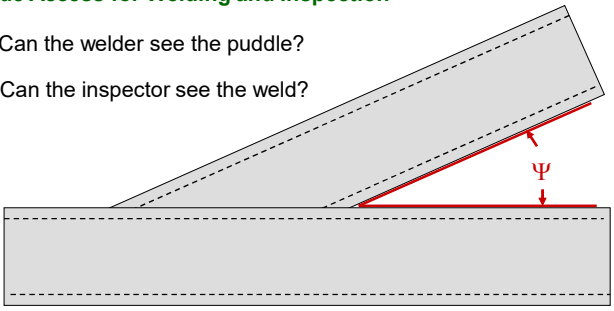


72

**SPECIAL WELDING APPLICATIONS**

**Provide Access for Welding and Inspection**

- Can the welder see the puddle?
- Can the inspector see the weld?



$\Psi = 30^\circ$  minimum

73

The diagram shows a cross-section of a horizontal HSS member with a sloped member attached to its top flange. A red line indicates the angle  $\Psi$  between the horizontal member's top surface and the sloped member. The AISC logo is in the bottom left corner.

**SPECIAL WELDING APPLICATIONS**

**14.6 Welding HSS**


- Connections and HSS member size
- Overall configuration
- ➔ Cutting and preparing HSS

74

The diagram shows a cross-section of a horizontal HSS member with a sloped member attached to its top flange. A green arrow points to the text 'Cutting and preparing HSS'. The AISC logo is in the bottom left corner.

**SPECIAL WELDING APPLICATIONS**

**Box HSS**

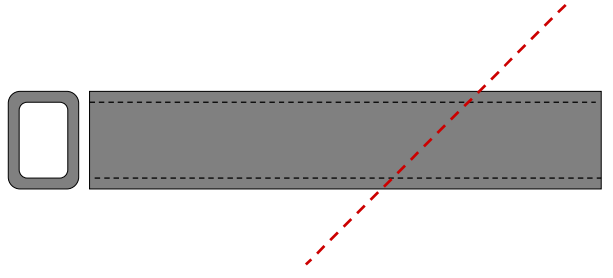


75

The diagram shows a side view of a box HSS member with a rectangular cutout on the left end. The AISC logo is in the bottom left corner.

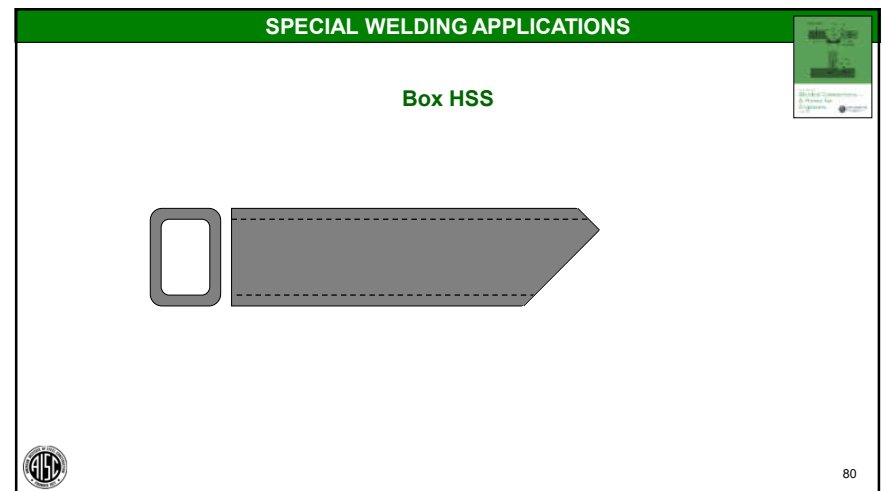
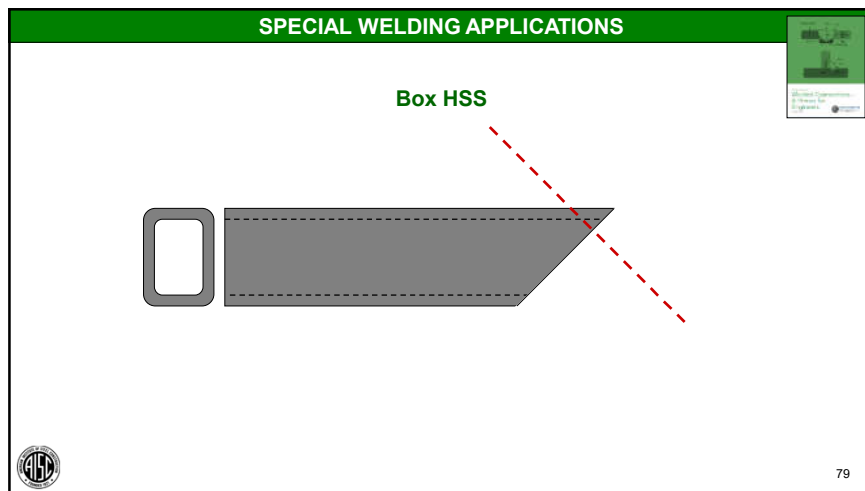
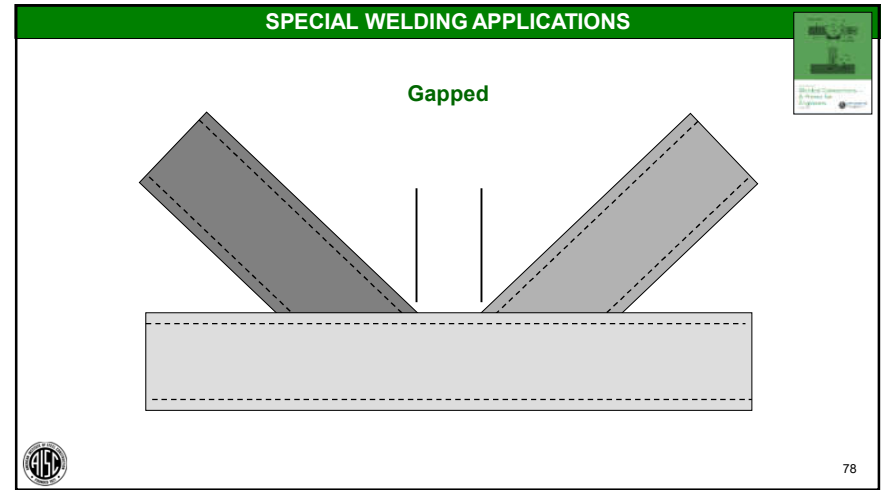
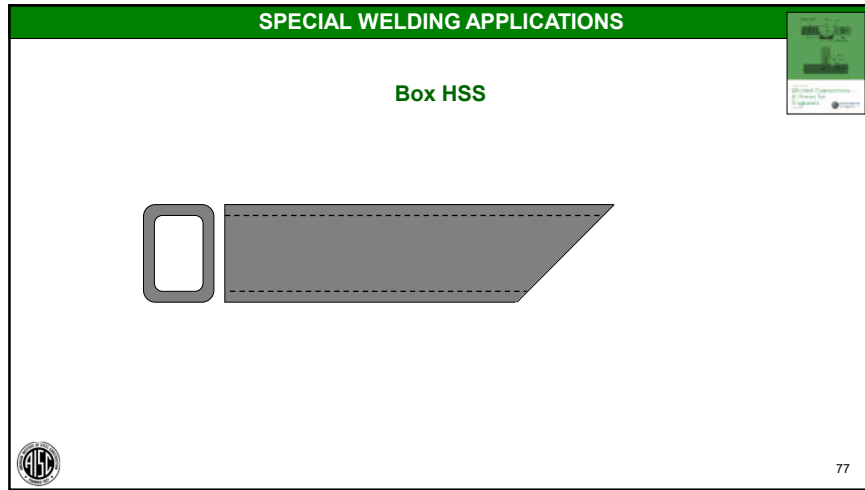
**SPECIAL WELDING APPLICATIONS**

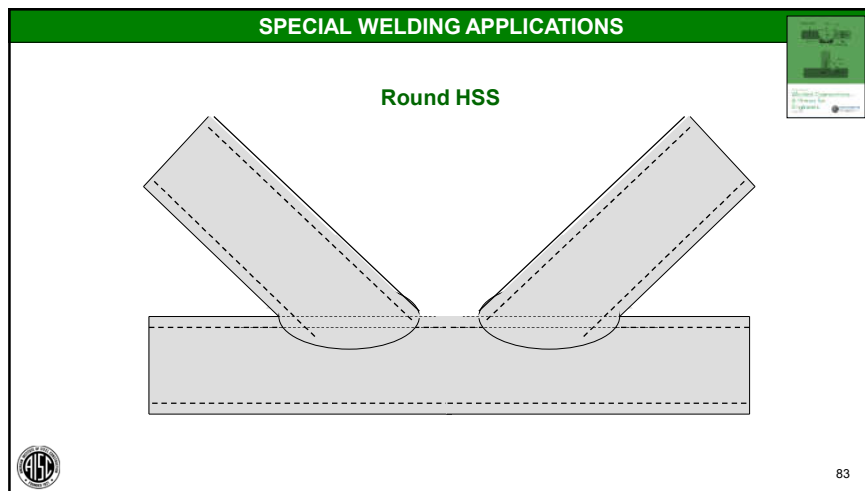
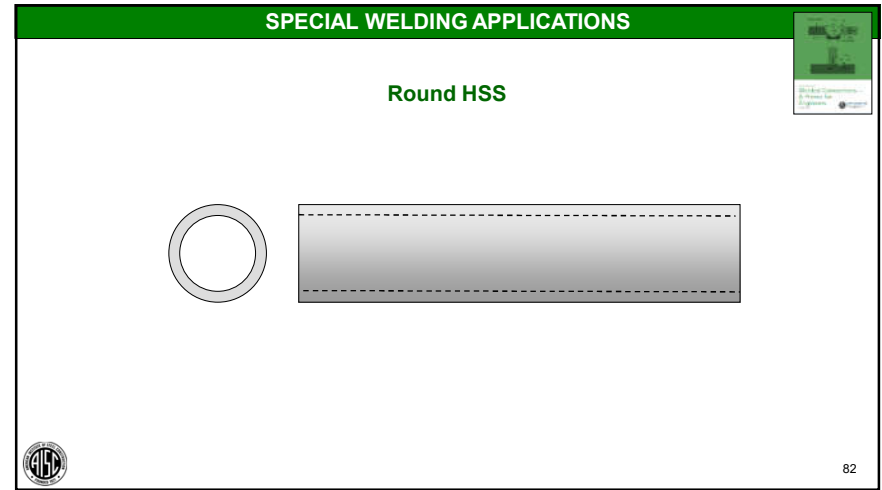
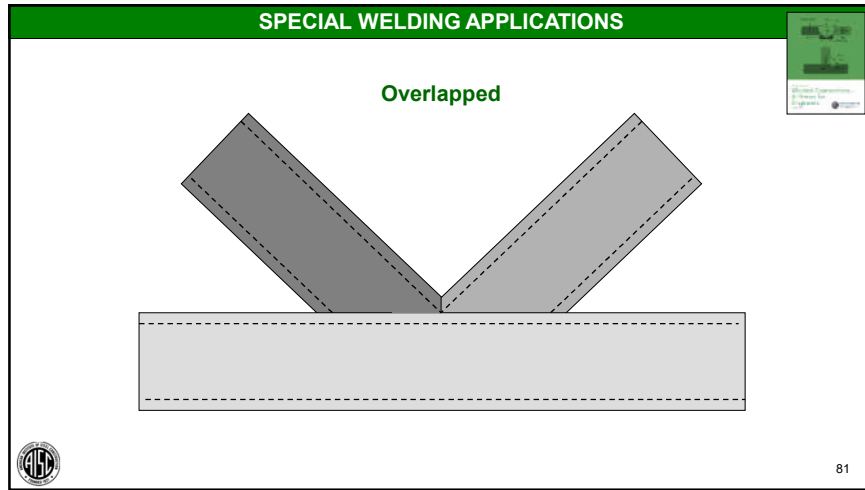
**Box HSS**



76

The diagram shows a side view of a box HSS member with a rectangular cutout on the left end. A dashed red line indicates a diagonal cut through the member. The AISC logo is in the bottom left corner.





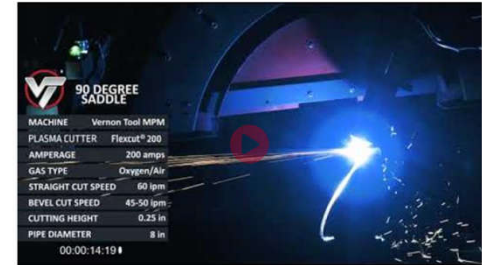


85

90 degree saddle cut



90 Degree Saddle



86

Size on size, 45 degree lateral



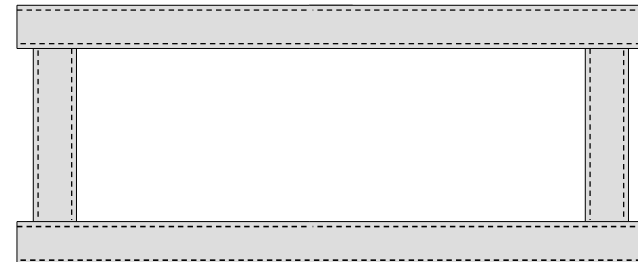
Size on Size 45 Degree Lateral



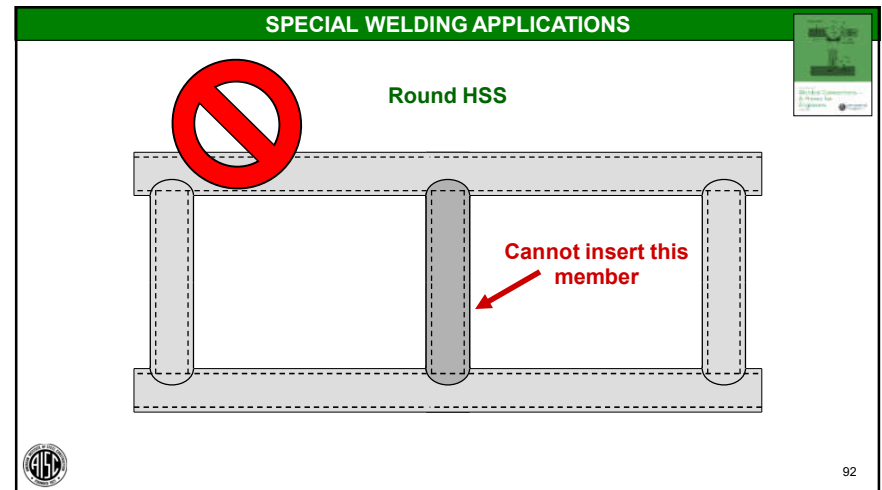
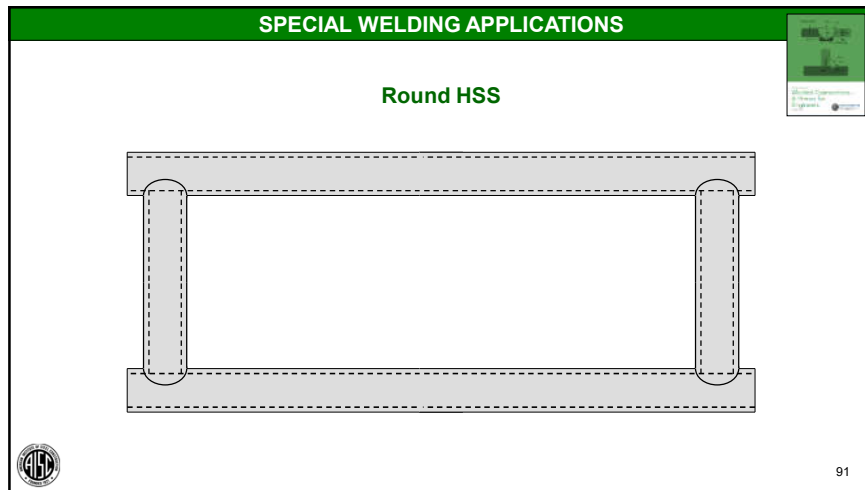
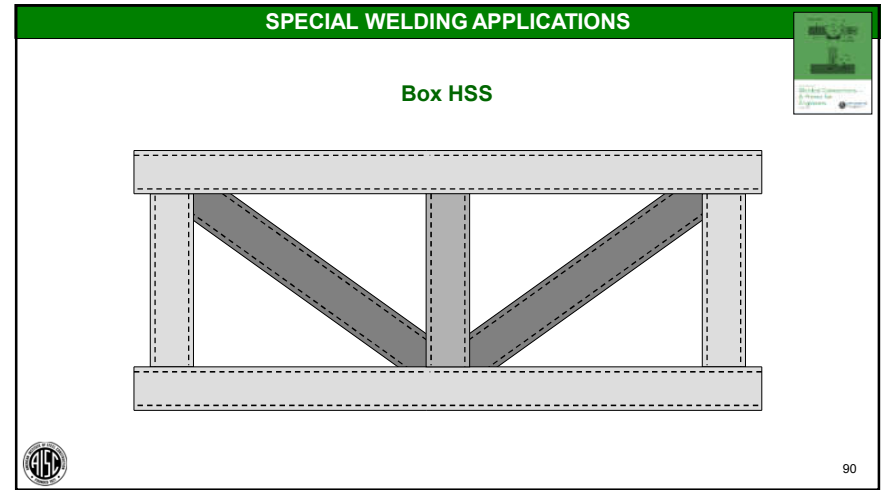
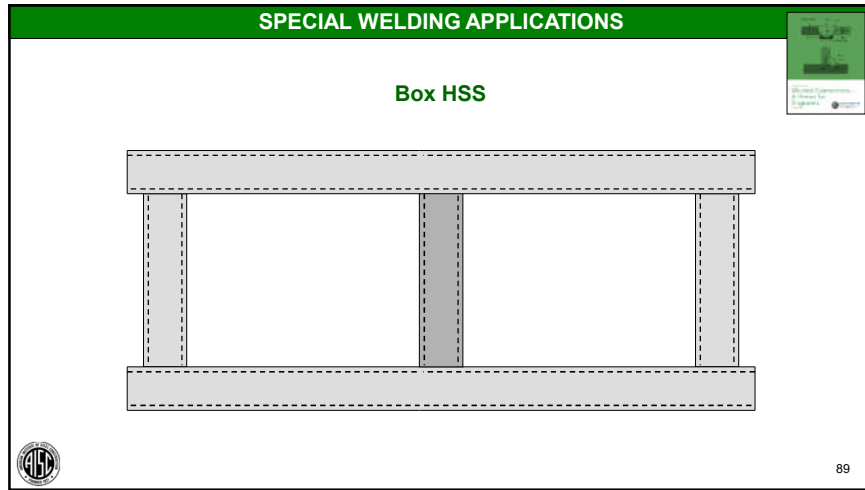
87

