

There's always a solution in steel.

AISC Live Webinars

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

Thank you.

Need Help?
Call ReadyTalk Support: 800.843.9166



AISC Live Webinars

Today's audio will be broadcast through the internet.

Alternatively, to hear the audio through the phone, dial:

(866) 519-2796

Passcode: 638011



There's always a solution in steel!



AISC Live Webinars

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

As a reminder, all lines have been muted. Please type any questions or comments through the Chat feature on the left portion of your screen.

Today's audio will be broadcast through the internet.
Alternatively, to hear the audio through the phone, dial:

(866) 519-2796

Passcode: 638011



There's always a solution in steel!

AISC Live Webinars

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 is registered with 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.



There's always a solution in steel!

AISC Live Webinars

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 2017

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.



There's always a solution in steel!

Course Description

Session L1: Steel Bridge Fabrication

October 12, 2017

This session will address the fabrication process of steel plate and box girders. All steps will be presented, from cutting the plates to size and fitting and welding the plates together to form the girders, to the fitting of the field splice connections. The impact of design on fabrication costs will be discussed, and recommendations will be made on design features from a fabrication standpoint. The welding processes used to join the plates including submerged arc weld, flux cored electrode, and narrow gap electroslag welding will be described. The inspection techniques and requirements used to ensure the quality of the welds will be presented. The session will conclude with a glimpse into the future of fabrication showing the virtual assembly process.



There's always a solution in steel!



Learning Objectives

- Become familiar with the fabrication process of steel plate and box girders.
- Gain an understanding of how design impacts fabrication costs and become familiar with constructible design recommendations.
- Become familiar with the common weld processes for joining plates including submerged arc weld, flux cored electrode, and narrow gap electroslag welding.
- Gain an understanding of weld inspection techniques and requirements used to ensure quality.



There's always a solution in steel!

There's always a solution in steel.

Introduction to Steel Bridge Design

Session L1: Steel Bridge Fabrication



Presented by
Karl H. Frank
Consultant
Austin, Texas



Introduction to Steel Bridge Design

- R1: Introduction to Bridge Engineering
- R2: Introduction and History of AASHTO LRFD Bridge Design Specifications
- R3: Steel Material Properties
- R4: Loads and Analysis

- **L1: Steel Bridge Fabrication**
- L2: Plate Girder Design and Stability
- L3: Effects of Curvature and Skew
- L4: Fatigue and Fracture Design



9

Outline

- Plate Girder Design
- Building a Bridge Girder
 - How we do it now
 - How we want to do it in the future






10



Modular Design

Crane and Wrenches Required for Assembly
No Post Tensioning Required






 

11

Plate Girder

3 plates: 2 flanges plus a web



12

Strong and Ductile



13

Plate Girder Design

- No List of Properties Like a Rolled Beam
- Designer Starts with a Clean Sheet of Paper
 - Develop Custom Designed Section
 - Typically Deeper and Thinner Webs Than Rolled Beam
 - Deeper Sections- Stronger and Stiffer
 - Choice of Steel Strengths
 - Not Symmetric, Composite Design-Deck Used as Compression Flange



14

Girder Dimension Requirements Positive Moment

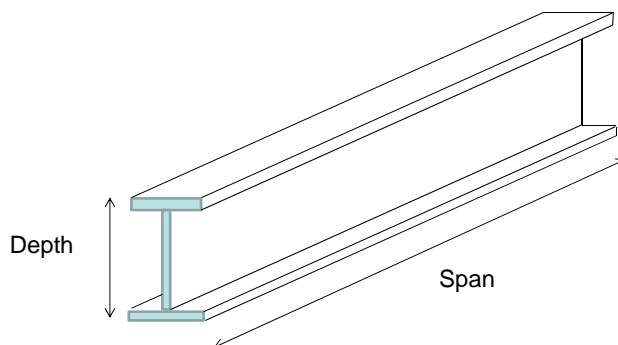
- **Top Compression Flange**
 - Non Composite Construction and Deck Casting Controls Design
 - Limit States
 - Lateral Torsional Buckling (flange lateral stiffness)
 - Yielding or Local Buckling of Flange ($b/2t_f$)
- **Web**
 - Shear at Pier
 - Web Bend Buckling ($2D_c/t_w$)
- **Bottom Flange- Yielding**



15

Typical Girder Proportions

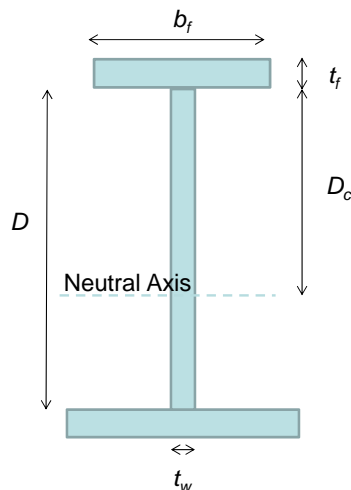
- Span/Depth=25-30



16

Typical Girder Proportions

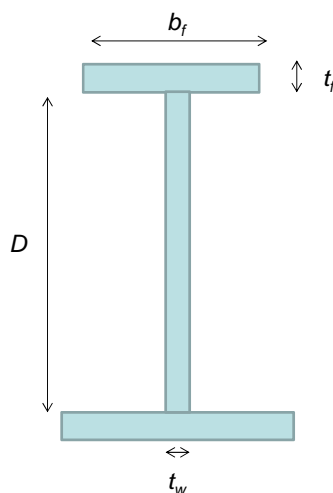
- $\frac{D}{t_w} \leq 120$
- $\frac{2D_c}{t_w} \leq 137$



17

Typical Girder Proportions

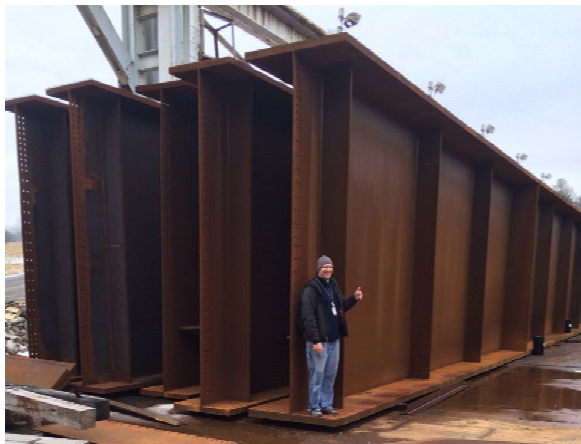
- **Compression Flange**
 - $\frac{1}{4} > \frac{b_f}{D} > \frac{1}{6}$
 - $\frac{b_f}{2t_f} \leq 12$ and < 9.2 for 50 ksi
 - $A_{f\ top} \approx \frac{2}{3} A_{f\ bottom}$



18

Typical Girder Proportions

- Transverse Stiffeners only as Required



19

Typical Girder Proportions

200 ft. Span

- Span/Depth=25-30

- $\frac{D}{t_w} \leq 120$ $\frac{2D_c}{t_w} \leq 137$

- Compression Flange

- $\frac{1}{4} > \frac{b_f}{D} > \frac{1}{6}$

- $\frac{b_f}{2t_f} \leq 12$ and < 9.2 for 50 ksi

$$D = 8 \text{ ft} \quad \frac{S}{D} \leq 25$$

$$t_w = 7/8 \text{ in.} \quad \frac{D}{t_w} = 110 \leq 120$$

$$b_f = 24 \text{ in.} \quad \frac{b_f}{D} \leq 0.25$$

$$t_f = 1.375 \text{ in.} \quad \frac{b_f}{2t_f} = 8.7$$



20

Cross Sectional Limits

AASHTO LRFD Specifications

6.10.2.2—Flange Proportions

Compression and tension flanges shall be proportioned such that:

$$\frac{b_f}{2t_f} \leq 12.0, \quad \text{Too slender, 9.2 for Grade 50} \quad (6.10.2.2-1)$$

$$b_f \geq D/6, \quad \text{Too slender, } D/4 \text{ better choice} \quad (6.10.2.2-2)$$

$$t_f \geq 1.1t_w, \quad \text{Should be 1.5 to 2 x web thickness} \quad (6.10.2.2-3)$$

and:

$$0.1 \leq \frac{I_{yc}}{I_{yt}} \leq 10 \quad \text{Important limit, eliminates "T" like sections} \quad (6.10.2.2-4)$$



21

3/8 in. Top Flange-1/2 in. Web

$$\frac{b_f}{2t_f} = \frac{16 \text{ in.}}{2 \times \frac{3}{8} \text{ in.}} = 21.3 > 12.0 \Rightarrow \text{NO GOOD}$$



22

Flange Thickness Transition



23

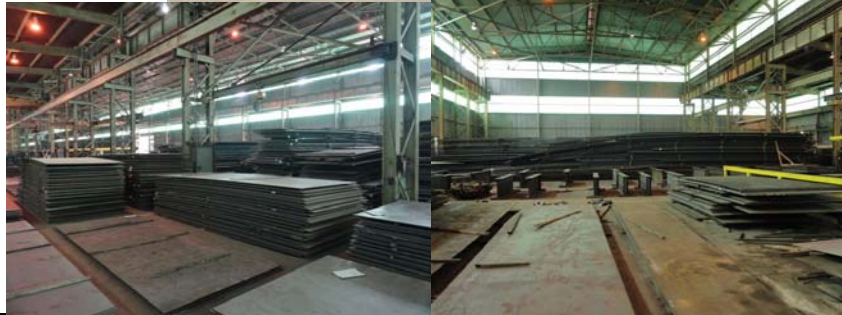
Building a Girder



24

Raw Material

**Longest
Plate
80 feet
Limited by
Railcar**



25

Mill Lead Times

A572 gr. 50 & A588 = 4 to 8 weeks

HPS 70W = 4 to 10 weeks

Rolled beams = 3 to 8 weeks

Material Not Stocked by Fabricator



26

Raw Material



27

First Steps

- Splice Flange and Web Plates
 - Full Penetration Weld
 - Nest Flange Plates if Possible
- Trim Mill Edges
- Rip Flange Plates to Width From Wide Plates (Cut Curve Small Radius)
- Cut Curve Webs for Desired Camber