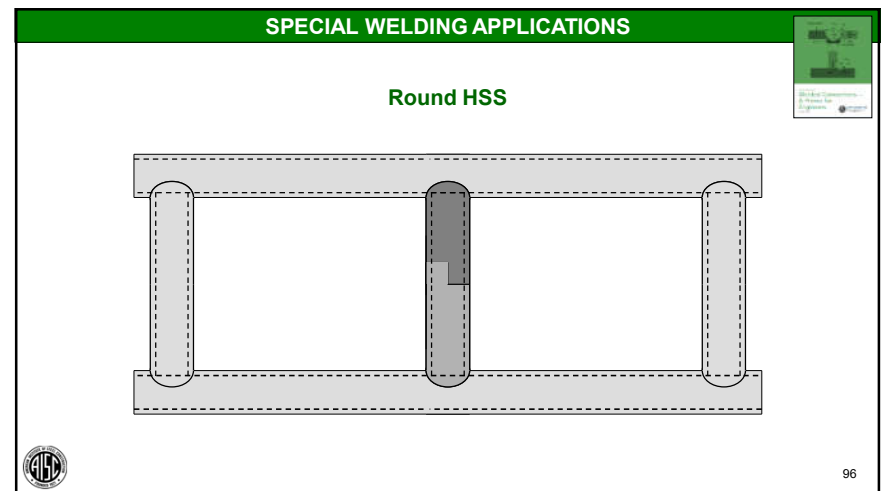
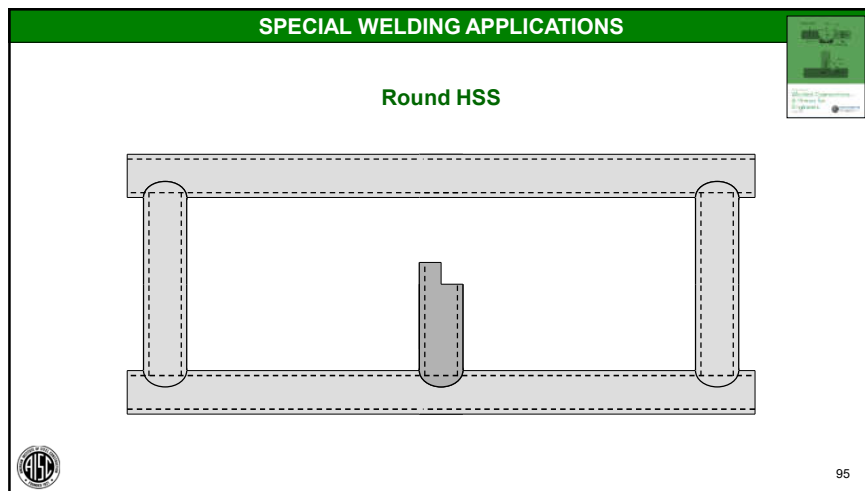
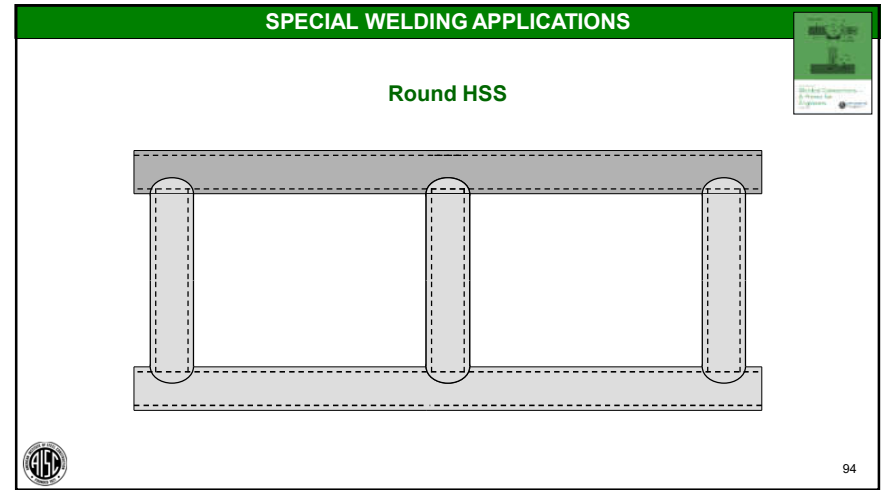
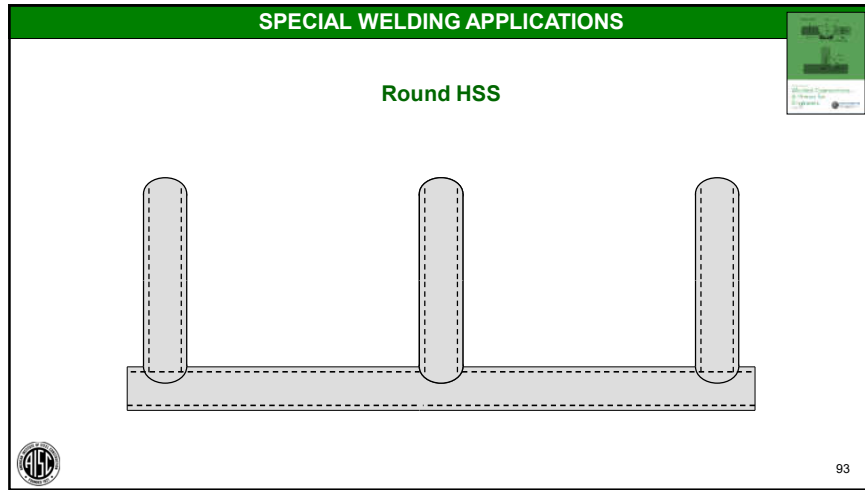
SPECIAL WELDING APPLICATIONS

Box HSS



88





**SPECIAL WELDING APPLICATIONS**

**Round HSS**

Cannot insert this member

97

**AWS D1.1:2020 STRUCTURAL WELDING CODE**

**9. Tubular Structures**

**9.1 General**  
 This Clause supplements Clauses 1–8. The specific requirements of Clause 9 apply only to tubular connections. For design purposes this clause shall be used with the applicable requirements of Clause 2, Part A. All provisions of Clause 9 apply to static applications and cyclic applications, with the exception of the fatigue provisions of 9.2.7, which are unique to cyclic applications.  
 This clause is divided into parts, as follows:  
 Part A — Design of Tubular Connections  
 Part B — Prequalification of Welding Procedure Specifications (WPSs)  
 Part C — Welding Procedure Specification (WPS) Qualification  
 Part D — Performance Qualification  
 Part E — Fabrication

**9.2.3 Tubular Section Limitations.** Limitations on diameter/thickness for circular sections, and largest flat width/thickness ratio for box sections, beyond which local buckling or other local failure modes shall be considered, shall be in conformance with the governing design code. Limits of applicability for the criteria given in 9.6 shall be observed as follows:  
 (1) Circular tubes:  $D/t < 3300/F_y$  [for  $F_y$  in ksi],  $22\,800/F_y$  (for  $F_y$  in MPa)  
 (2) Box section gap connections:  $D/t \leq 210/\sqrt{F_y}$  [for  $F_y$  in ksi],  $550/\sqrt{F_y}$  (for  $F_y$  in MPa) but not more than 35  
 (3) Box section overlap connections:  $D/t \leq 190/\sqrt{F_y}$  [for  $F_y$  in ksi],  $500/\sqrt{F_y}$  (for  $F_y$  in MPa)

**9.2.4 Welds Stresses.** The allowable stresses in welds shall not exceed those given in Table 9.2, or as allowed

98

**SPECIAL WELDING APPLICATIONS**

**Welding HSS: Summary**

- Welds are usually unevenly stressed
- Connection details may control member sizes
- Round vs square/rectangular: box tubes usually easier
- Cutting and assembly
- Access for welding and inspection
- May also have AESS concerns

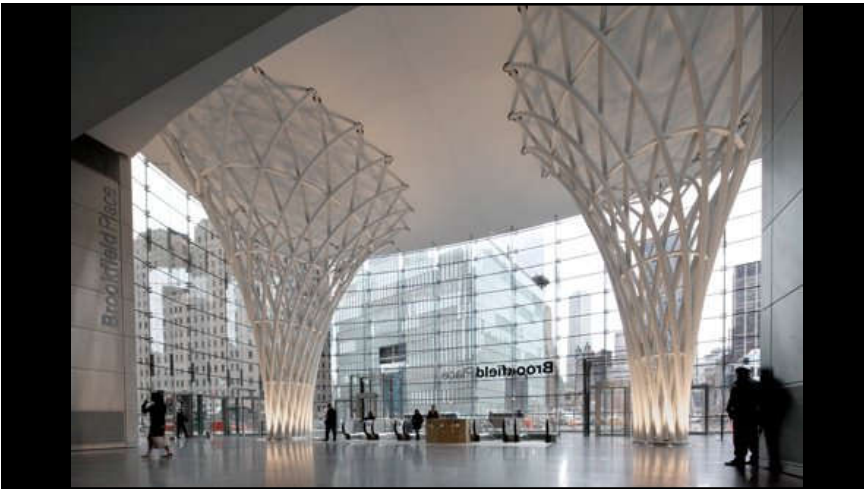
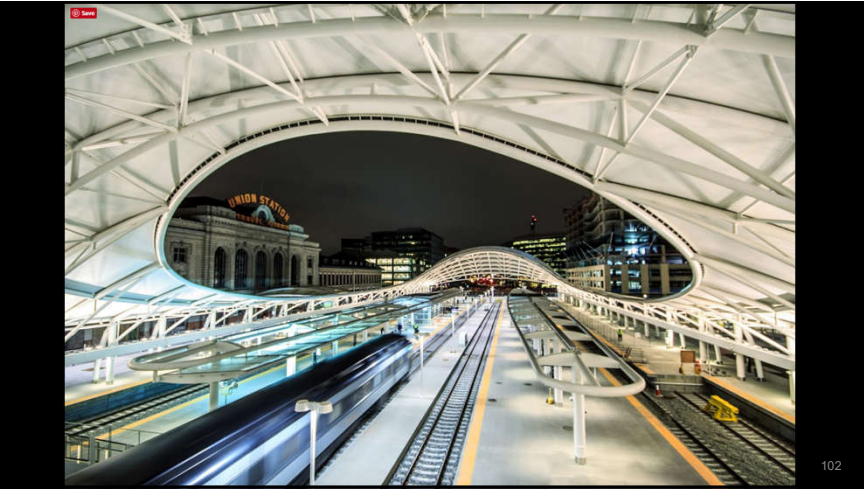
99

**SPECIAL WELDING APPLICATIONS**

**Today's Webinar**

- 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- ➔ 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- 14.16 Buttering


100



**SPECIAL WELDING APPLICATIONS**

**Welding AESS**

- ➔ Defining “pretty”
- Use of Mock-ups
- Technical issues
- Note requirements on drawings



105

**AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges**


**AISC 303-16**

**Code of Standard Practice for Steel Buildings and Bridges**

Section 10.  
 Architecturally Exposed Structural Steel

Category	AESS C	AESS 4	AESS 3	AESS 2	AESS 1	SSS
	Custom Elements	Showcase Elements	Feature Elements in close view	Feature Elements not in close view	Basic Elements	Standard Structural Steel
1.1 Surface preparation to SSPC-SP 6	*	*	*	*	*	*
1.2 Sharp edges ground smooth	*	*	*	*	*	*
1.3 Continuous weld appearance	*	*	*	*	*	*
1.4 Standard structural bolts	*	*	*	*	*	*
1.5 Weld spatters removed	*	*	*	*	*	*
2.1 Visual samples	*	*	optional			
2.2 One-half standard fabrication tolerances	*	*	*	*	*	*
2.3 Fabrication marks not apparent	*	*	*	*	*	*
2.4 Welds uniform and smooth	*	*	*	*	*	*
3.1 Mill marks removed	*	*	*	*	*	*
3.2 Butt and plug welds ground smooth and filed	*	*	*	*	*	*
3.3 HSS weld seam oriented for reduced visibility	*	*	*	*	*	*
3.4 Cross sectional abutting surface aligned	*	*	*	*	*	*
3.5 Joint gap tolerances minimized	*	*	*	*	*	*
3.6 All welded connections	optional	optional				
4.1 HSS seam not apparent	*	*	*	*	*	*
4.2 Welds contoured and blended	*	*	*	*	*	*
4.3 Surfaces filed and sanded	*	*	*	*	*	*
4.4 Weld show-through minimized	*	*	*	*	*	*
C.1						
C.2						
C.3						
C.4						
C.5						


Use Note:  
 1.1 Prior to blast cleaning, grease and oil are removed by solvent cleaning to meet SSPC-SP-1.  
 1.2 Rough surfaces are deburred and ground smooth. Sharp edges resulting from flame cutting, grinding and especially shearing are softened.  
 1.5 Interference welds are made continuous, either with additional welds, chisel or back file. For recessed areas...