28

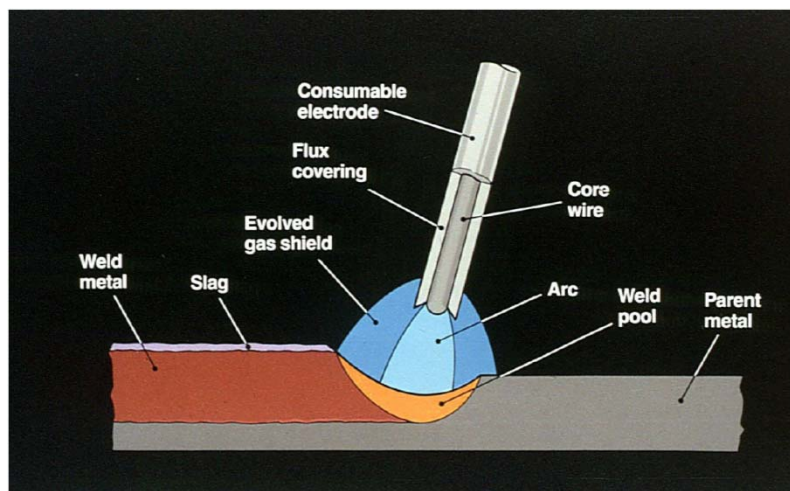
Welding

- Fusion Welding
 - Consumable Electrode and Base Metal Melted to Form Weld
 - Arc or Resistance Heating in the Flux Provides the Heat to Melt the Base Metal
 - Shielding Gas use to Protect the Molten Metal and Spray from Electrode Melting from the Atmosphere
 - Flux to Clean Molten Weld Pool and also used to Produce Shielding Gas in SMAW
- Base Metal Chemistry Must Be Controlled



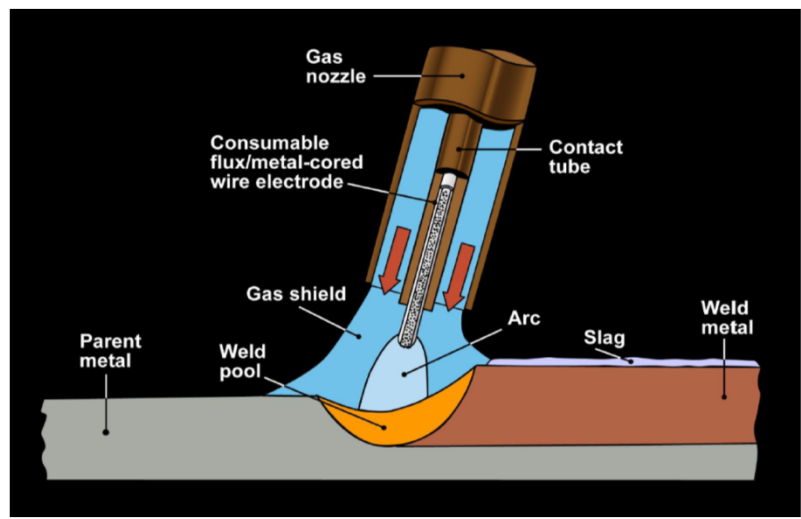
29

SMAW (Shielded Metal Arc Welding) Stick Welding



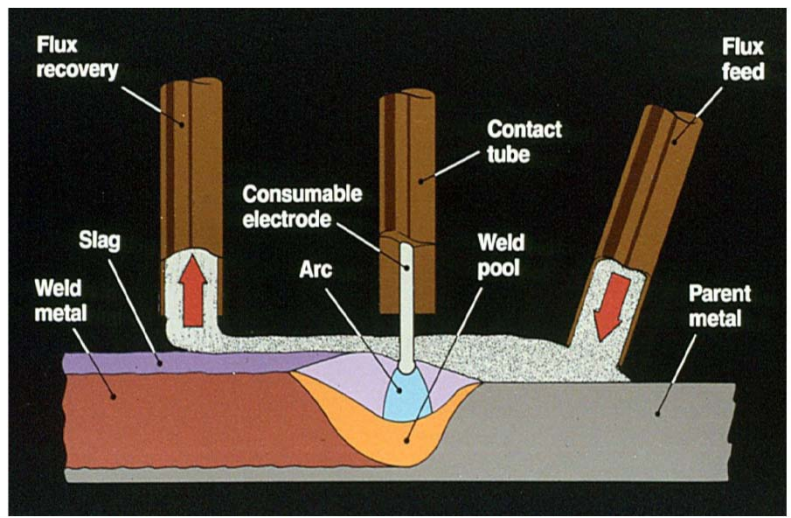
30

FCAW (Flux Cored Arc Welding)



31

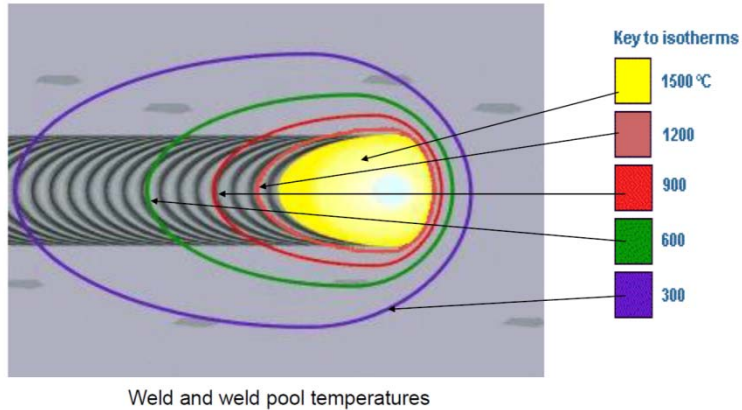
SAW (Submerged Arc Welding)



32

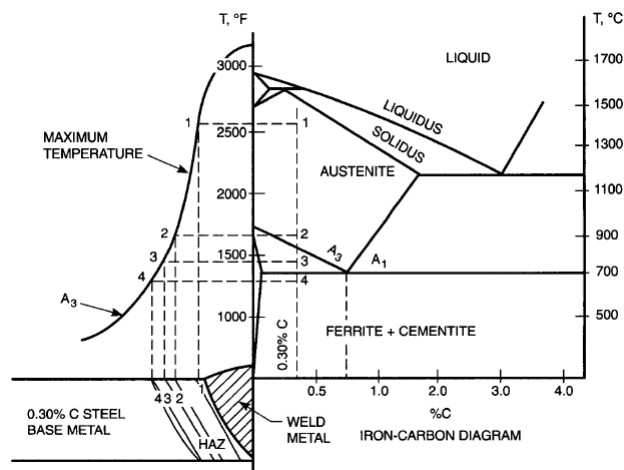
Cooling Weld by Conduction of Heat Into Plate

Thicker Plates Provide Larger Heat Sink Resulting in More Rapid Cooling



33

What Happens to Base Metal During Welding

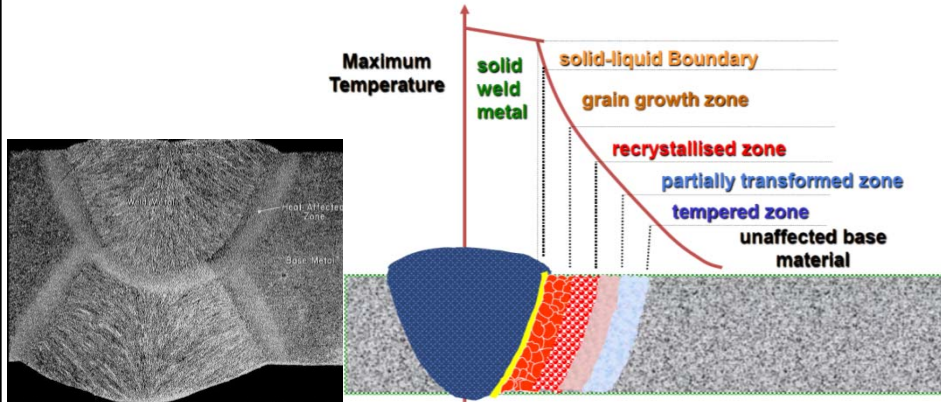


Critical That Material Heated to Austenite Temperature is Cooled Slowly Enough to Not Form Martensite



34

Generation of Heat Affected Zone (HAZ)



35

Preheat and Interpass Temperatures AWS D1.5 Chap. 4

- Preheat- Temperature before welding
- Interpass-Temperature before starting next weld pass

Steel	To 3/4 in. Incl.	3/4 to 1- 1/2 in. Incl.	1- 1/2 to 2- 1/2 in. Incl.	Over 2- 1/2 in.
A709 Grade 36,50,50S,50W & HPS 50W	≥50 °F	≥70 °F	≥150 °F	≥225 °F
A709 Grade HPS 70W	50 to 450 °F	125 to 450 °F	175 to 450 °F	225 to 450 °F
A709 Grade HPS 100W	50 to 400 °F	125 to 400 °F	175 to 450 °F	225 to 450 °F

Higher Preheats Slow Cooling Rate



36

WPS (Welding Procedure Specification) Qualification

- Purpose- Weld Metal Meets Mechanical Properties
 - Strength
 - Ductility
 - Notch Toughness Requirements
 - Done by Welding a Test Plate
- Generates a Procedure Qualification Record (PQR)
 - Documents Welding Variables
 - Documents Physical Test Results
- Exempt (Prequalified)
 - SMAW Welds (except E100 and E110)
 - Tack Welds Remelted by Subsequent SAW Welds
 - Welds of Ancillary Products



37

Heat Input

- Basis of Qualification Tests Limits
- Heat Input $\left(\frac{kJ}{in}\right) = \frac{\text{Amperage} \times \text{Voltage} \times 0.06}{\text{Travel Speed (in. per minute)}}$
- Each pass with +/- 10% of overall average
 - Table 5.10 Gives Min. and Max. Amperage for each Process and Electrode Diameter



38

Qualification Options

- 5.12.1 Maximum Heat Input Qualification
 - Production Welds Heat Input <100% Qualification Test
 - Production Weld Heat Input > 60% Qualification Test
- 5.12.2 Maximum-Minimum Heat Input Qualification (Two Test Welds Required)
 - Production Heat Input Must be Between the Max. and Min. of Test Welds
- 5.12.4 Production Procedure Qualification
 - Multiple Pass SAW with Active Flux
 - Non Standard Joint Details
 - Matching Electrodes for HPS100W
- Most Procedures are Qualified Using 5.12.1



39

PREFERRED
DIRECTION OF ROLLING

AWS D1.5

TEST PLATE A

650 [25] MIN. SAW, FCAW, GMAW
ESW, ESW

230 [9] MIN. 230 [9] MIN.

10 [3/8] MIN.
20 [3/4] MAX.

75 [3] MIN.

T (SEE 5.6)

ALL DIMENSIONS IN mm [in]

WPS Qualification Test Plate

Specimen	Number of Specimens
CVN	5 or 8 for NGSW
Side Bend	4
Reduced Section Transverse Tensile	2
All Weld Metal Tensile	1
Macro Etch	2
RT	RT+UT for NGSW

For SAW
 T= 1 in.
 $\alpha = 20^\circ$
 R= 5/8 in.



40

Test Requirements

Base Metal	Minimum Yield Strength (ksi)	Minimum Tensile Strength (ksi)	Minimum Elongation	CVN Zone I and II (ft-lbs)	CVN Zone III (ft-lbs)	Fracture Critical
Grade 36	45	60	22	20 @ 0°F	20 @ -20°F	25 @ -20°F
Grade 50, 50S	50	65	22	20 @ 0°F	20 @ -20°F	25 @ -20°F
Grade 50W Grade HPS 50W	50	70	22	20 @ 0°F	20 @ -20°F	25 @ -20°F
Grade HPS 70W	70	90	17	25 @ -10°F	25 @ -20°F	30 @ -20°F
Grade HPS 100W >2.5 in.	90	100	16	20 @ -40°F	Engr. Approval	35 @ -30°F
Grade HPS 100W ≤2.5 in.	100	110	20	20 @ -40°F	Engr. Approval	35 @ -30°F



AWS D1.5

41

Welding of Components

- Butt Welding of Flanges
 - SAW
 - NGESW
 - Nesting of Girder Flanges
- Welding Web to Flange
 - Plate Girders
 - Box/Tub Girders



42

SAW Weld Preparation Required to Get Access to Bottom of Weld



43

Prepared Plates Tacked Together Ready to Weld



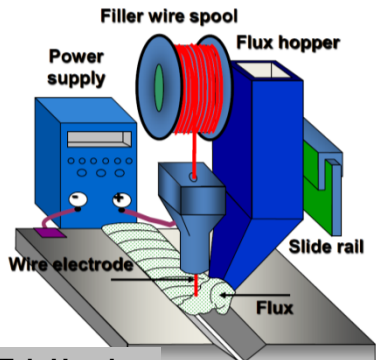
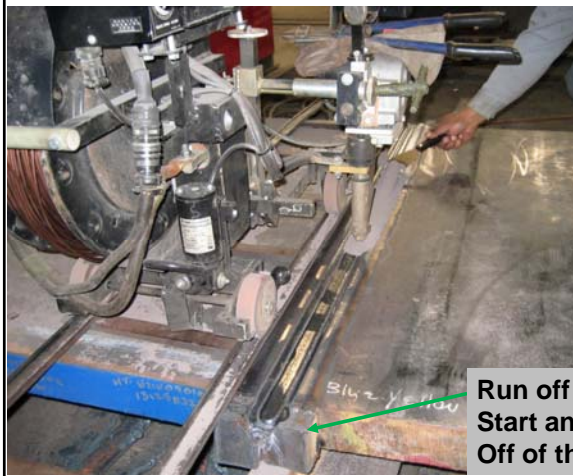
44

Flange Thickness Transition

Note Weld in Thinner Plate at the End of The Transition



Submerged Arc Welding-SAW



Run off Tab Used to Start and Stop Weld Off of the Plate



Close Up of Arc Submerged in the Flux
Multiple Pass Welds
Number of Passes Dependent Upon Plate Thickness



47

Back Gouge Weld Root and Clean By Grinding
Weld Back Side



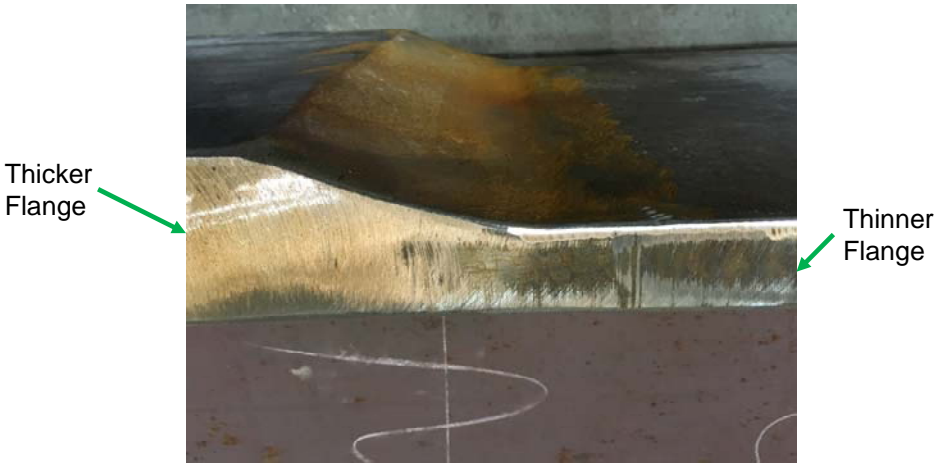
48

Finished Weld Ground Flush and Ready for Inspection by Radiography and Ultrasonics



49

Finished Flange Thickness Transition Butt Weld All Surfaces Ground Smooth



50

A New Way to Weld Narrow Gap Electroslag Welding



51

Narrow Gap Electroslag Welding NGEW

- Developed in an Extensive Research Study at the Oregon Graduate Institute by Wood and Turpin
- Based Upon Results of the Research, FHWA Lifted Moratorium March 2000
- Included in AWS D1.5 (2010)



52

Advantages of NSW for Flange Welds

- Single Pass Vertical Weld-No turning of plate and no back gouging
- Fast- Approximately 5 to 10 increase in productivity (*2.5 to 1.5 in/minute, 3 foot long weld in about an hour*)
- Completely Automated Equipment- Computer controlled wire and flux feed as well as voltage control



53

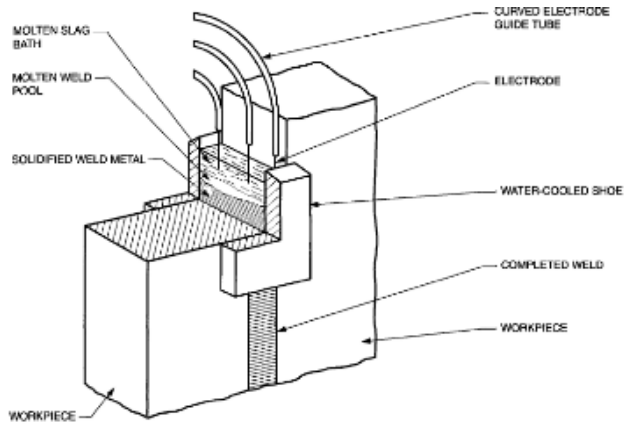
Characteristics

- Single Pass Vertical Up Weld
- Molten Weld Metal Contained by Water Cooled Copper Shoes
- Narrow Gap- 3/4 +/- 1/8 inch with square plate edge preparation
- Consumable Guide Tube to Guide Welding Wire
- Submerged Arc-Molten Flux Pool on Top of Weld Metal



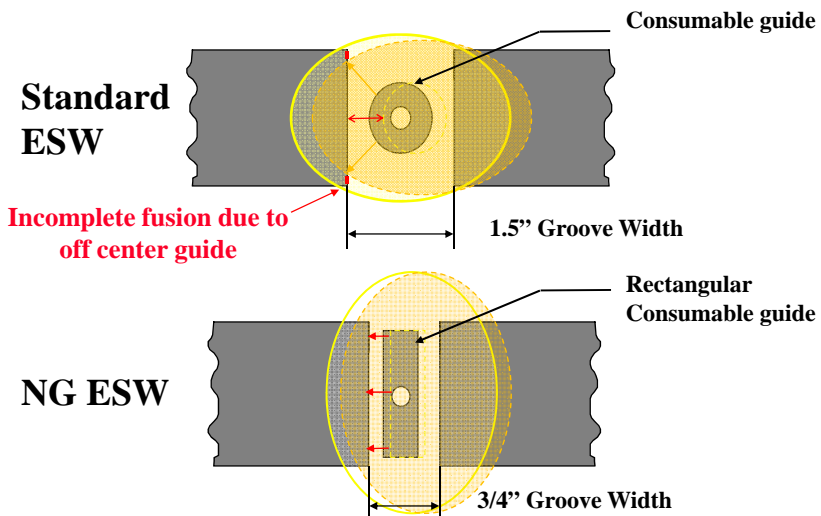
54

Schematic of ESW



55

Narrow Gap Reduces Susceptibility to Incomplete Fusion



56

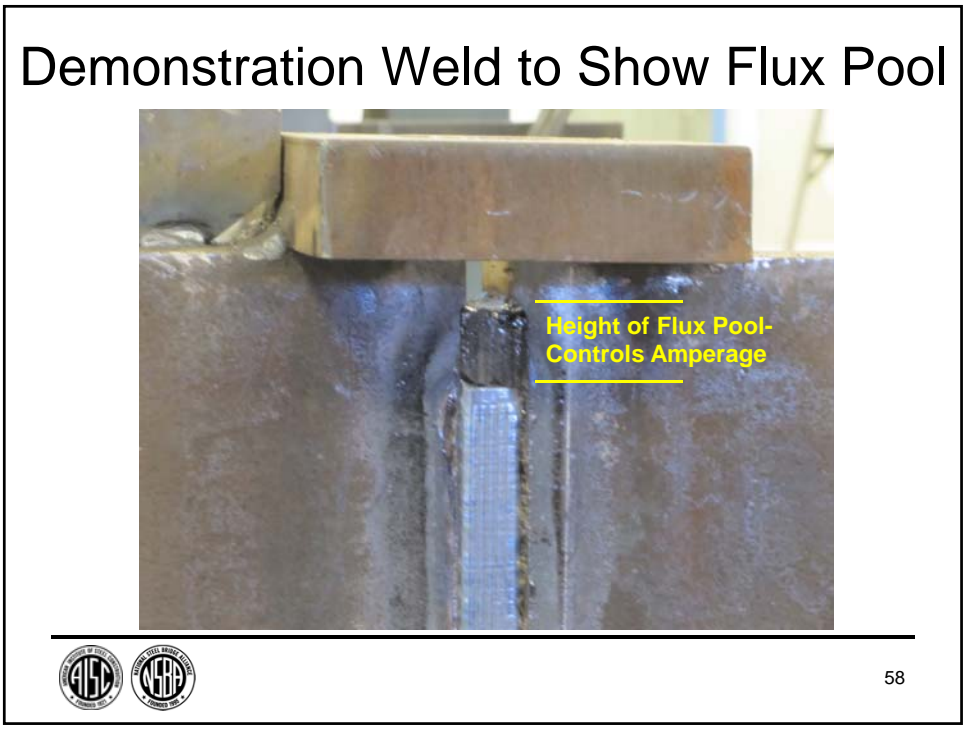
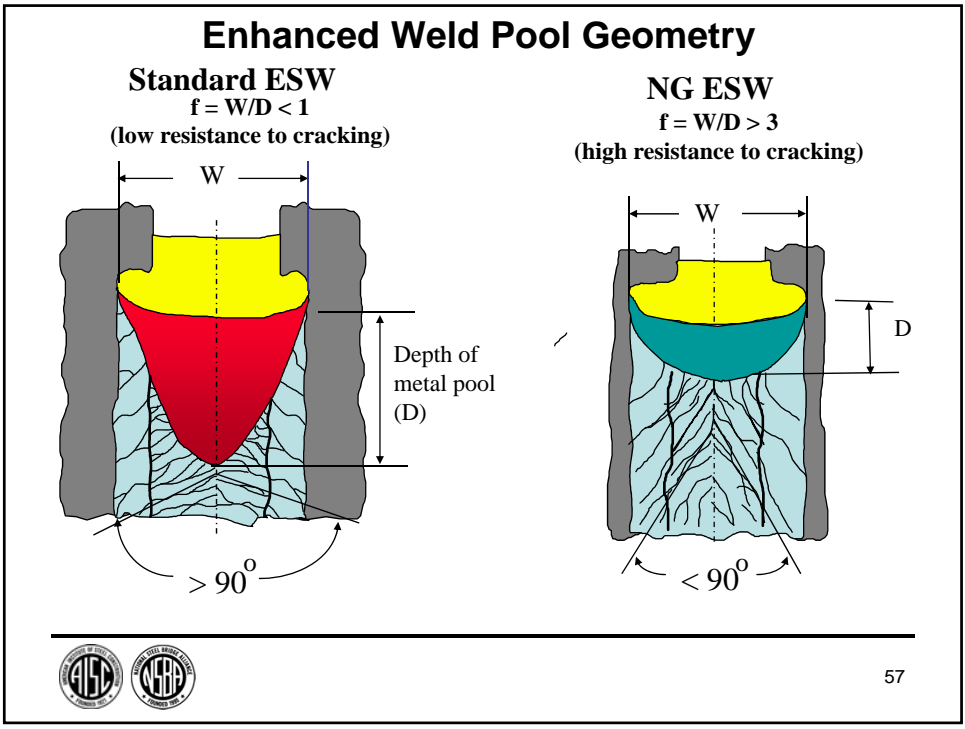