106

**AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges**

Category	AESS C	AESS 4	AESS 3	AESS 2	AESS 1	SSS
	Custom Elements	Showcase Elements	Feature Elements in close view	Feature Elements not in close view	Basic Elements	Standard Structural Steel
1.1 Surface preparation to SSPC-SP 6	*	*	*	*	*	*
1.2 Sharp edges ground smooth	*	*	*	*	*	*
1.3 Continuous weld appearance	*	*	*	*	*	*
1.4 Standard structural bolts	*	*	*	*	*	*
1.5 Weld spatters removed	*	*	*	*	*	*
2.1 Visual samples	*	*	optional			
2.2 One-half standard fabrication tolerances	*	*	*	*	*	*
2.3 Fabrication marks not apparent	*	*	*	*	*	*
2.4 Welds uniform and smooth	*	*	*	*	*	*
3.1 Mill marks removed	*	*	*	*	*	*
3.2 Butt and plug welds ground smooth and filed	*	*	*	*	*	*
3.3 HSS weld seam oriented for reduced visibility	*	*	*	*	*	*
3.4 Cross sectional abutting surface aligned	*	*	*	*	*	*
3.5 Joint gap tolerances minimized	*	*	*	*	*	*
3.6 All welded connections	optional	optional				
4.1 HSS seam not apparent	*	*	*	*	*	*
4.2 Welds contoured and blended	*	*	*	*	*	*
4.3 Surfaces filed and sanded	*	*	*	*	*	*
4.4 Weld show-through minimized	*	*	*	*	*	*
C.1						
C.2						
C.3						
C.4						
C.5						



107

**AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges**

Category	AESS C	AESS 4	AESS 3	AESS 2	AESS 1	SSS
	Custom Elements	Showcase Elements	Feature Elements in close view	Feature Elements not in close view	Basic Elements	Standard Structural Steel
1.1 Surface preparation to SSPC-SP 6	*	*	*	*	*	*
1.2 Sharp edges ground smooth	*	*	*	*	*	*
1.3 Continuous weld appearance	*	*	*	*	*	*
1.4 Standard structural bolts	*	*	*	*	*	*
1.5 Weld spatters removed	*	*	*	*	*	*
2.1 Visual samples	*	*	optional			
2.2 One-half standard fabrication tolerances	*	*	*	*	*	*
2.3 Fabrication marks not apparent	*	*	*	*	*	*
2.4 Welds uniform and smooth	*	*	*	*	*	*

108

**AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges**

**TABLE 10.1  
 AESS Category Matrix**

Category	AESS C	AESS 4	AESS 3	AESS 2	AESS 1	SSS
Id	Custom Elements	Showcase Elements	Feature Elements in close view	Feature Elements not in close view	Basic Elements	Standard Structural Steel
1.1	Surface preparation to SSPC-SP 6	*	*	*	*	*
1.2	Sharp edges ground smooth	*	*	*	*	*
1.3	Continuous weld appearance	*	*	*	*	*
1.4	Standard structural bolts	*	*	*	*	*
1.5	Weld spatters removed	*	*	*	*	*
2.1	Visual samples	*	*	optional	*	*
2.2	One-half standard fabrication tolerances	*	*	*	*	*
2.3	Fabrication marks not apparent	*	*	*	*	*
2.4	Welds uniform and smooth	*	*	*	*	*

109

**AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges**

1.1	Surface preparation to SSPC-SP 6	*	*	*	*
1.2	Sharp edges ground smooth	*	*	*	*
1.3	Continuous weld appearance	*	*	*	*
1.4	Standard structural bolts	*	*	*	*
1.5	Weld spatters removed	*	*	*	*
2.1	Visual samples	*	*	optional	*
2.2	One-half standard fabrication tolerances	*	*	*	*
2.3	Fabrication marks not apparent	*	*	*	*
2.4	Welds uniform and smooth	*	*	*	*
3.1	Mill marks removed	*	*	*	*
3.2	Butt and plug welds ground smooth and filled	*	*	*	*
3.3	HSS weld seam oriented for reduced visibility	*	*	*	*
3.4	Cross sectional abutting surface aligned	*	*	*	*
3.5	Joint gap tolerances minimized	*	*	*	*
3.6	All welded connections	optional	optional	*	*
4.1	HSS seam not apparent	*	*	*	*
4.2	Welds contoured and blended	*	*	*	*
4.3	Surfaces filed and sanded	*	*	*	*
4.4	Weld show-through minimized	*	*	*	*

Many welding-related issues


110



**SPECIAL WELDING APPLICATIONS**

**Welding AESS**

- Defining “pretty”
- ➔ • Use of Mock-ups
- Technical issues
- Note requirements on drawings




113

**AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges**

1.1	Surface preparation to SSPC-SP 6	•	•	•	•
1.2	Sharp edges ground smooth	•	•	•	•
1.3	Continuous weld appearance	•	•	•	•
1.4	Standard structural bolts	•	•	•	•
1.5	Weld spatters removed	•	•	•	•
➔ 2.1	Visual samples	•	•	optional	
2.2	One-half standard fabrication tolerances	•	•	•	
2.3	Fabrication marks not apparent	•	•	•	
2.4	Welds uniform and smooth	•	•	•	
3.1	Mill marks removed	•	•		
3.2	Butt and plug welds ground smooth and filled	•	•		
3.3	HSS weld seam oriented for reduced visibility	•	•		
3.4	Cross sectional abutting surface aligned	•	•		
3.5	Joint gap tolerances minimized	•	•		
3.6	All welded connections	optional	optional		
4.1	HSS seam not apparent	•			
4.2	Welds contoured and blended	•			
4.3	Surfaces filed and sanded	•			
4.4	Weld show-through minimized	•			

**Mock-ups**




114

**AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges**

**SECTION 10. ARCHITECTURALLY EXPOSED STRUCTURAL STEEL**

10.1.2. A mock-up shall be required for AESS 3, 4 and C. If a mock-up is to be used in other AESS categories, it shall be specified in the *contract documents*. When required, the nature and extent of the mock-up shall be specified in the *contract documents*. Alternatively, when a mock-up is not practical, the first piece of an element or *connection* can be used to determine acceptability.




115

**AISC 303-16 Code of Standard Practice for Steel Buildings and Bridges**

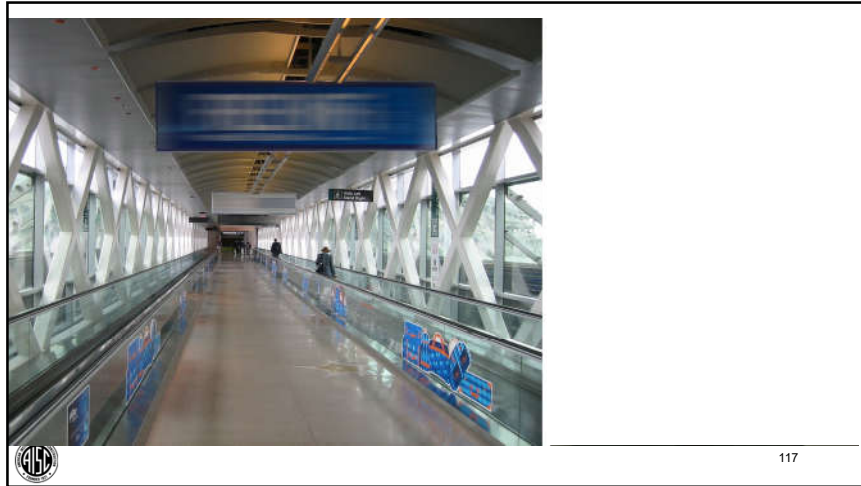
**SECTION 10. ARCHITECTURALLY EXPOSED STRUCTURAL STEEL**

**Commentary:**  
 Generally, a mock-up is produced and approved in the shop and subsequently placed in the field. The acceptability of the mock-up can be affected by many factors, including distance of view, lighting and finishing. The expectations for the location and conditions of the mock-up at time of approval should be defined in the *contract documents*.

**Suggestion: View mock-up at the same distance as the viewer will be from the final welded connection in service.**



116





117

### SPECIAL WELDING APPLICATIONS

#### Welding AESS

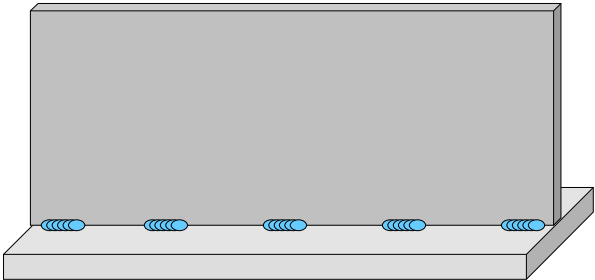
- Defining “pretty”
- Use of Mock-ups
- ➔ • Technical issues
- Note requirements on drawings




118

### SPECIAL WELDING APPLICATIONS

#### Sufficient for strength



A 3D diagram showing a vertical steel plate welded to a horizontal base plate. Five blue welds are shown along the bottom edge of the plate, connecting it to the base plate.

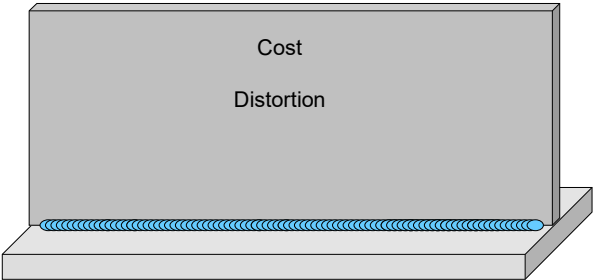


119


### SPECIAL WELDING APPLICATIONS

#### May be required for AESS

Cost  
Distortion



A 3D diagram showing a vertical steel plate welded to a horizontal base plate. A single, continuous blue weld is shown along the bottom edge of the plate, connecting it to the base plate.

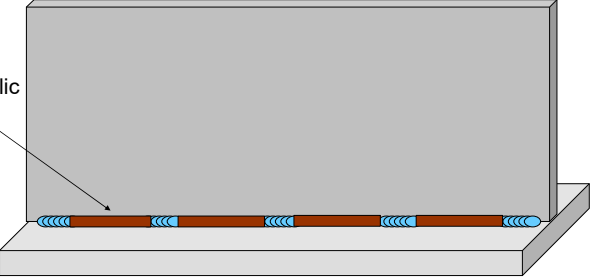


120

**SPECIAL WELDING APPLICATIONS**

**Sufficient for strength**

Non-metallic filler



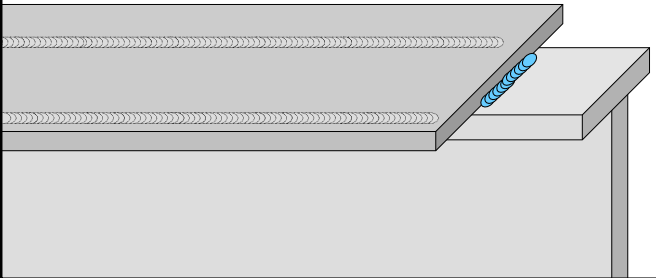
The diagram shows a cross-section of a butt joint between two steel plates. A thick, brown, segmented filler material is placed in the gap between the plates. The filler is held in place by blue welds on both the top and bottom surfaces. An arrow points from the text 'Non-metallic filler' to the brown material.

121

**SPECIAL WELDING APPLICATIONS**

**D1.1 code required practice\***

\*modified in 2015 edition



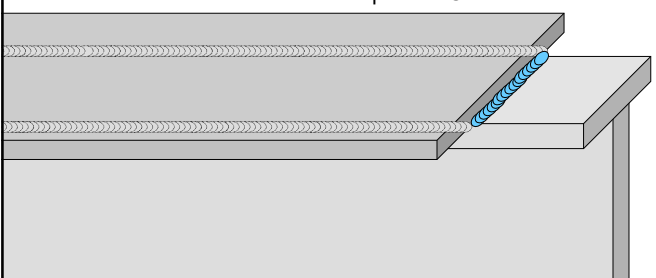
The diagram shows a lap joint where two steel plates overlap. A blue fillet weld is applied to the top surface of the overlap. The bottom surface of the overlap is also shown with a weld line.

122

**SPECIAL WELDING APPLICATIONS**

**May be AESS specified practice**

Workmanship Concerns  
Inspection Concerns

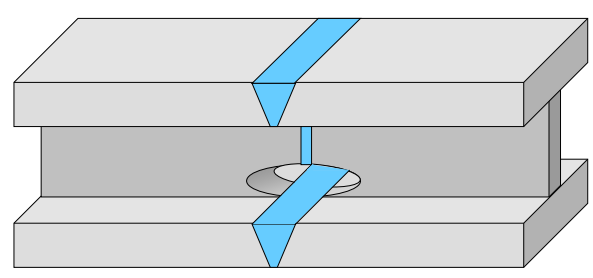


The diagram shows a lap joint similar to slide 122, but with a blue fillet weld applied to the bottom surface of the overlap. The top surface of the overlap also has a weld line.

123

**SPECIAL WELDING APPLICATIONS**

**Code required practice**

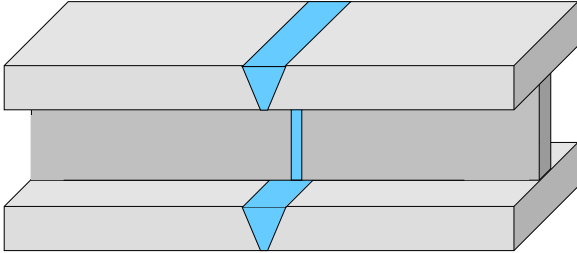


The diagram shows a lap joint with a blue fillet weld on the top surface. A blue arrow points to the weld, and another blue arrow points to the gap between the plates.

124

**SPECIAL WELDING APPLICATIONS**

May be AESS specified practice



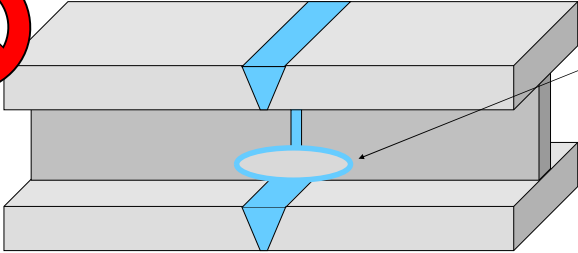
How can flange CJP groove weld be made?

125

The diagram shows a 3D perspective of a flange connection. Two horizontal plates are joined by a groove weld. A vertical plate is attached to the flange. Blue arrows indicate the weld lines. The AISC logo is in the bottom left corner.

**SPECIAL WELDING APPLICATIONS**

May be AESS specified practice



Welded insert

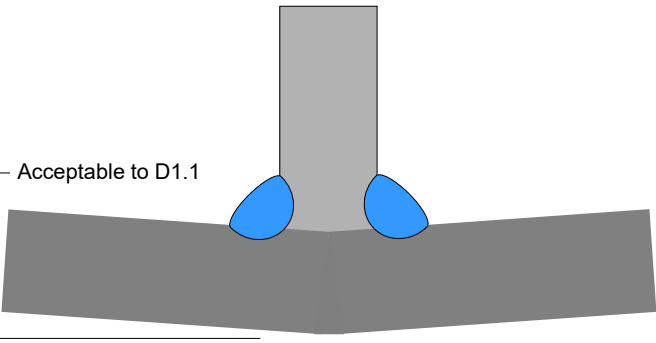
Will splice crack when insert is welded?

126

The diagram is similar to slide 125 but includes a red circle with a diagonal slash (a prohibition sign) over the top flange. A blue oval labeled "Welded insert" is shown on the vertical plate. The AISC logo is in the bottom left corner.

**SPECIAL WELDING APPLICATIONS**

Distortion



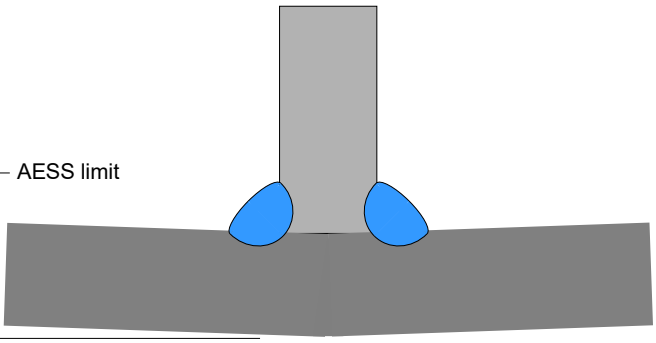
Acceptable to D1.1

127

The diagram shows a T-joint with a vertical stem and a horizontal base. Two blue welds are shown at the base of the stem. The horizontal base is distorted downwards. A vertical dimension line on the left indicates the distortion level, labeled "Acceptable to D1.1". The AISC logo is in the bottom right corner.