Plate Setup to Weld



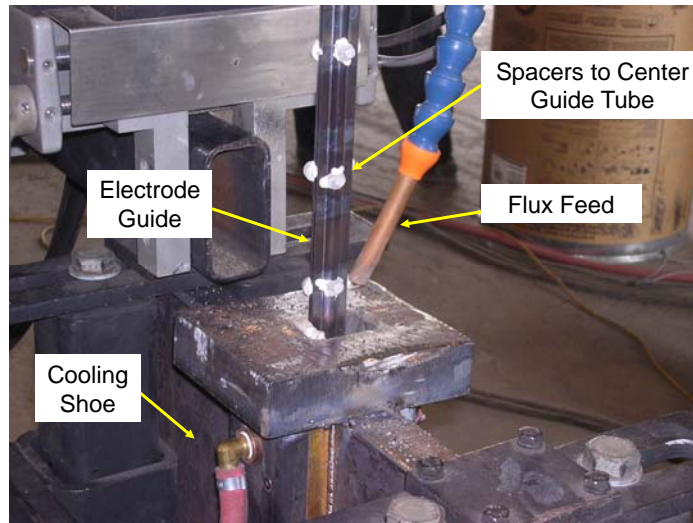
- Square Preparation
- Remove Mill Scale From Fusion Zone
- Sump at Bottom to Start Weld
- No Beveling or Turning of Plate
- Cast Weld Vertically in One Pass

Starting Sump



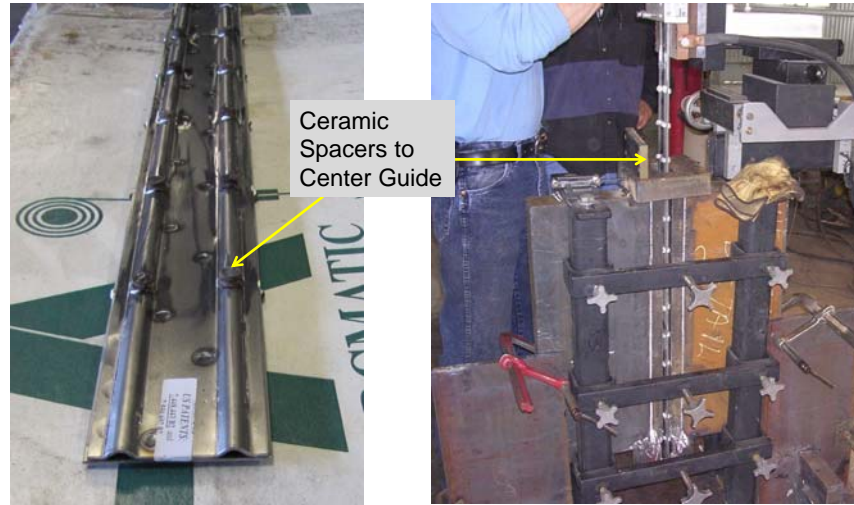
59

Final Preparation



60

Consumable Guide and Spacers



61

Plate Ready to Weld

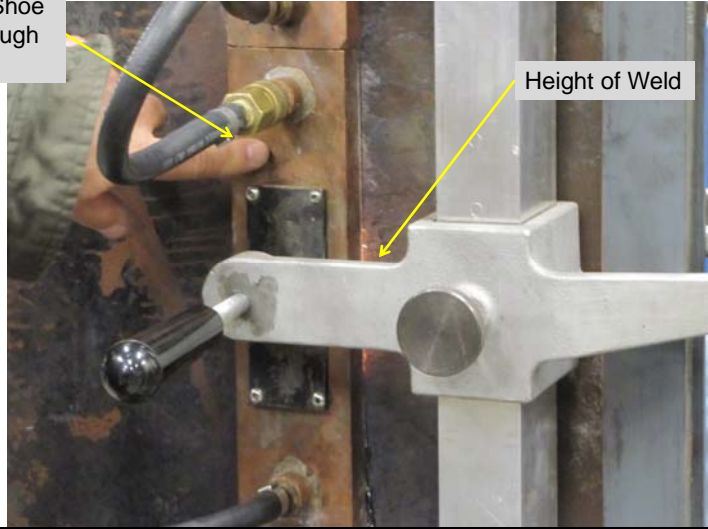


- Water Cooled Copper Shoes to Contain Molten Weld Metal
 - Water Temperature and Flow Controlled to Produce Desired Cooling Rate
- Automatic Process
 - Computer Controlled Wire Feed
 - Computer Controlled Flux Addition




62

The Weld in Progress




Cooling Shoe Cool Enough to Touch

Height of Weld




63

End of Weld



- Guide Consumed
- Note Molten Metal in Run Off Pad



64

Completed Weld

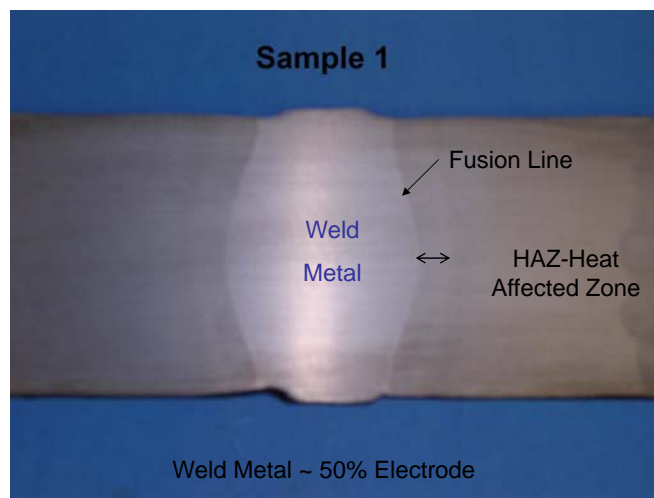


Welding Time
Approximately-10
to 20% of multiple
pass weld
*Minutes versus
Hours*



65

Weld Cross Section



66

Efficient Flange Sizing

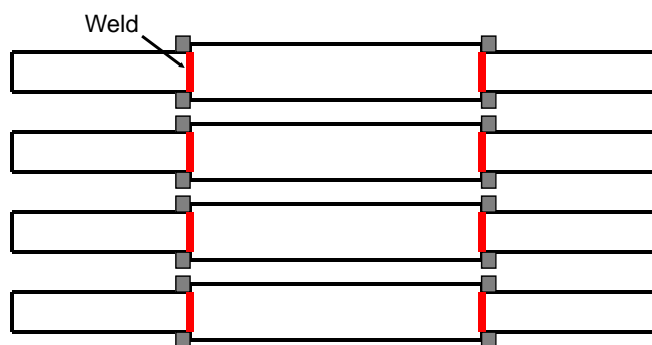
- Change Flange Width at Field Splice to Allow Welds to Be Slabbed
- Align Flange Thicknesses Transitions to Allow Slabbing
- Minimize the Number of Plate Thicknesses (plates come in 12 foot width and 80 foot lengths)
- Design it Like You are Going to Build it.



67

The Costly Method of Changing Flange Size by Changing Width

Weld and grind 8 splices





68

A Better Way- Change Flange Thickness

Bevel (4) and taper (2) plate edges

Bevel Taper

CHANGE THICKNESS





69

- Flange Sizing - change thickness

Weld and grind 2 splices

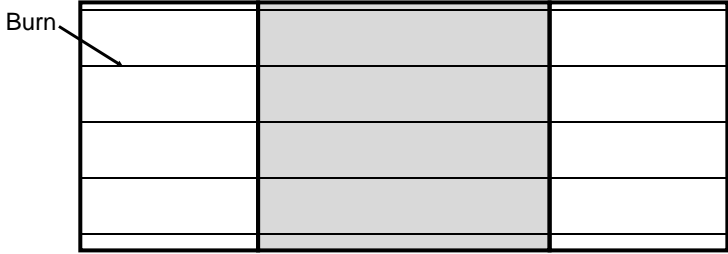
Weld



70

- Flange Sizing - change thickness

Burn 4 flanges from 1 assembly



- Flange Sizing - change thickness

4 flanges from 1 assembly



Good Practice

- Flange Sizing
 - Width transitions increase labor for flange assemblies up to 35%
 - If you must change flange width, do so at bolted field splice (do not clip corners of top flanges)
 - Allow fabricators to eliminate splices within a shipping piece by carrying thicker material through to next designed splice location