**SPECIAL WELDING APPLICATIONS**

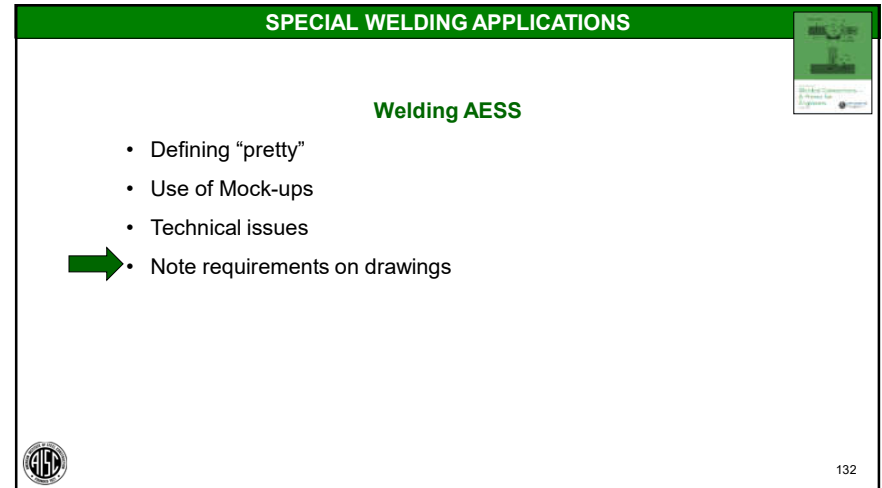
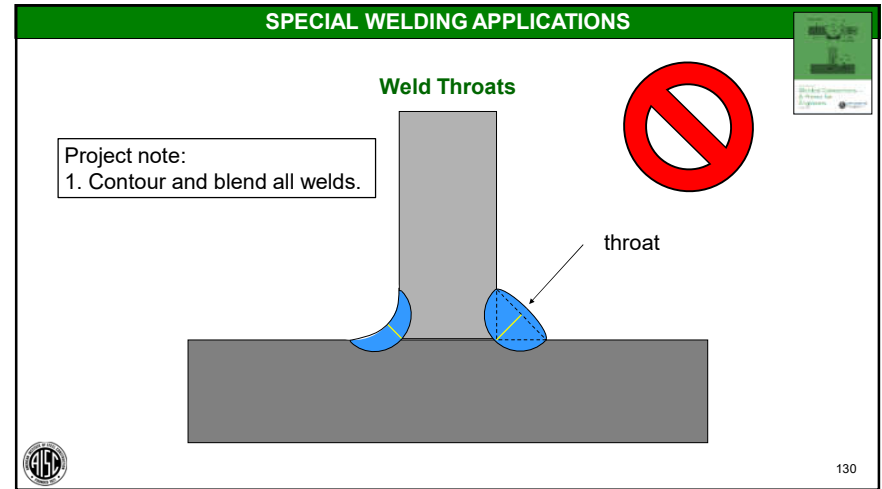
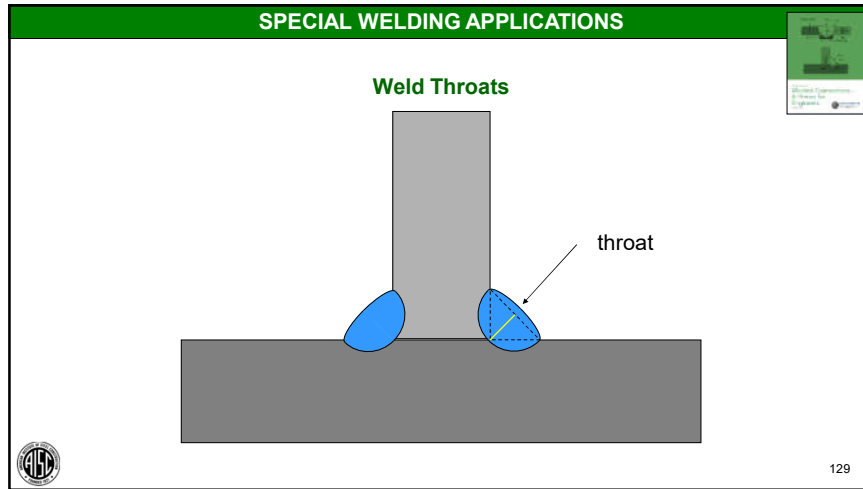
Distortion



AESS limit

128



The diagram is similar to slide 127 but shows a different level of downward distortion of the horizontal base. A vertical dimension line on the left indicates this level, labeled "AESS limit". The AISC logo is in the bottom right corner.



**SPECIAL WELDING APPLICATIONS**

**Welding AESS: Summary**

- Defining “pretty”; use AISC 303 Section 10
- Mock-ups are often critical; view from an appropriate distance
- Define all expectations; some requirement may conflict with code requirements



133

**SPECIAL WELDING APPLICATIONS**

**Today's Webinar**

- 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- 14.7 Welding AESS
- ➔ 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- 14.16 Buttering





134



**SPECIAL WELDING APPLICATIONS**

**Shop versus Field Welding**

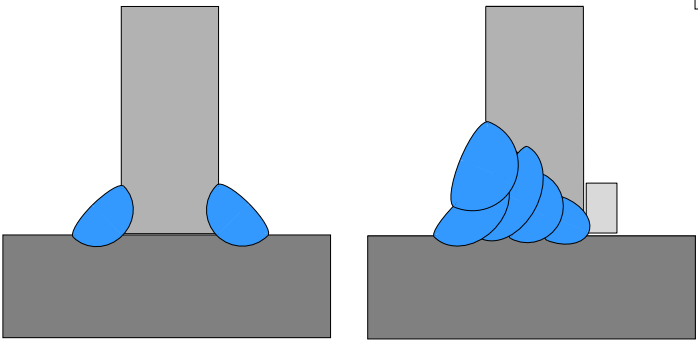
- Primarily an issue of cost
- Some environmental issues (cold, wind, rain, etc.)
- Out-of-position welding may be needed



136

**SPECIAL WELDING APPLICATIONS**

**Usually Preferred**

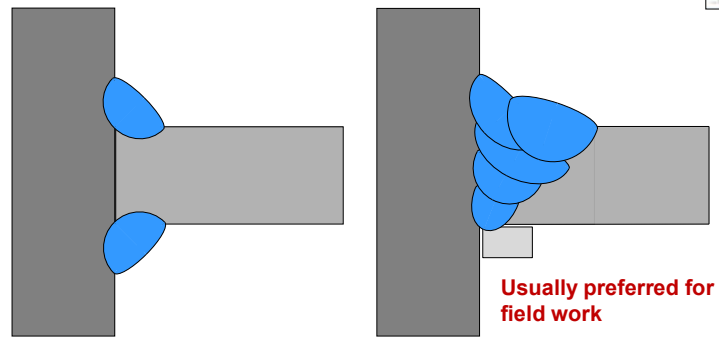


137

**SPECIAL WELDING APPLICATIONS**

Requires overhead welding

All flat welding



**Usually preferred for field work**

138

**SPECIAL WELDING APPLICATIONS**

**Shop versus Field Welding**

- Primarily an issue of cost
- Some environmental issues (cold, wind, rain, etc.)
- Out-of-position welding may be needed
- Easier to control projects in a shop environment

139

**SPECIAL WELDING APPLICATIONS**

**Myths**


- You can't get quality welds out-of-position

140

**AWS D1.1:2015 STRUCTURAL WELDING CODE**

**Table 4.12**  
**Welding Personnel Performance Essential Variable Changes**  
**Requiring Requalification (see 4.19)**


Essential Variable Changes to WPQR Requiring Requalification	Welding Personnel		
	Welders <sup>b</sup>	Welding Operators <sup>b,c</sup>	Tack Welders
(1) To a process not qualified (GMAW-S is considered a separate process)	X	X	X
(2) To an SMAW electrode with an F-number (see Table 4.13) higher than the WPQR electrode F-number	X		X
➔ (3) To a position not qualified	X	X	X
(4) To a diameter or thickness not qualified	X	X	
(5) To a vertical welding progression not qualified (uphill or downhill)	X		
(6) The omission of backing (if used in the WPQR test)	X	X	
(7) To multiple electrodes (if a single electrode was used in the WPQR test) but not vice versa		X <sup>a</sup>	

 141

**SPECIAL WELDING APPLICATIONS**

**Myths**

- You can't get quality welds out-of-position
- You can't get quality in the field


 142



**SPECIAL WELDING APPLICATIONS**

**Myths**

- You can't get quality welds out-of-position
- You can't get quality in the field
- Codes do not apply to field welding

 144

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

**7. Fabrication**

**7.1 Scope**

This clause contains requirements for the **fabrication and erection of welded assemblies and structures** produced by any process applicable under this code (see 5.5 and 6.15) related to:



- (1) Materials
- (2) Processes and WPSs
- (3) Weld Details
- (4) Weld Quality and Repairs
- (5) Member Dimensional Tolerances



**SPECIAL WELDING APPLICATIONS**

**Myths**

- You can't get quality welds out-of-position
- You can't get quality in the field
- Codes do not apply to field welding
- Field welders are not "certified" (qualified)





146

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

**6. Qualification**

**6.2.2.2 Qualification Responsibility**



**Each manufacturer or Contractor shall be responsible for the qualification of welders, welding operators and tack welders, whether the qualification is conducted by the manufacturer, Contractor, or an independent testing agency.**



**SPECIAL WELDING APPLICATIONS**

**Myths**

- You can't get quality welds out-of-position
- You can't get quality in the field
- Codes do not apply to field welding
- Field welders are not "certified" (qualified)
- WPSs are not used in the field



148

**AISC 360-16 Specification for Structural Steel Buildings**

**CHAPTER N**

**QUALITY CONTROL AND QUALITY ASSURANCE**

**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 <sup>(a)</sup>	O	O
Fit-up of groove welds (including joint geometry) <ul style="list-style-type: none"> <li>• Joint preparations</li> <li>• Dimensions (alignment, root opening, root face, bevel)</li> <li>• Cleanliness (condition of steel surfaces)</li> <li>• Tacking (tack weld quality and location)</li> <li>• Backing type and fit (if applicable)</li> </ul>	O	O
Fit-up of CJP groove welds of HSS T, Y- and X-joints without backing (including joint geometry) <ul style="list-style-type: none"> <li>• Joint preparations</li> <li>• Dimensions (alignment, root opening, root face, bevel)</li> <li>• Cleanliness (condition of steel surfaces)</li> <li>• Tacking (tack weld quality and location)</li> </ul>	P	O
Configuration and finish of access holes	O	O
Fit-up of fillet welds <ul style="list-style-type: none"> <li>• Dimensions (alignment, gaps at root)</li> <li>• Cleanliness (condition of steel surfaces)</li> <li>• Tacking (tack weld quality and location)</li> </ul>	O	O
Check welding equipment	O	-

<sup>(a)</sup> The fabricator or erector, as applicable, shall maintain a system by which a welder who has welded a joint or member can be identified. Stamps, if used, shall be the low-stress type.

149

**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 <sup>(a)</sup>	O	O
Fit-up of groove welds (including joint geometry) <ul style="list-style-type: none"> <li>• Joint preparations</li> <li>• Dimensions (alignment, root opening, root face, bevel)</li> <li>• Cleanliness (condition of steel surfaces)</li> <li>• Tacking (tack weld quality and location)</li> <li>• Backing type and fit (if applicable)</li> </ul>	O	O

150

**SPECIAL WELDING APPLICATIONS**

Myths

- You can't get quality welds out-of-position
- You can't get quality in the field
- Codes do not apply to field welding
- Field welders are not "certified" (qualified)
- WPSs are not used in the field
- There is no audit program for field contractors

151

**AMERICAN INSTITUTE OF STEEL CONSTRUCTION  
CERTIFICATION PROGRAMS**

PROUDLY RECOGNIZE THAT

ABC Company

MAINTAINS OPERATIONS LOCATED AT

123 Main St., Chicago, IL 60600

THAT SUCCESSFULLY MEET THE QUALITY CERTIFICATION REQUIREMENTS FOR

Erector (Advanced)  
Bridge Endorsement  
Seismic Endorsement  
Metal Deck Endorsement

---

PRESIDENT

CERTIFICATION NUMBER

C-00011111

ISSUED

September 7, 2021

VALID THROUGH



September 30, 2021

152

**SPECIAL WELDING APPLICATIONS**

**Myths**

- You can't get quality welds out-of-position
- You can't get quality in the field
- Codes do not apply to field welding
- Field welders are not "certified" (qualified)
- WPSs are not used in the field
- There is no audit program for field contractors
- There are no contractor-supplied inspectors for field work



153



**AISC 360-16 Specification for Structural Steel Buildings**

**CHAPTER N**

QUALITY CONTROL AND QUALITY ASSURANCE

**N2. FABRICATOR AND ERECTOR QUALITY CONTROL PROGRAM**

The **fabricator and erector** shall establish, maintain and implement QC procedures to ensure that their work is performed in accordance with this Specification and the construction documents.





154

**SPECIAL WELDING APPLICATIONS**

**Shop vs Field Welding: Summary**

- There are some legitimate differences/concerns
- Shop operations generally preferred due to lower costs
- Mature codes control field welding
- Field contractor certification programs exist
- Inspection requirements have been made clearer in Chapter N



155

**SPECIAL WELDING APPLICATIONS**

**Today's Webinar**

- 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- ➔ 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- 14.16 Buttering





156

**SPECIAL WELDING APPLICATIONS**

**14.9 Welding on Existing Structures**

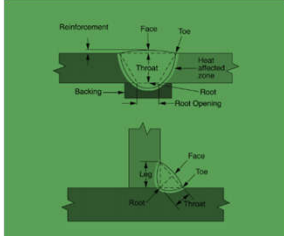
- Historic steels
- Welding under load
- Fire
- Cold working / strain aging





157

**AISC Design Guide 21**  
**Chapter 4 Metallurgical Issues**

- Historic (obsolete) steels
  - ASTM A9
  - ASTM A7
  - ASTM A373
  - ASTM A242
- Check weldability of steel (especially if riveted)



Design Guide 21  
**Welded Connections—  
A Primer for  
Engineers**  
Second Edition