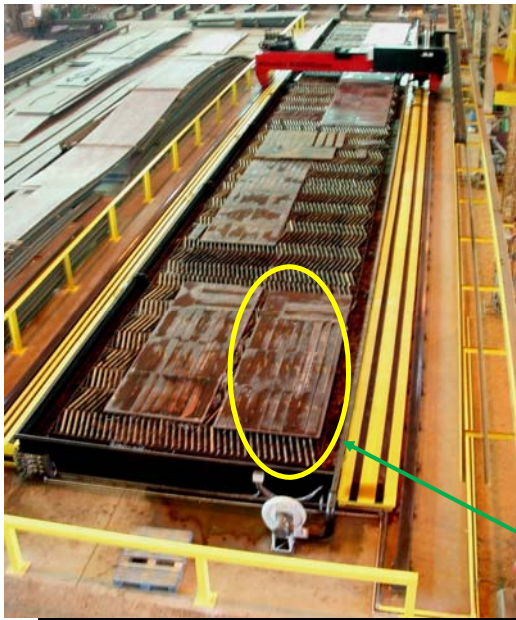
73

Plate Girder Flange Sizing

- Shop butt splices within a shipping piece – when to change area?
 - No more than 2 shop splices
 - Minimum change; 1/8" (to 2 1/2" thick), 1/4"
 - Maximum change; thinner piece at least 1/2 of thicker...
 - ONLY when material cost saved > labor cost spent



74



CNC Cutting and Drilling Equipment


Equipment:
 16.75 ft. x 165 ft. bed

2-48 HP Drill Heads
 12 tool Changer station

Plasma Automated
 Contour
 Bevel Cutting System

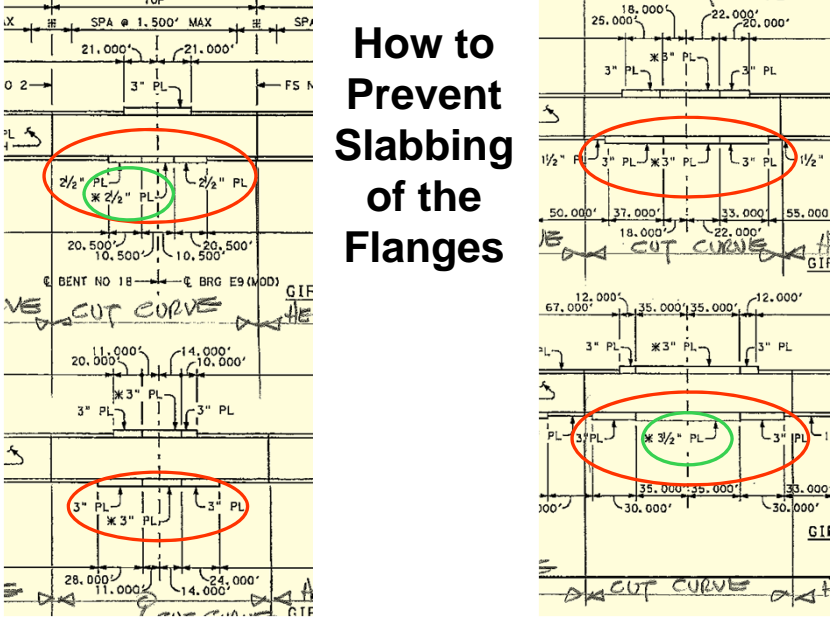

6-Oxy-Fuel Torch
 Stations

Flanges Stripped From
 Wider Plate











75

How to Prevent Slabbing of the Flanges






76

Bottom Flanges at Pier

Girder 1	 2.5 inch Plate	
Girder 2	 3 inch Plate	
Girder 3	 3 inch Plate	
Girder 4	 3 and 3.5 inch Plate	



As Designed-All Flanges
Equal Width Flange
Thickness Depicted
Preferred Design- Vary Flange Width on Girders
Flange Width Depicted
(All Flanges Same Thickness and Length)

77

Attaching the Web to the Flanges

- Plate Girders
- Box Girders

78

Assemble the Plates to Form Girder Camber Cut Into Web

- 1. Flanges
Squeezed to Fit
Cambered Web
- 2. Tack Welds
Used as
Temporary
Connection
Between The
Web and Flange



SAW Welding the Flanges to the Web Tack Welds Consumed by SAW Weld



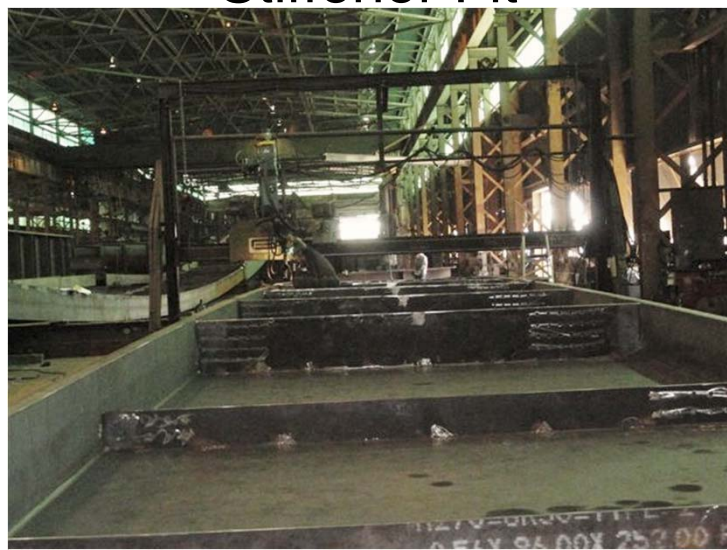
Weld Both Sides at Once



Welding Head and Preheat Torches



Stiffener Fit



81

Stiffener Dart Welding SAW Both Sides Welded at the Same Time



82

Tub (Box) Girders Hand Assembled



Flanges and Connection
Plates Welded to Web

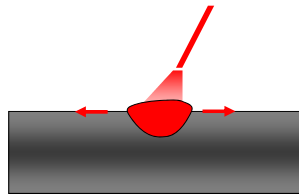


Cross Frames Used to
Control Box Geometry

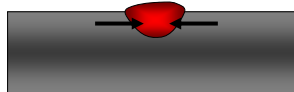


83

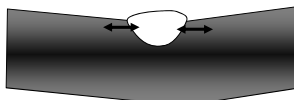
Residual Stress Due to Welding



Thermal expansion due to
heat input from welding



Shrinkage of beads due to
cooling and solidification

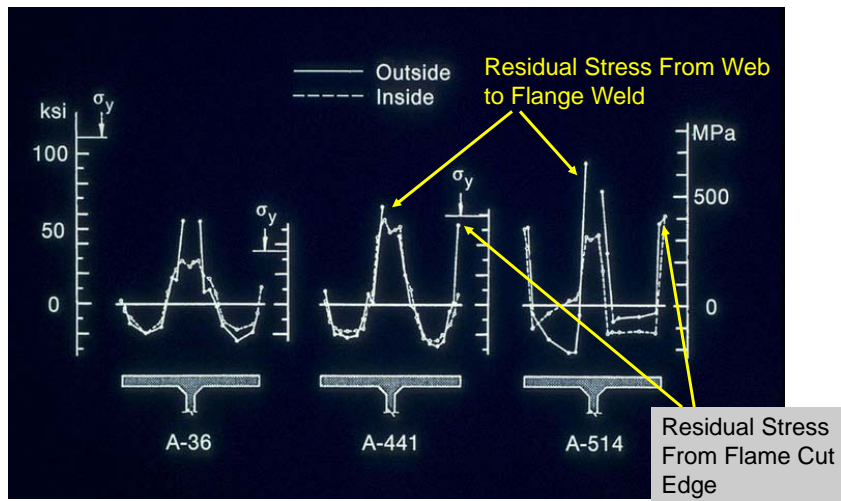


Tensile residual stress in
the vicinity of weld



84

Residual Flange Stresses in Welded Shape



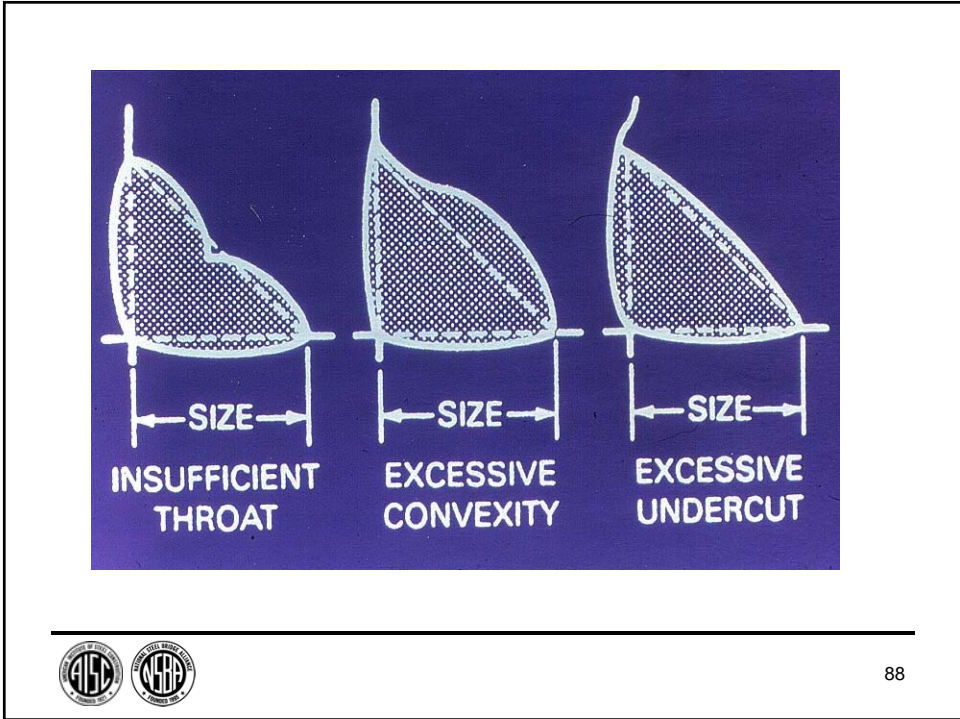
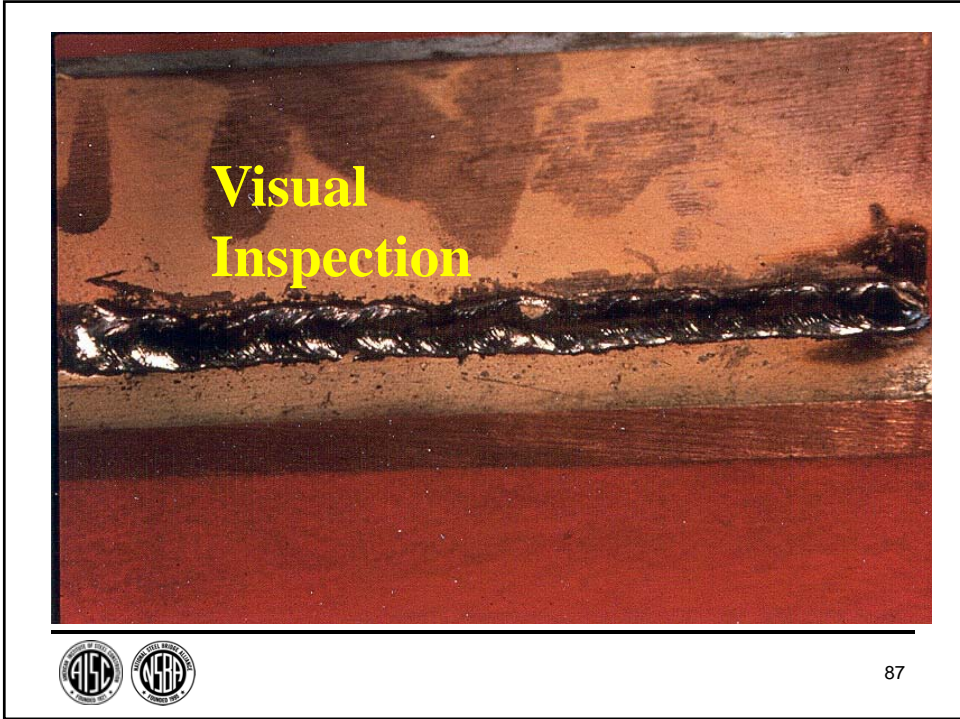
85