158

**SPECIAL WELDING APPLICATIONS**



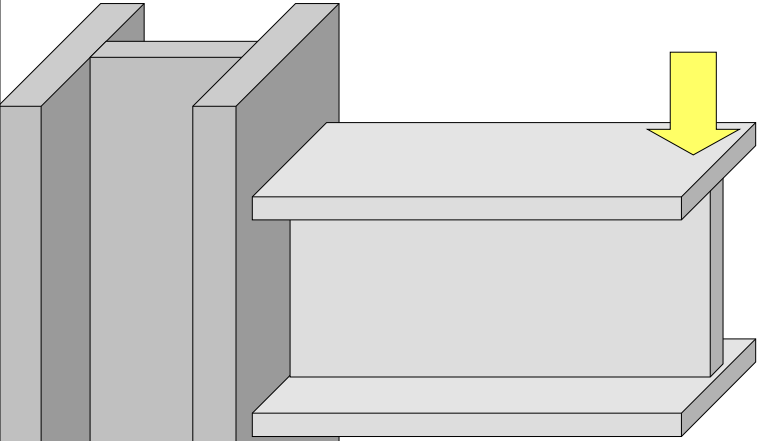
**14.9 Welding on Existing Structures**

- Historic steels
- Welding under load
- Fire
- Cold working / strain aging

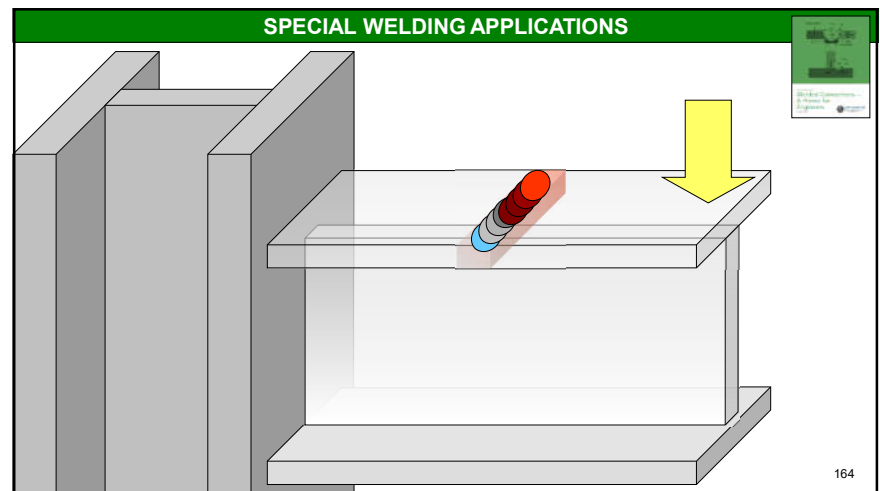
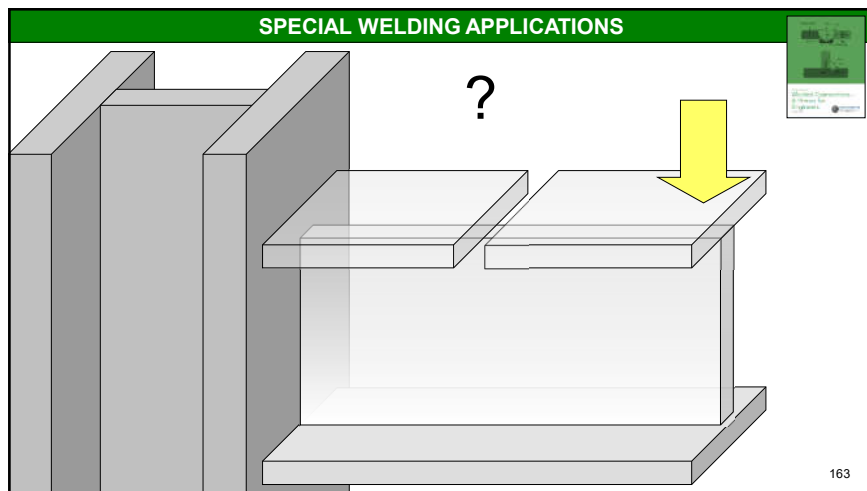
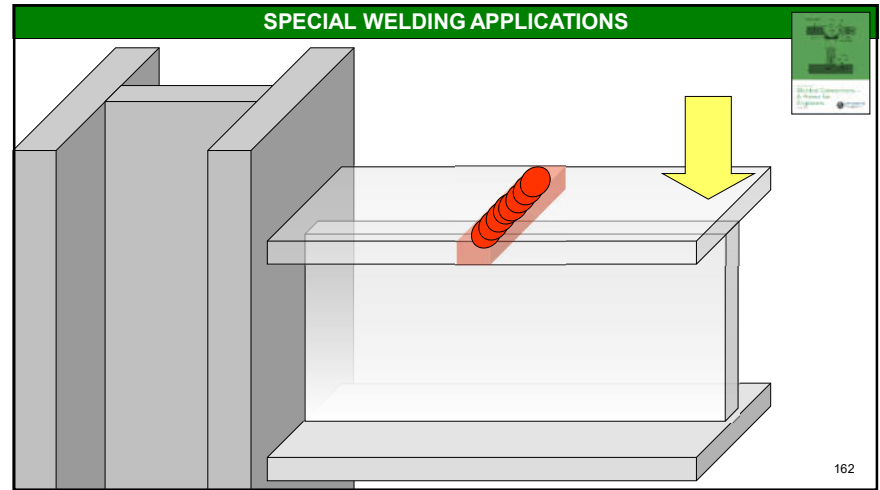
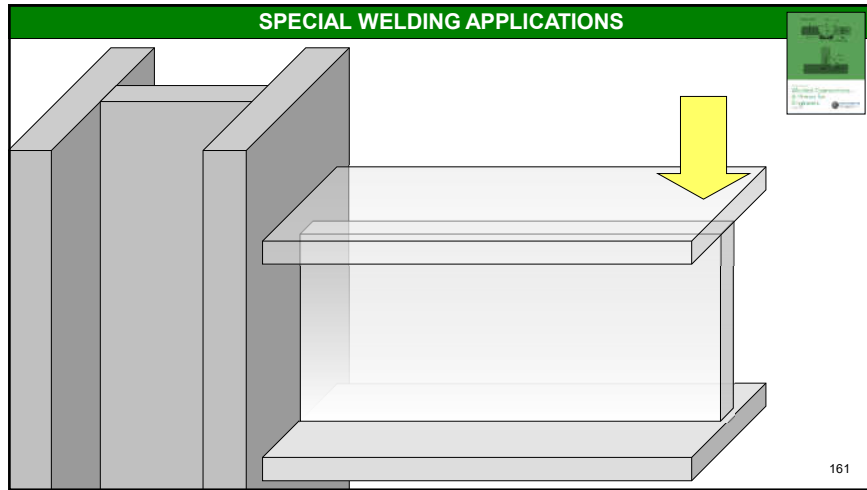


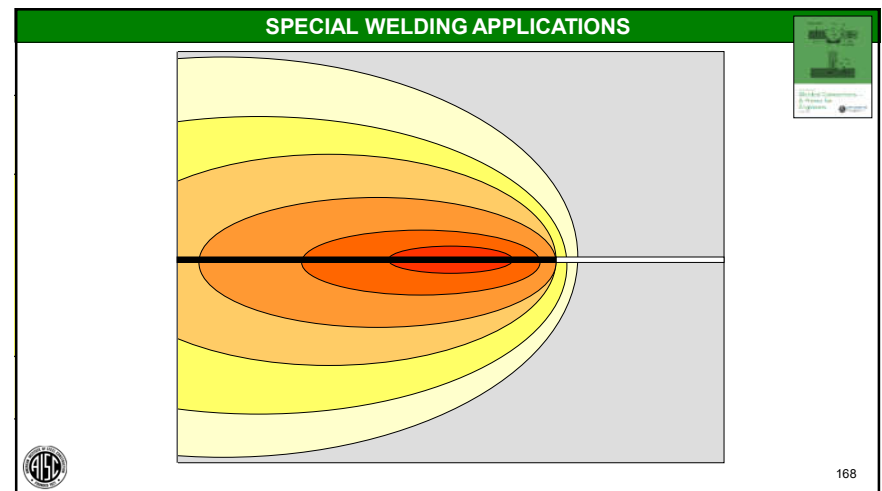
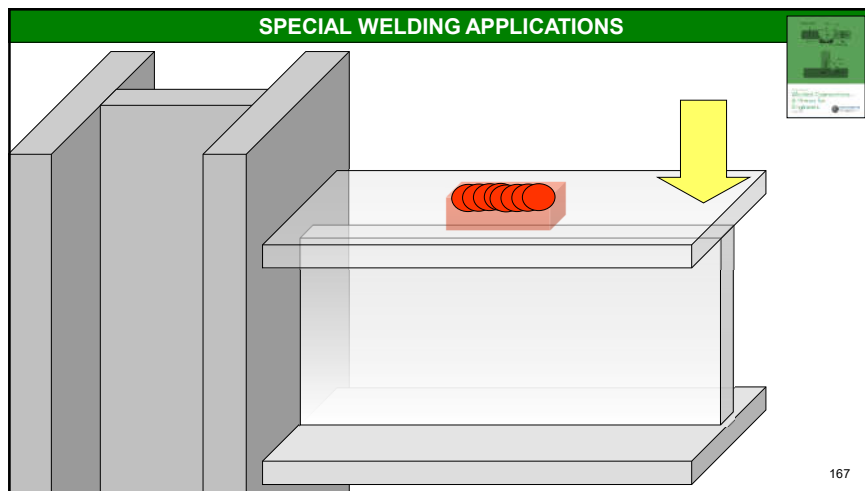
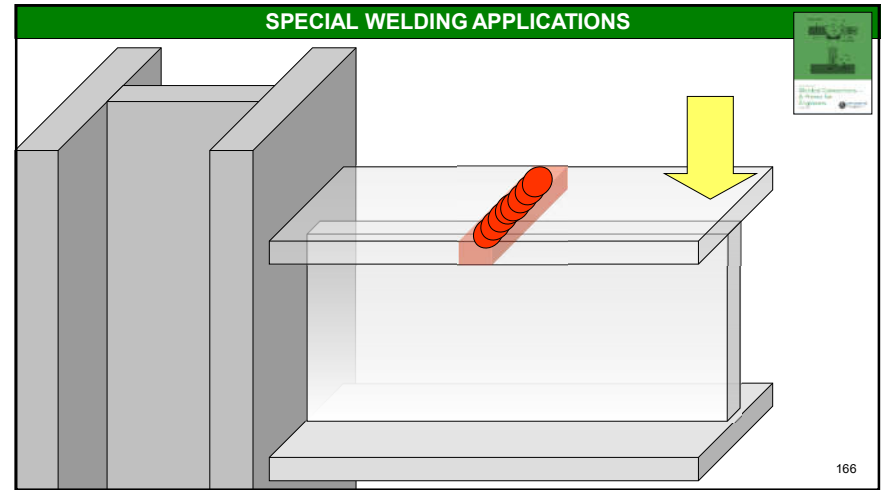
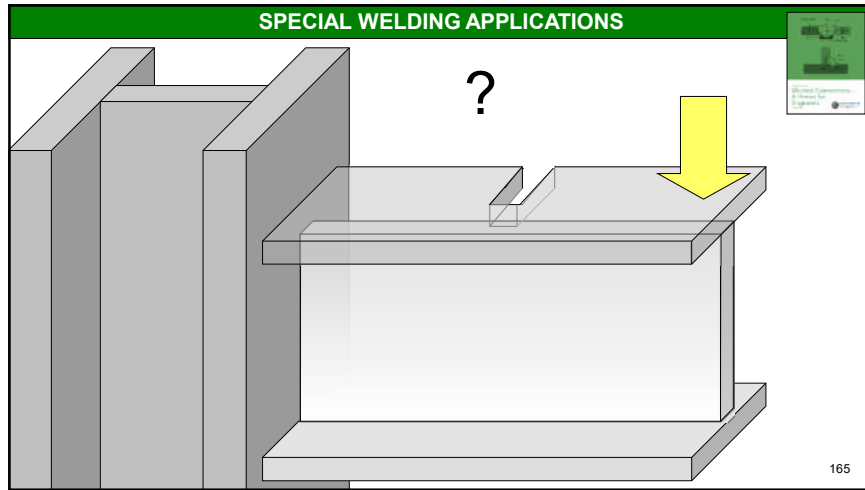
159

**SPECIAL WELDING APPLICATIONS**



160





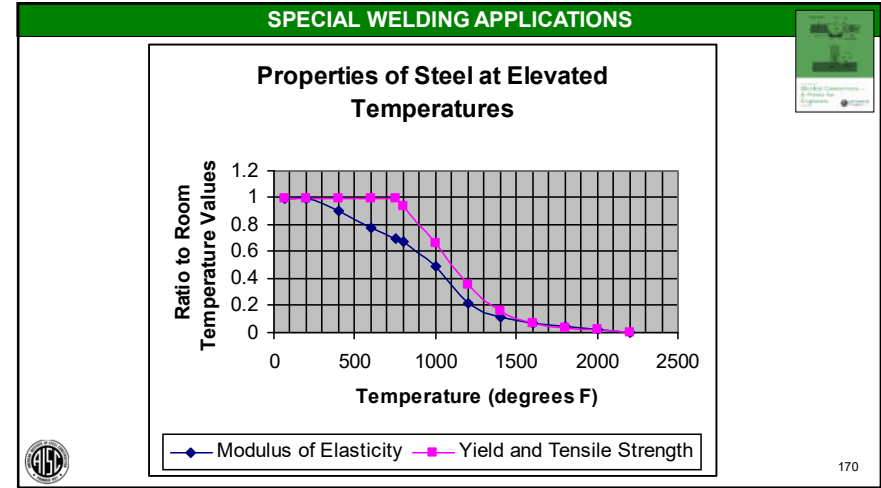
**AISC 360-16 Specification for Structural Steel Buildings**

**Table A-4.2.1  
 Properties of Steel at Elevated Temperatures**

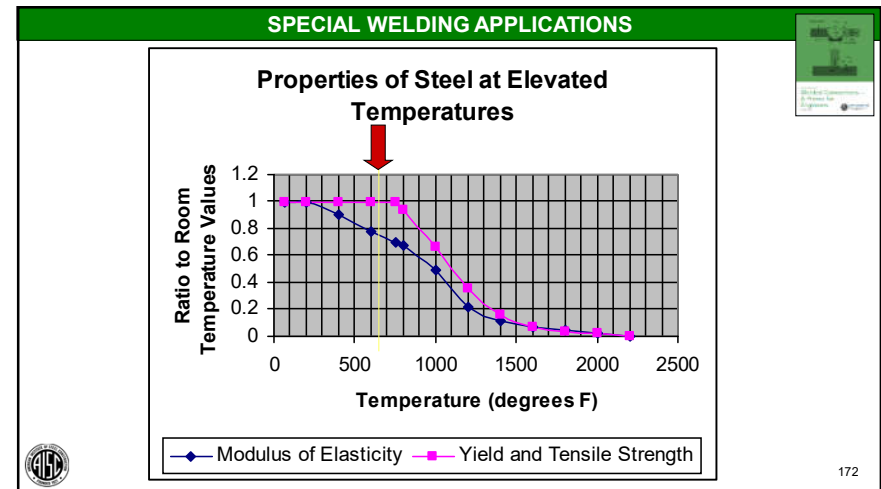
Steel Temperature (°F) [°C]	$k_E = E_m/E$	$k_y = F_{ym}/F_y$	$k_u = F_{um}/F_y$
68 [20]	*	*	*
200 [93]	1.00	*	*
400 [204]	0.90	*	*
600 [316]	0.78	*	*
750 [399]	0.70	1.00	1.00
800 [427]	0.67	0.94	0.94
1000 [538]	0.49	0.66	0.66
1200 [649]	0.22	0.35	0.35
1400 [760]	0.11	0.16	0.16
1600 [871]	0.07	0.07	0.07
1800 [982]	0.05	0.04	0.04
2000 [1093]	0.02	0.02	0.02
2200 [1204]	0.00	0.00	0.00

\*Use ambient properties.