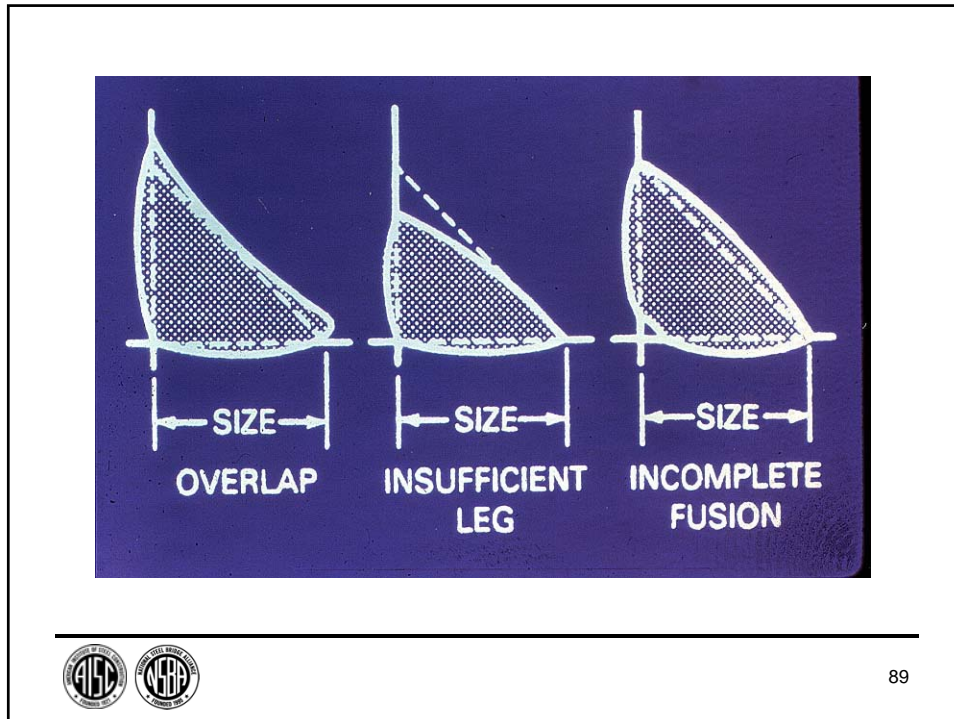
Weld Inspection

- Fillet Welds
 - Visual
 - Magnetic Particle
- Butt Welds
 - Ultrasonic
 - Radiography



86





Magnetic Particle

- Inspection of Web to Flange Fillet Welds and Other Fillet Welds
- Surface or Near Surface Inspections



Magnetic Particle (MT)



Current Carrying Wire

Magnetic Flux In Legs of Yoke

Crack Indication

Magnetic Flux In Part

Fish & Associates





91

Magnetic Particle (MT)


Magnetic Flux Leakage around suitably oriented flaws attract Magnetic Particles

Fish & Associates



92


Magnetic Particle (MT)



Hydrogen Cracking on Lateral Connection Plate Weld

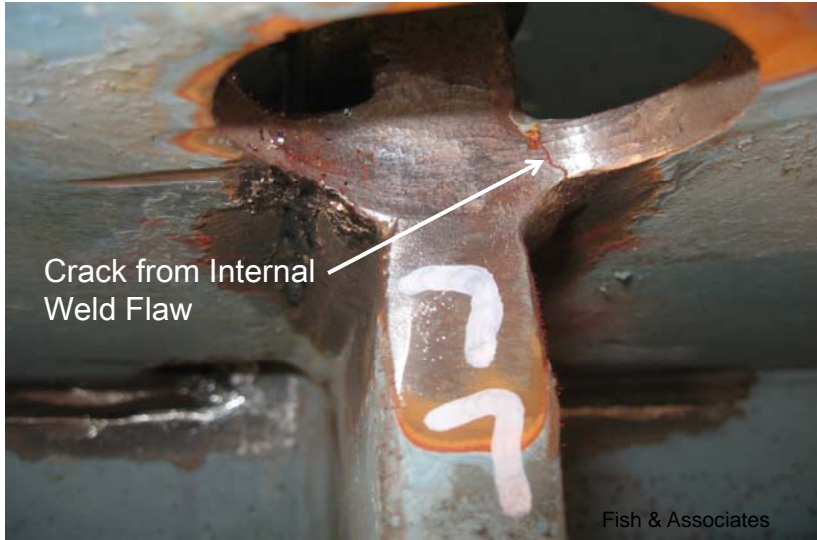
T1 US#1 WP-DV-K

Fish & Associates



93


Magnetic Particle (MT)



Crack from Internal Weld Flaw

77

Fish & Associates



94

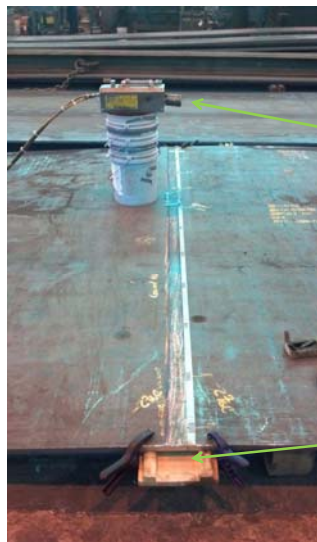
Radiography

- Gamma Ray (Nuclear) Source or X-Ray Source
- Internal Defects
- Very Good for Volumetric Defects
 - Slag
 - Porosity
- Provides a Visual Permanent Record on Film or Digital Record



95

Radiography



Gamma Ray Source

One Shot at a Time-
about 2 feet/per shot

Measures Density
Along Ray Path

Film Holder



96

Radiation Hazard



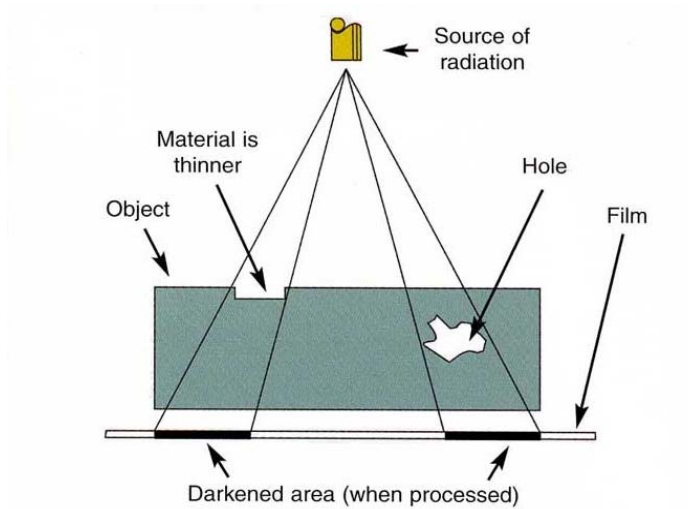
Weld

Inspect at Night
Or Move Plate
Out of Shop



97

Radiography (RT)



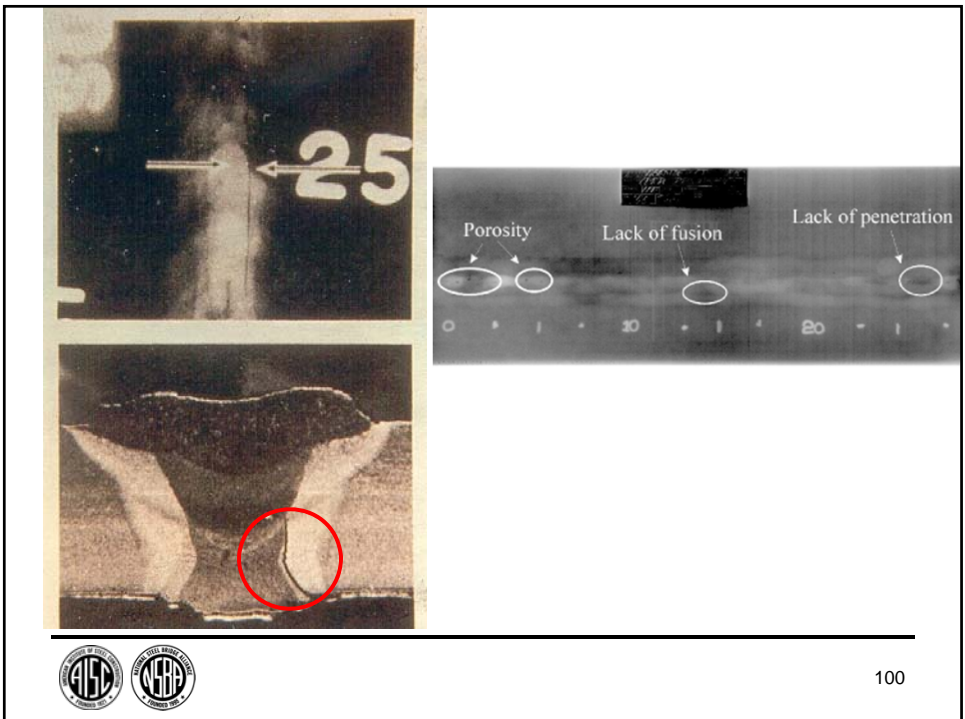
Fish & Associates



98

Approximate Thickness Limitations

Radioisotope	Thickness, in.
Iridium-192	0.5-2.5
Cesium-137	0.5-3.5
Cobalt-60	>3



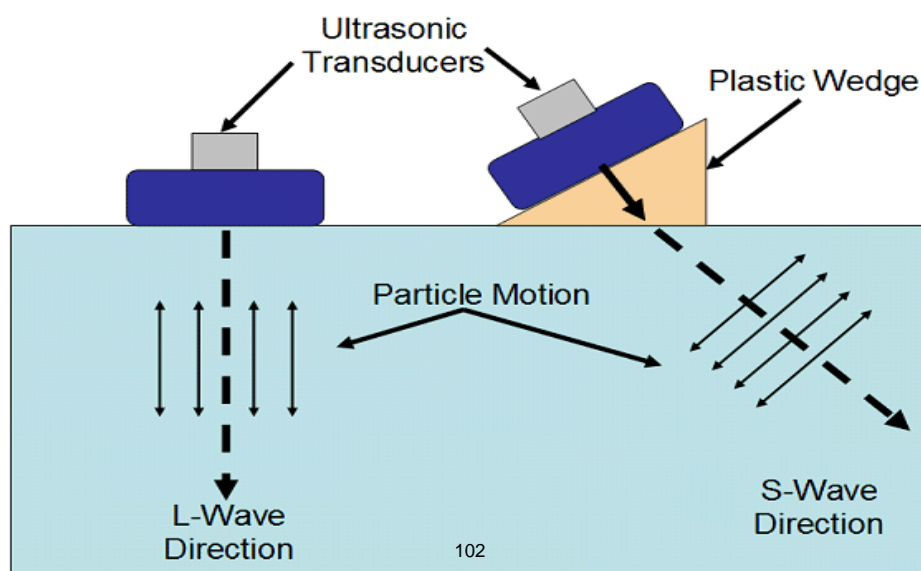
Ultrasonic Inspection

- Similar to Radar and Sonar
- Interrogate Weld Using High Frequency Waves (2-5 MHz)
- Sound Reflected Back to Transducer by Metal Air Interface (Defect)
- Portable and No Radiation Hazard



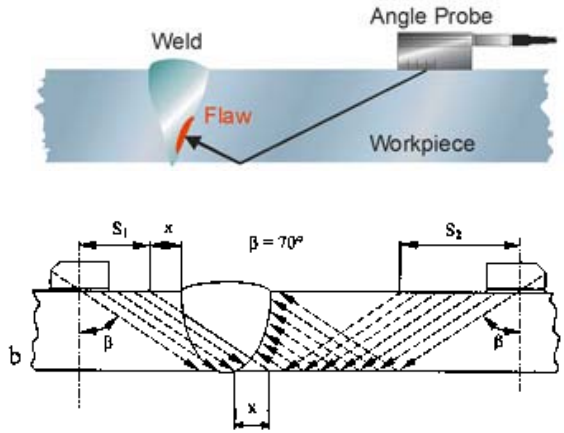
101

Conventional Ultrasonic Testing

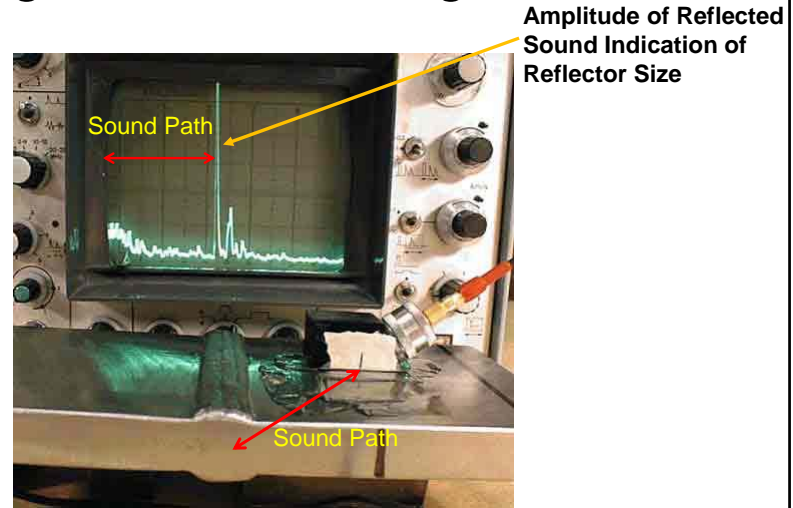


102

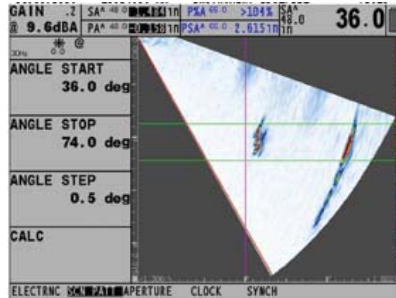
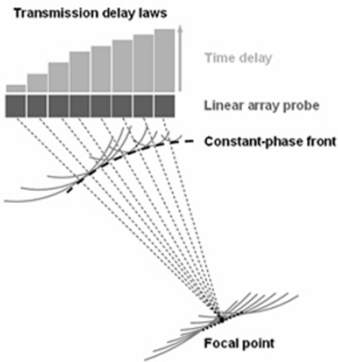
Ultrasonic Inspection



Angle Beam Testing of Weld



A New Technology Phased Array Ultrasonic Inspection

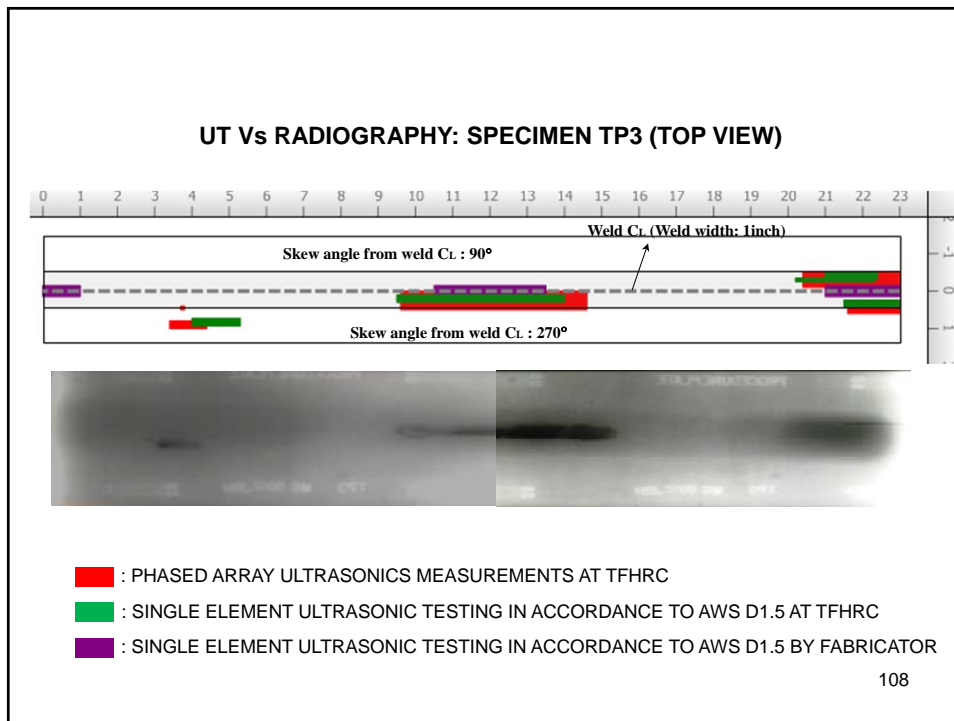
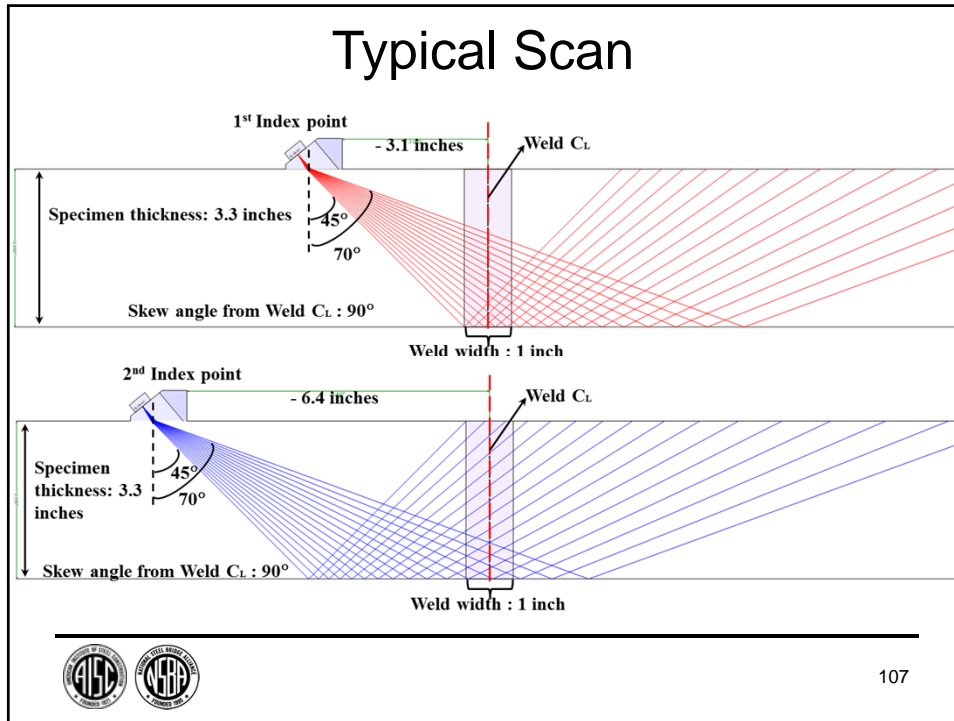


105

Transducer Contains Multiple Elements



106



Ability to Change the View of the Data

The screenshot displays a software interface for ultrasonic testing. At the top, a 3D perspective view of a rectangular scan volume is shown with the text "RT image is equivalent to UT C-Scan" and a red dashed line indicating a "Cross Section of S-scan". Below this are four 2D scan views: "A-Scan" (a line graph with amplitude vs. time), "S-Scan" (a fan-shaped sector scan), "C-Scan" (a color-coded plan view of the scan area), and another "B-Scan" (a depth vs. distance view). The AISC and NSRB logos are visible in the bottom left corner.

Set to Scan Weld

The photograph shows a practical setup for ultrasonic testing on a steel beam. A large ultrasonic flaw detector is connected to a probe that is positioned along a weld on the surface of the steel. A blue keyboard is placed on the table next to the equipment. The AISC and NSRB logos are visible in the bottom left corner.