169





- SPECIAL WELDING APPLICATIONS**
- Welding on members under load**
- The amount of material at temperatures >650 °F is negligible (Blodgett)
  - Only a very small percentage of the cross section experiences reduced properties (Tide)
  - The impact of the weld orientation (longitudinal versus transverse) is typically inconsequential (Ricker)
  - Each situation should be checked
- 171



**SPECIAL WELDING APPLICATIONS**

**14.9 Welding on Existing Structures**

- Historic steels
- Welding under load
- ➔ • Fire
- Cold working / strain aging





173

**SPECIAL WELDING APPLICATIONS**

**Welding on Existing Structures**

- General precaution: Fire!
  - From combustibles
  - From unintended work circuits
  - Thermal cutting is typically >> problem than welding





174

**SPECIAL WELDING APPLICATIONS**

**14.9 Welding on Existing Structures**

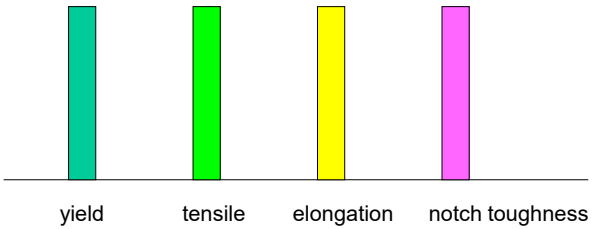
- Historic steels
- Welding under load
- Fire
- ➔ • Cold working / strain aging





175

**SPECIAL WELDING APPLICATIONS**

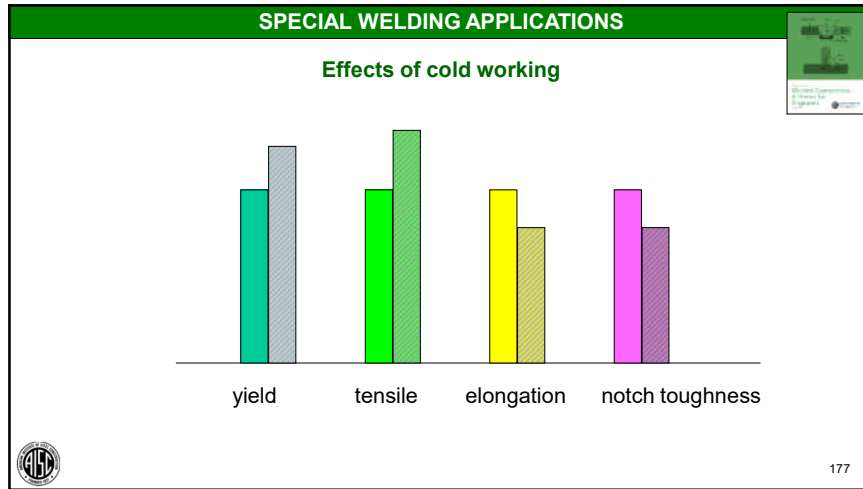
**As received hot rolled steel**



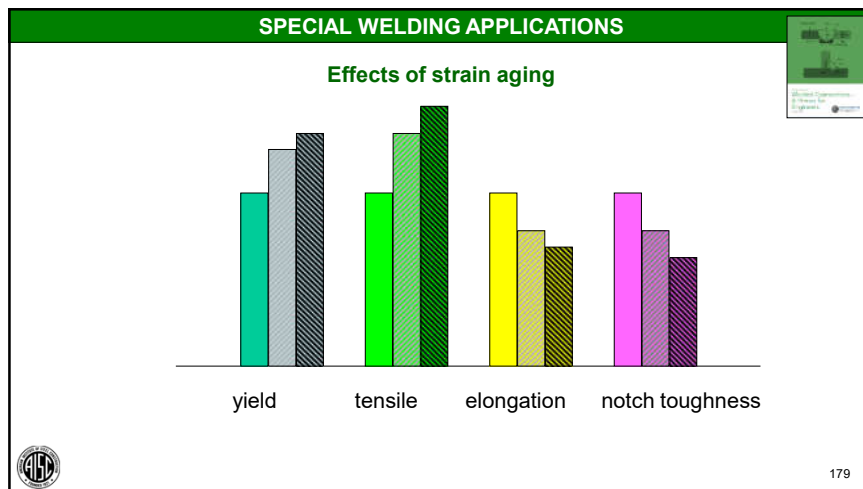
yield      tensile      elongation      notch toughness



176



- SPECIAL WELDING APPLICATIONS**
- Strain Aging**
- Occurs when steel is heated to 400-700 °F
  - Yield, tensile increase
  - Ductility, notch toughness decrease
  - Aggravated by presence of "free" nitrogen
  - Stress relief helps, but...
    - Typically impractical
    - Depending on alloy, may experience cracking (Cr, Mo, V, B)
- 178





- SPECIAL WELDING APPLICATIONS**
- Welding on plastically deformed members**
- Reduced notch toughness
    - Make sure material is crack and notch free
  - Reduced ductility
    - Minimize practices that increase ductility demand
- 180

**AWS D1.1:2020 STRUCTURAL WELDING CODE**

### 11. Strengthening and Repair of Existing Structures

#### 11.1 Scope

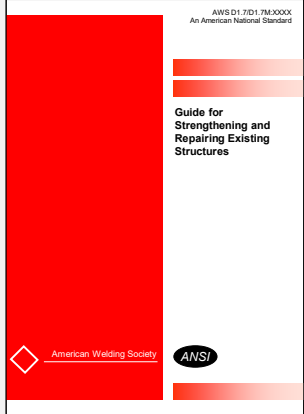
Strengthening or repair of an existing structure shall consist of modifications to meet design requirements, specified by the Engineer. This clause includes requirements for a comprehensive plan for the work, including design, workmanship, inspection, and documentation. The use of fatigue life enhancement methods is also described.



181

**AWS D1.7**


### Guide for Strengthening and Repairing Existing Structures



AWS D1.7/D1.7M:XXXX  
An American National Standard

Guide for Strengthening and Repairing Existing Structures

American Welding Society  
ANSI





182

**SPECIAL WELDING APPLICATIONS**

### Welding on Existing Structures: Summary

- May involve historic steel: see DG 21 Chapter 4
- Welding on members under load: Caution
- Fire potential: sparks, resistance heating: Caution
- Welding on cold worked steel: local reduced ductility



183

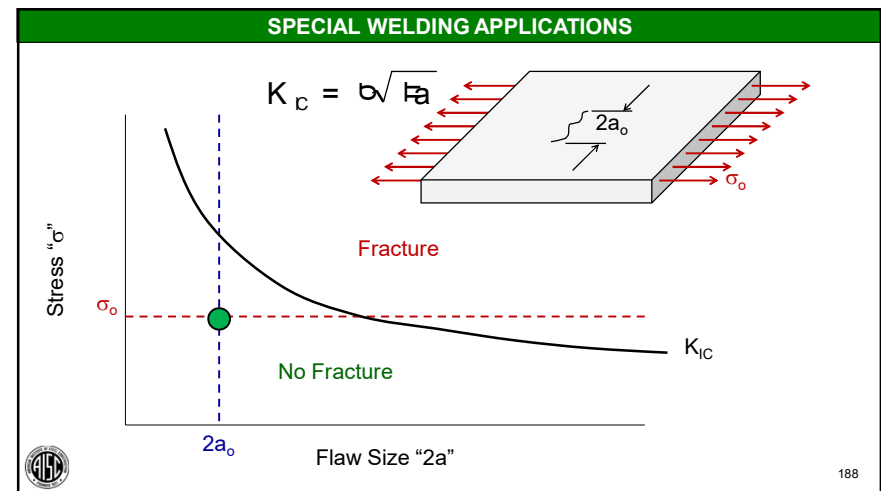
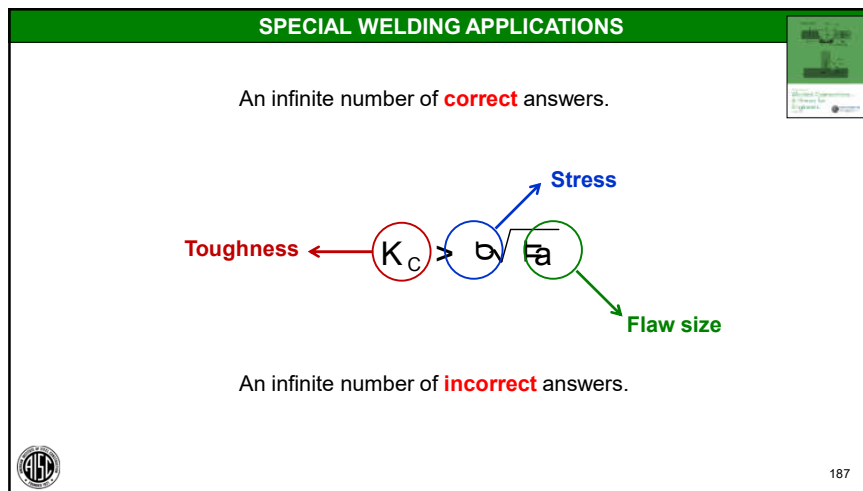
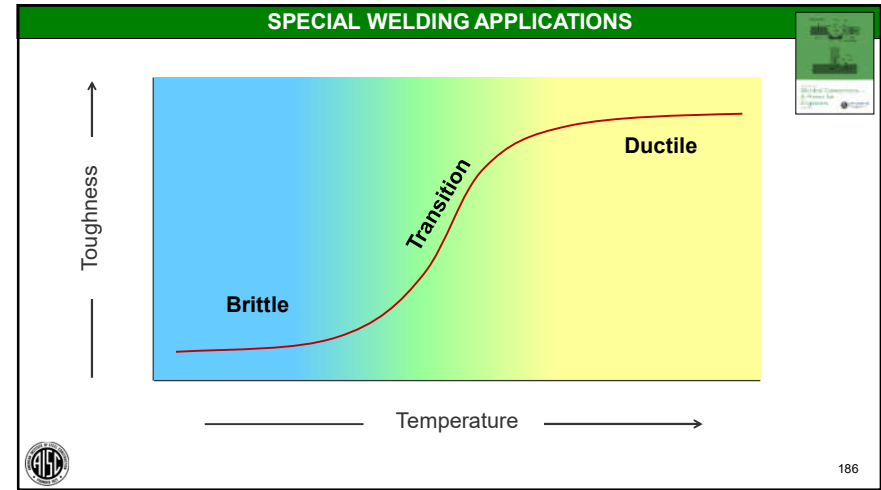
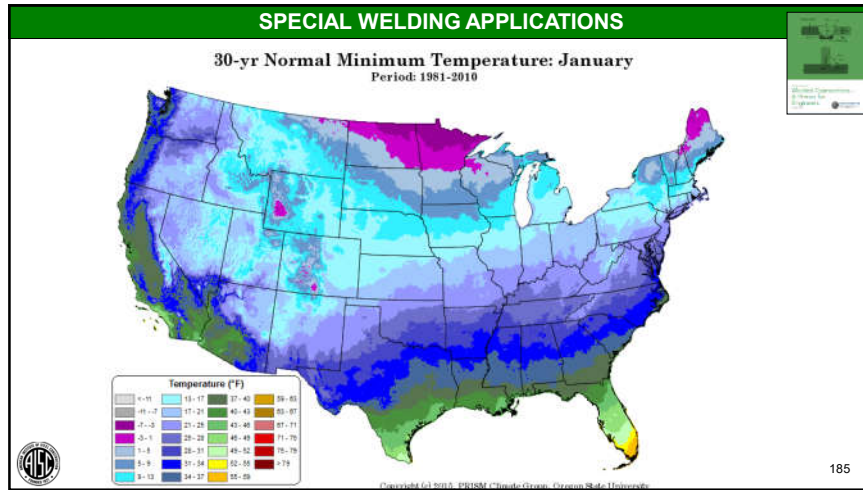
**SPECIAL WELDING APPLICATIONS**

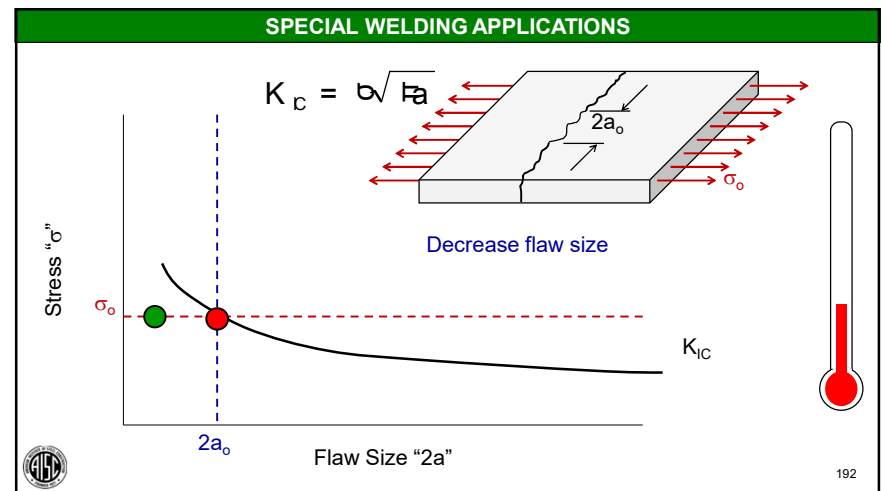
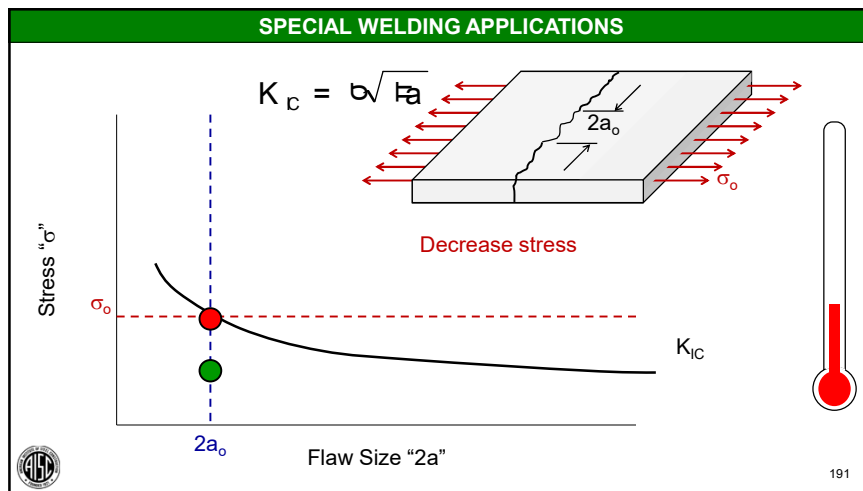
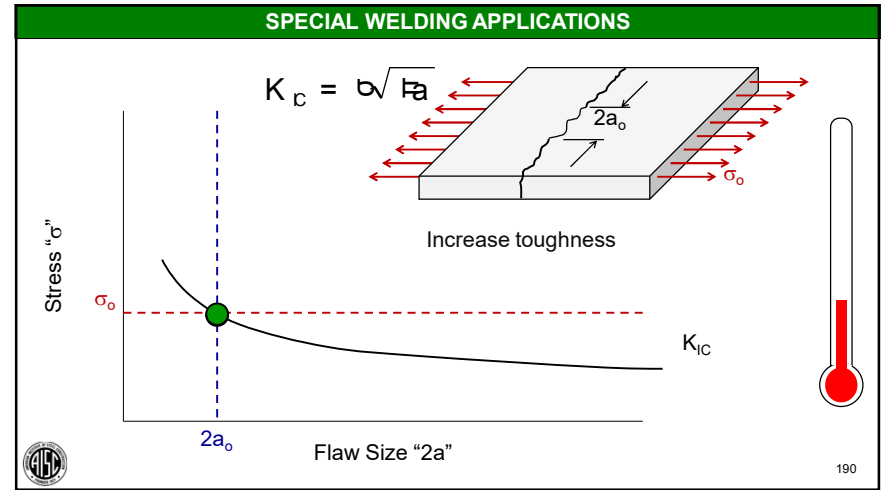
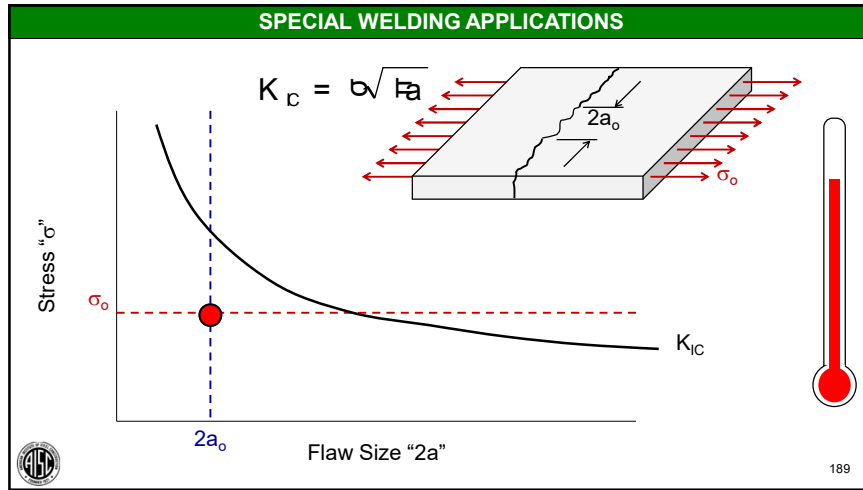
### Today's Webinar

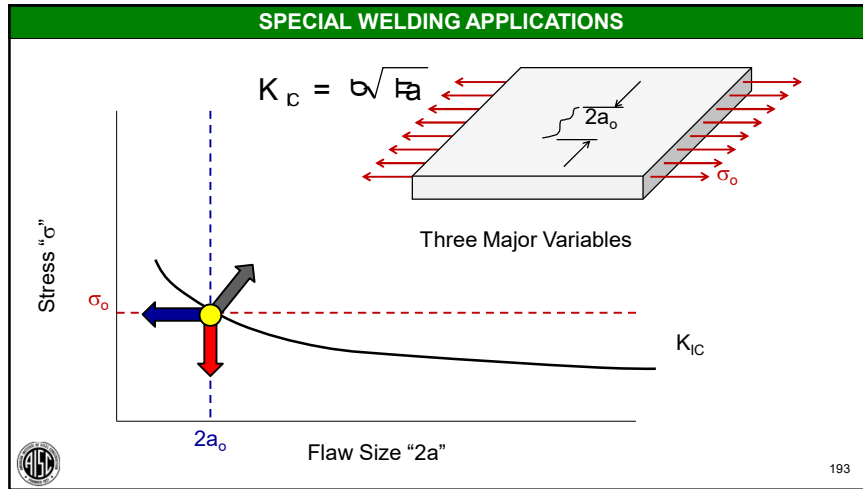
- 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- ➔ 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- 14.16 Buttering



184







**AISC 360-16 Specification for Structural Steel Buildings**

**Commentary A3. MATERIAL**

**1a. ASTM Designations**

"For especially demanding service conditions such as structures exposed to low temperatures, particularly those with impact loading, the specification of steels with superior notch toughness may be warranted."

$K_{IC} > \sigma \sqrt{Fa}$

194

**AISC 360-16 Specification for Structural Steel Buildings**

**Commentary A3. MATERIAL**

**1a. ASTM Designations**

"Good workmanship and good design details incorporating joint geometry that avoids severe stress concentrations are generally the most effective means of providing fracture-resistant construction."

$K_{IC} > \sigma \sqrt{Fa}$

195

**SPECIAL WELDING APPLICATIONS**

**Cold Temperature Applications: Summary**

Material

Details

Workmanship

Inspection

For "good design details" and joint geometries that "avoid severe stress concentrations", consider Appendix 3 Design for Fatigue.

196

**SPECIAL WELDING APPLICATIONS**

**Today's Webinar**

- 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- ➔ 14.15 Heat Shinking
- 14.16 Buttering




197

**SPECIAL WELDING APPLICATIONS**


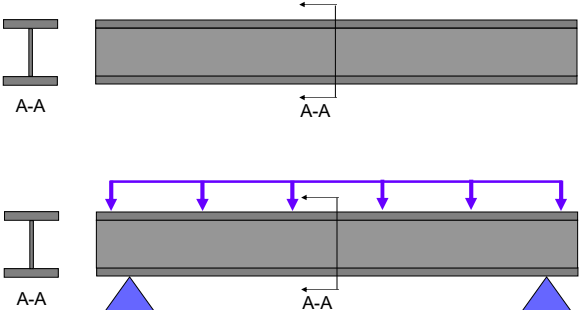
**Heat Shinking**

- Used to curve straight steel
- Used to straighten bent steel
- Used to correct for distortion
- Also known as “heat straightening”




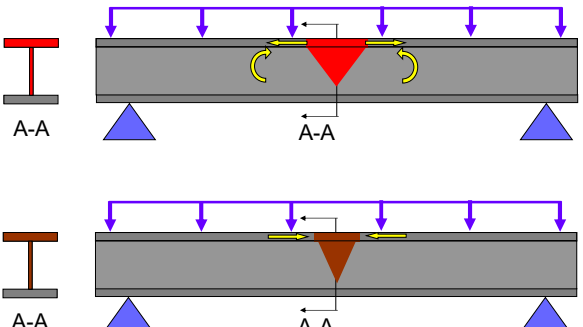
198

**SPECIAL WELDING APPLICATIONS**

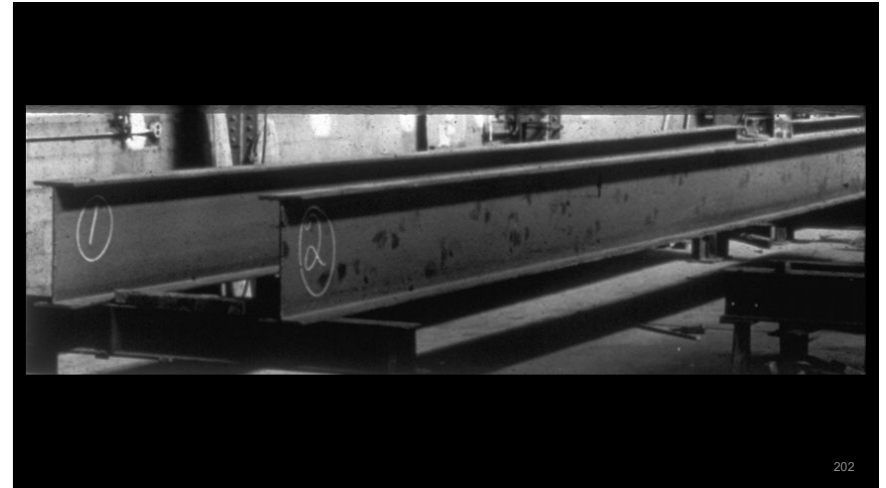
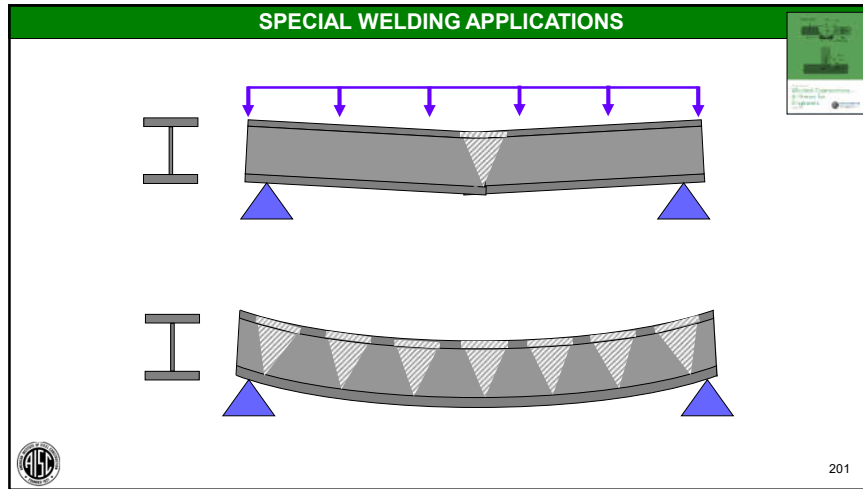


199

**SPECIAL WELDING APPLICATIONS**





200



**SPECIAL WELDING APPLICATIONS**

### Heat Shrinking

- 1200 °F temperature limit for hot rolled steels
- 1100 °F temperature limit for quenched and tempered steels
- New limits for QST steels
- Pre-stress of up to 50% of room temperature yield (Avent)





205

**AWS D1.1:2020 STRUCTURAL WELDING CODE**

### 7.25.2 Localized Heat Repair Temperature Limitations.

Members distorted by welding shall be straightened by mechanical means or by application of a limited amount of localized heat. The temperature of heated areas as measured by approved methods shall not exceed 1100°F [600°C] for quenched and tempered steel nor 1200°F [650°C] for other steels. The part to be heated for straightening shall be substantially free of stress and from external forces, except those stresses resulting from the mechanical straightening method used in conjunction with the application of heat.





206

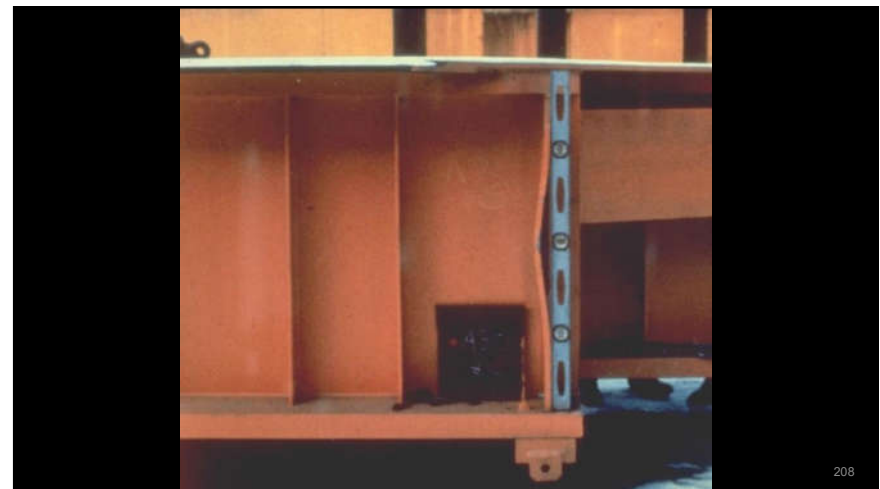
**SPECIAL WELDING APPLICATIONS**

### Heat Shrinking

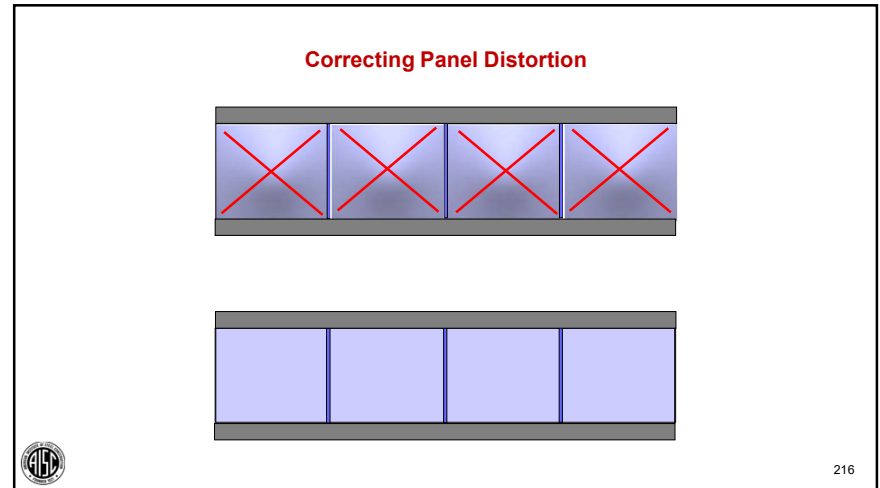
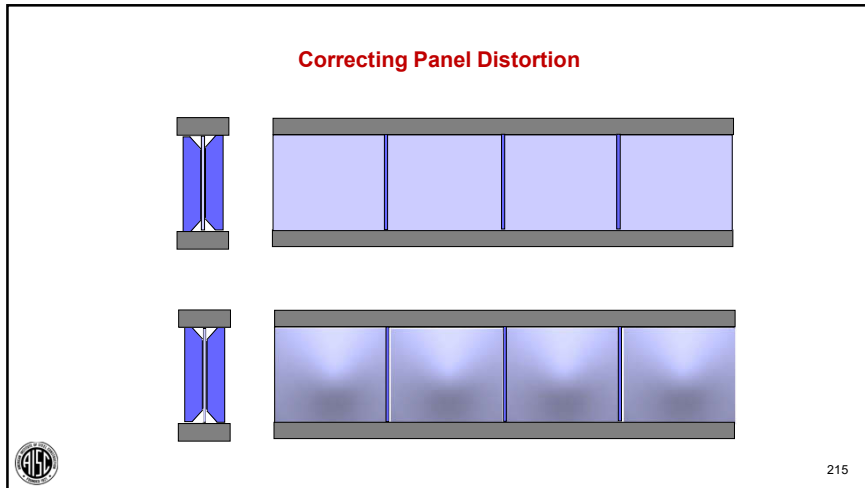
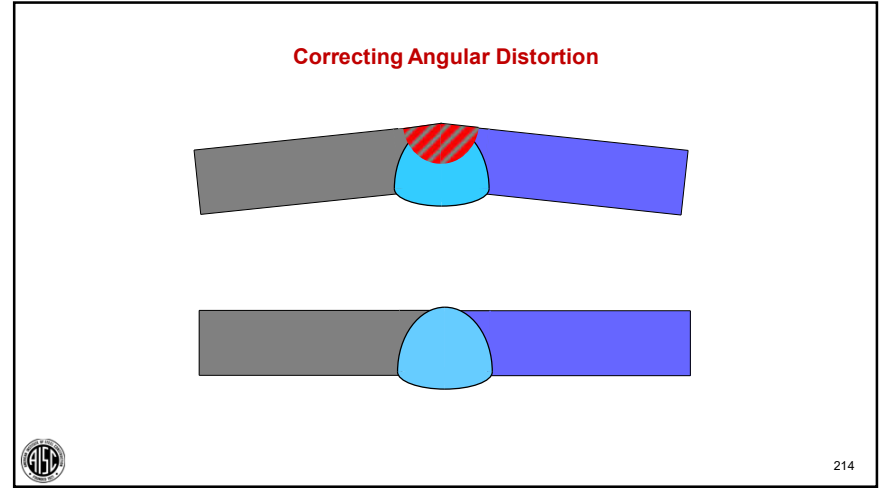
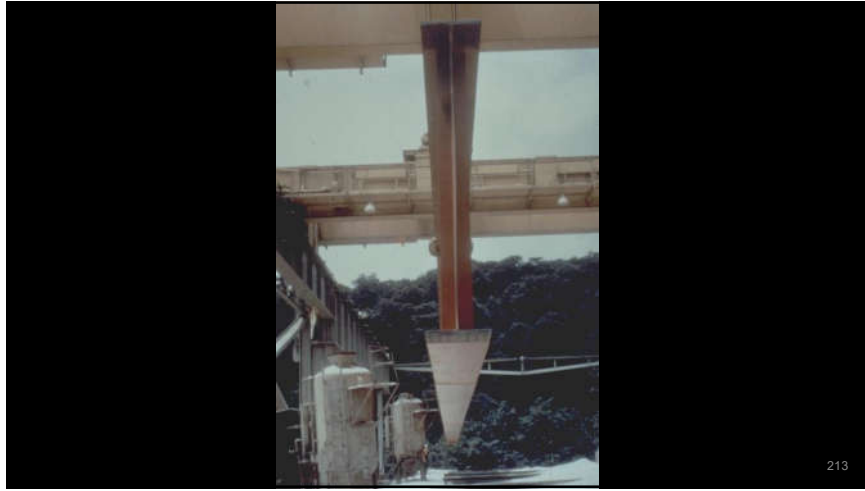
- For new steel being curved
  - No change in modulus of elasticity (E)
  - Slight increase in yield and tensile strength
  - 10-25% increase in ductility
- For bent steel being straightened
  - Yield strength increases 10%
  - Tensile strength increases 4-6%



207








**SPECIAL WELDING APPLICATIONS**

**Heat Shrinking: Summary**

- Used for shaping and straightening steel
- Code limits on temperatures
- Material is not damaged if properly done



217

**SPECIAL WELDING APPLICATIONS**

**Today's Webinar**

- 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- ➔ 14.16 Buttering



218

**SPECIAL WELDING APPLICATIONS**

**BUTTERING**




219

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

**buttering**

A surfacing variation primarily use to provide metallurgically compatible weld metal for the subsequent completion of the weld.

See also buildup, cladding, and hardfacing.



220

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

**surfacing weld**  
A weld applied to a surface, as opposed to making a joint, to obtain desired properties or dimensions. See Figures B15(C) and B30(C).

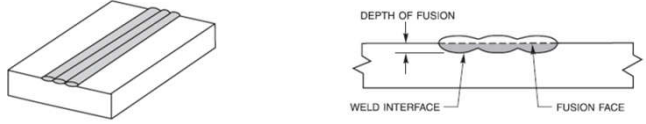


Figure B15(C) shows a 3D perspective view of a surfacing weld on a rectangular block. Figure B30(C) shows a cross-sectional view of a surfacing weld with labels: DEPTH OF FUSION, WELD INTERFACE, and FUSION FACE.

(C) SURFACING WELD  
Figure B15(C)

(C) SURFACING WELD  
Figure B30(C)

221

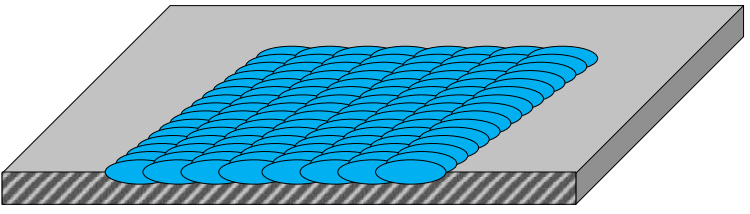
**SPECIAL WELDING APPLICATIONS**

**Buttering is used to:**

- Mitigate lamellar tearing tendencies
- Build up the faces of groove weld joint cavities where root openings are excessive
- Restore material from steel that was damaged by corrosion
- Enable welding on “hard to weld” steels

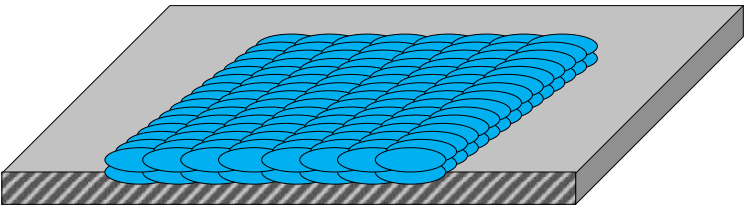
222

**SPECIAL WELDING APPLICATIONS**

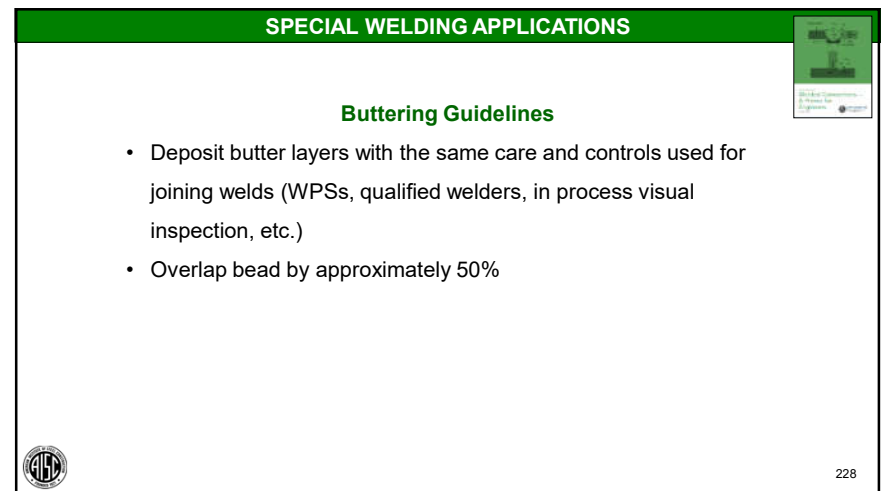
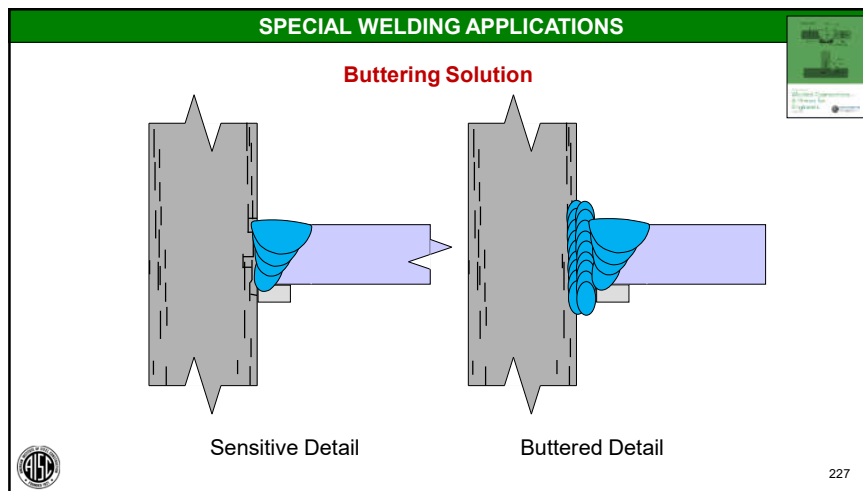
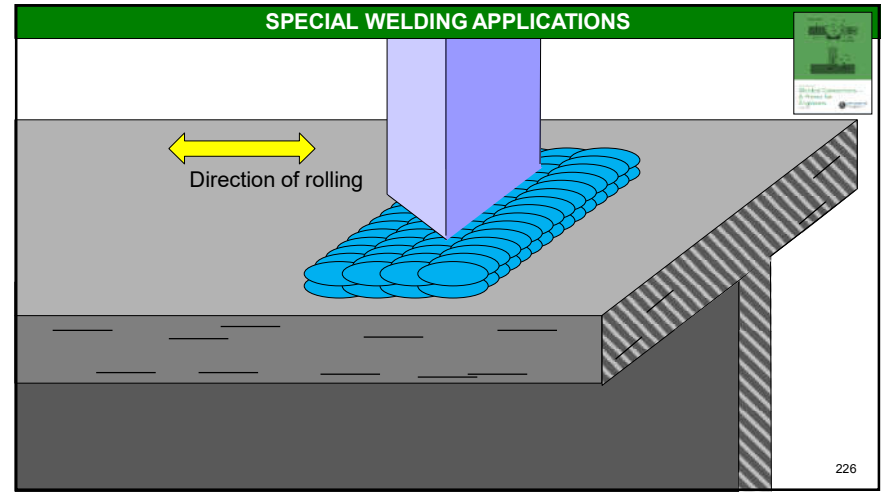
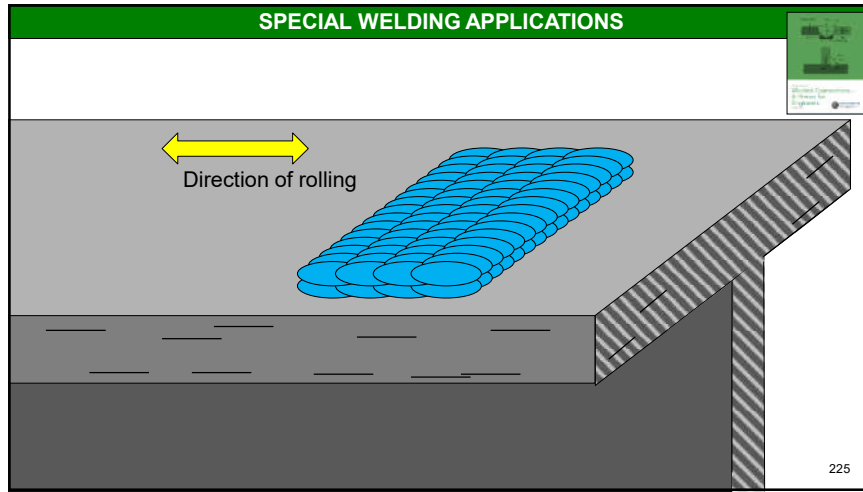


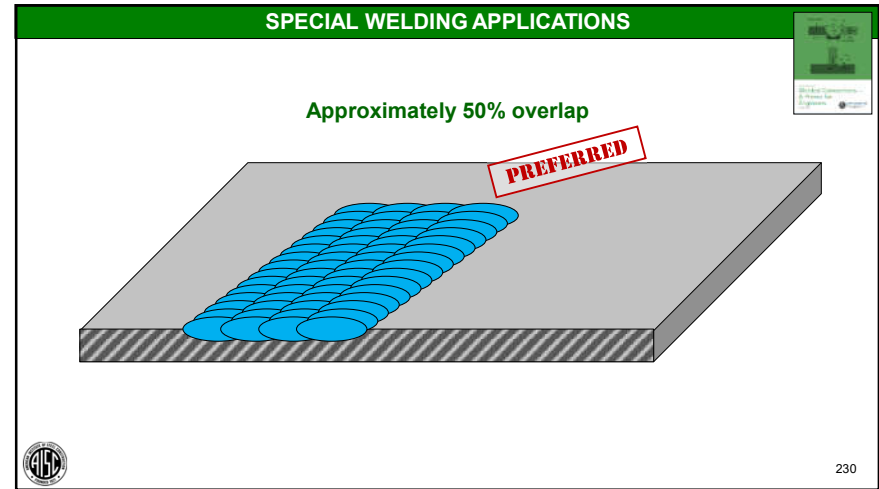
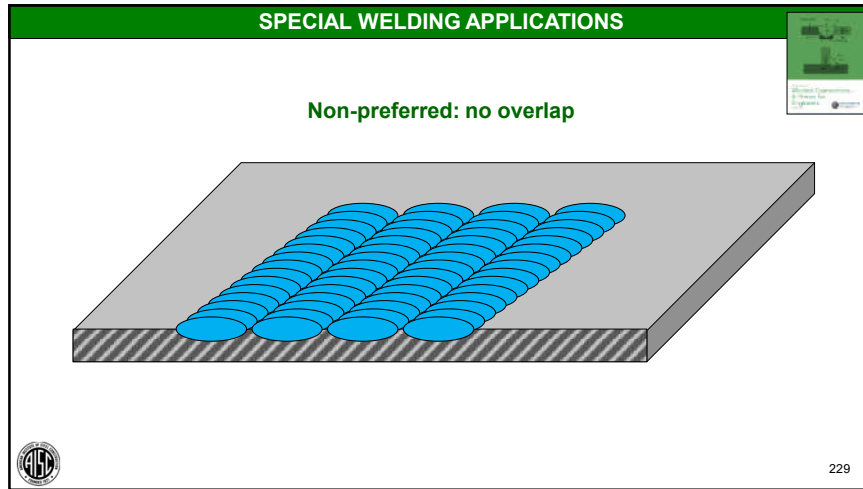
223

**SPECIAL WELDING APPLICATIONS**



224





**SPECIAL WELDING APPLICATIONS**

**Buttering Guidelines**

- Deposit butter layers with the same care and controls used for joining welds (WPSs, Qualified welders, in process visual inspection, etc.)
- Overlap bead by approximately 50%.
- If NDT of the weld to be made to the butter layer is required, the butter layer should also receive NDT.

231

**SPECIAL WELDING APPLICATIONS**

**Buttering: Summary**

- Build up out-of-tolerance joints
- One method to mitigate lamellar tearing
- Buttering procedures should be consistent with the applicable code, including final quality requirements

232

**SPECIAL WELDING APPLICATIONS**



**Today's Webinar**

- 14.4 Welding on Heavy Shapes
- 14.6 Welding HSS
- 14.7 Welding AESS
- 14.8 Shop Versus Field Welding
- 14.9 Welding on Existing Structures
- 14.12 Cold Temperature Applications
- 14.15 Heat Shrinking
- 14.16 Buttering



233


**SPECIAL WELDING APPLICATIONS**



234

**Thank you!**

**AISC** | Questions



**Smarter.  
Stronger.  
Steel.**

**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](mailto: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](mailto:NIGHTSCHOOL@AISC.ORG).

### Quiz and attendance records

Posted Friday mornings. [www.aisc.org/nightschool](http://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](mailto:NIGHTSCHOOL@AISC.ORG).

### PDHs via recording

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

## 8-Session Registrants

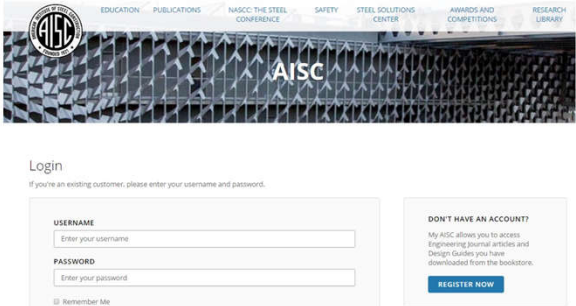
### Night School Resources

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](http://www.aisc.org) and sign in.



**Login**  
 If you're an existing customer, please enter your username and password.

**USERNAME**  
 Enter your username

**PASSWORD**  
 Enter your password

Remember Me

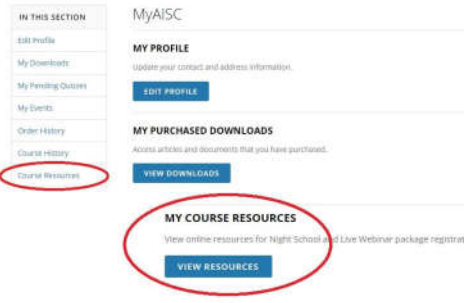
**DON'T HAVE AN ACCOUNT?**  
 My AISC allows you to access Engineering Journal articles and Design Guides you have downloaded from the bookstore.

[REGISTER NOW](#)

## 8-Session Registrants

### Night School Resources

Go to [www.aisc.org](http://www.aisc.org) and sign in.



**IN THIS SECTION**

- My Profile
- My Downloads
- My Pending Orders
- My Events
- Order History
- Course History
- Course Resources**

**MyAISC**


**MY PROFILE**  
 Update your contact and address information.  
[EDIT PROFILE](#)

**MY PURCHASED DOWNLOADS**  
 Access articles and documents that you have purchased.  
[VIEW DOWNLOADS](#)

**MY COURSE RESOURCES**  
 View online resources for Night School in a Live Webinar package registrant.  
[VIEW RESOURCES](#)

## 8-Session Registrants

### Night School Resources




[AISC](#) > [MyAISC](#) > [COURSE RESOURCES](#)

#### Course Resources

Event	Start Date
<a href="#">NS 11 8-Session Package Night School 11 - Design of Industrial Buildings</a>	1/6/2017 7:00:00 PM
<a href="#">NS 14 8-Session Package Night School 14 - Fundamentals of Bolting</a>	6/5/2017 7:00:00 PM

## 8-Session Registrants

### Night School Resources



[AISC](#) > [MyAISC](#) > [NIGHT SCHOOL RESOURCES](#) > [NS 13 8-SESSION PACKAGE RESOURCES](#)

#### Night School 13: Design of Industrial Buildings

##### 8-SESSION PACKAGE RESOURCES

Event	Date	Hours	Video	Quiz	Attendance
NS13 - Design Criteria	1/30/2017 7:00:00 PM	<a href="#">Download</a>	<a href="#">View</a>	Pass Period: NS1300N Score: 0	Pending
NS13 - Economic Considerations	2/6/2017 7:00:00 PM	<a href="#">Download</a>	<a href="#">View</a>	Available 02/08/2017 5pm EST	Pending
NS13 - Lateral Load Systems and Details	2/13/2017 7:00:00 PM	<a href="#">Download</a>	<a href="#">View</a>	Available 02/15/2017 5pm EST	Pending
NS13 - Preliminary Design Procedures	2/27/2017 7:00:00 PM	<a href="#">Download</a>	<a href="#">View</a>	Available 03/01/2017 5pm EST	Pending
NS13 - Crane Order Design and Frame Analysis	3/6/2017 7:00:00 PM	<a href="#">Download</a>	<a href="#">View</a>	Available 03/08/2017 5pm EST	Pending
NS13 - Frame Member and Connection Design	3/13/2017 7:00:00 PM	<a href="#">Download</a>	<a href="#">View</a>	Available 03/15/2017 5pm EST	Pending
NS13 - Transfer Crane Girders to Composite Box Beams	3/27/2017 7:00:00 PM	<a href="#">Download</a>	<a href="#">View</a>	Available 03/29/2017 5pm EST	Pending
NS13 - Building Envelope and Bracing Design	4/3/2017 7:00:00 PM	<a href="#">Download</a>	<a href="#">View</a>	Available 04/05/2017 5pm EST	Pending

## 8-Session Registrants

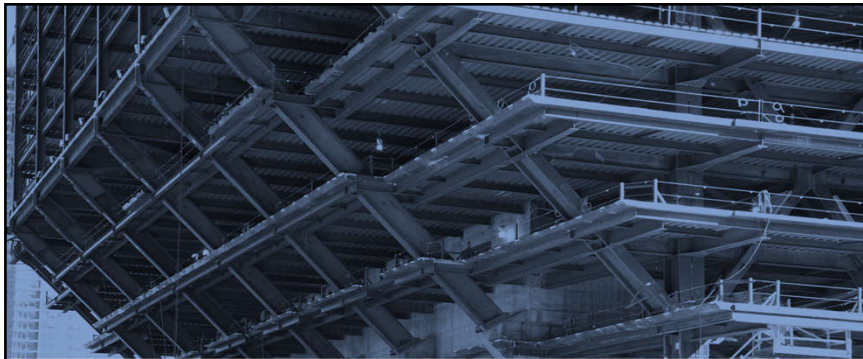
### Night School Resources

- Weekly “quiz and recording” email.
- Weekly updates of the master quiz and attendance record, found at [www.aisc.org/nightschool27](http://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



**AISC** | Thank you