Scanning Weld



Position
Along Weld
and
Returned
Signal
Recorded
Digitally



111

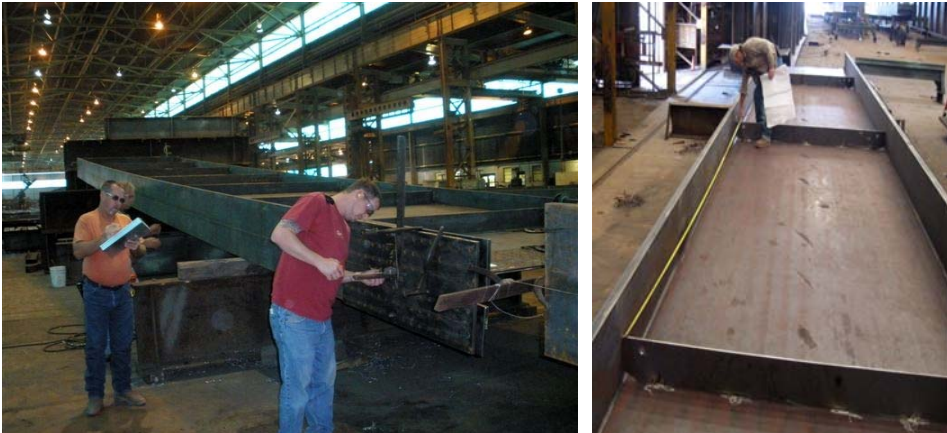
PAUT

- Digital Record of Inspection-not just an OK
- Less Operator Dependent but Requires Experienced User to Set Up Equipment
- Faster Than Conventional UT
- No Radiation Hazard
- Recognized in AWS D1.5



112

In Process Inspection



113

Heat Curved to Match Road Geometry



114

Girder Lay Down to Fit Field Splices



115

Flange Splice Splice Plate Used as Template



116

Web Splice



117

Match Drill Flanges and Webs Using Splice Plate for Template

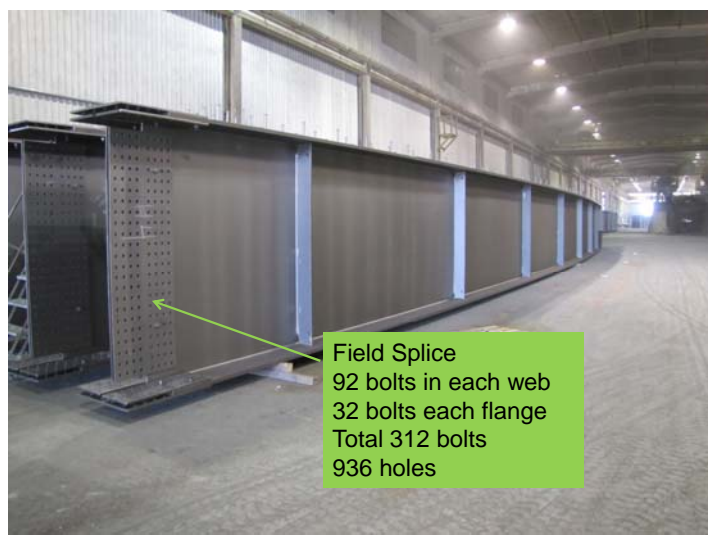


1. Fabricate Splice Plates
2. Lay Down Girders
3. Clamp Plates to Girders
4. Match Drill



118

Completed Girder Ready for Paint



Field Splice
92 bolts in each web
32 bolts each flange
Total 312 bolts
936 holes



119

Tub Girder Ready For Shipping



Field Splice
36 bolts each top flange
80 bolts in each web
85 bolts bottom flange
634 bolts
1,902 holes




120



New Methods (Virtual Assembly) Eliminate Manual Drilling and Shop Assembly

Operations:

1. Cut and Drill Plates on Cutting Table
2. Assemble Girder-Weld Web to Flanges
3. Measure Girders to Determine Exact Hole Locations and Girder Geometry 
4. Input Girder Geometry Into Computer
5. Assemble on Girders Virtually in Computer
6. Output Required Splice Plate Geometry to CNC Equipment



121

First Implementation

- Implemented in Virginia Sponsored Pooled Fund Study
 - Principal Investigator- Paul Fuchs (Fuchs Consulting, Inc.)
 - Tennessee DOT Bridge
 - Girder Fabrication by Hirschfeld Industries



122

Tennessee DOT Bridge Job

830 ft

1A1 6AB1 11B1-1 16B1-2 21BC1 26C1

123

Virtual Assembly Software

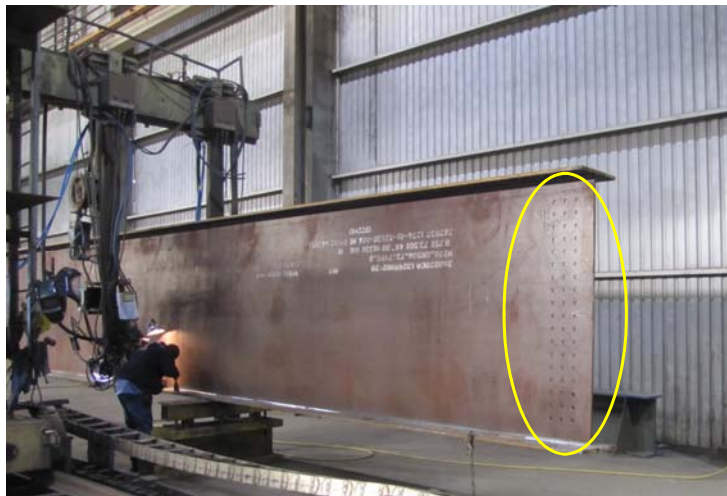
6AB1 11B1-1

Fit-Up Work Line

Output Splice Plate CAD Files

124

Welding of Girder With Splice Holes



125

Predrilled Girders Trimmed and Adjusted for Correct Length and Camber



126

Hole Location Measurement Using Laser



127

The Target-SMR Spherically Mounted Retroreflector



128

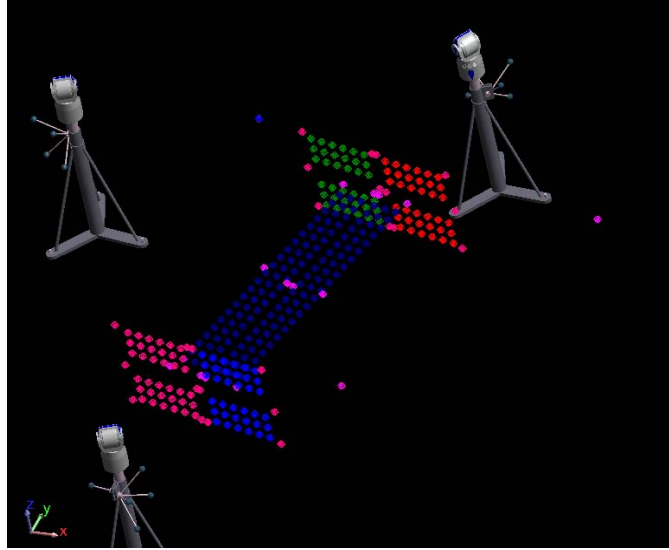


Measuring Connections on Curved Girder



129

Scan Ends of Girders in Lay Down



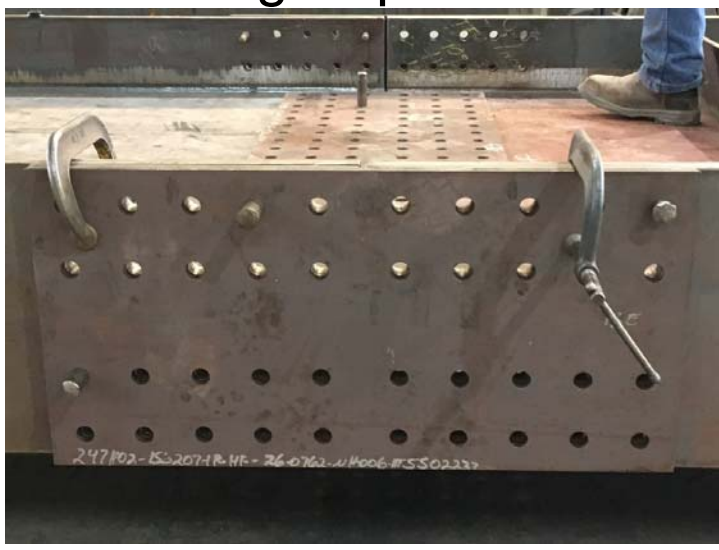
130

Check of Splice Plate Fitup



133

Flange Splice Fit



134

It Fits!



135

State of the Art

- Short Term:
 - Lay down two girders to determine splice geometry
 - Verify splice plate geometry by laser measurement
 - Verify fit up of stack up of splice plates and fillers on computer
- Long Term:
 - Full Virtual Assembly- Elimination of Lay Down of 2 Girders



136

The Savings

- Reduced Material Handling-Drilling and Cutting in One Operation
- Speed- Hole Drilling About 10 times faster (3 seconds a hole)
- No Girder Lay Down Required (Girders can be fabricated in separate shops)



137

Next Steps

- Painting
- Shipping



138

Girder Surface Prepared by Blasting Before Painting



139

Blasted Curved Girder



140



Painting Often 3 Coats



141

Final Inspection



Final inspection is performed first by in-house QC department and lastly by the owner's quality representative



142



Over Road Shipping



143

Too Tall-Ship with Web Flat



144

Super Loads Require Escorts and Special Permits



145

Too Long and Too Tall-Railroad as Last Resort



146

Tappan Zee Girders Loaded On Barge For Shipment From North Carolina to Hudson River Assembly Site



147

Optimal Fabrication Capacities Transportation Limits

Standard

Up to 120" Girders depths with parallel
Flanges

Up to 144" Haunched Girders

Conditional

Up to 168" with State permission for
Girder lay down during shipment



148

Shipping Permits

Annual Permit

12' wide and 75' long or less

Travel only allowed on Non Posted Roads and Bridges –
Specified Routes if over 80 kip

Single trip Permit

15' Wide, 14' Tall , Max. Length 120'

Over 14' tall loads require 2 more days review time

Gross weight Limits

5 Axle 112,000 Lbs

6 Axle 120,000 Lbs

7 Axle 132,000 Lbs

Superload Permit

Over 120' in length

10 day Minimum Review Time

Gross weight > 132 kip requires 3 additional days for Bridge review



149

Summary

- Welding and Weld Inspection
 - D1.5 Controls
 - PQR Demonstrate Ability of Fabricator to Make the Weld
 - WPS is the Procedure Based Upon the PQR
 - Thicker Higher Strength Plates Require Higher Preheats and Greater Welding Skill
 - SAW is the Most Common Welding Process
 - NGESW Gaining Popularity
- Weld Inspection
 - RT is Slow and Dangerous, Film Record
 - UT Portable and Fast, no Record
 - PAUT Ease of UT with Digital Record



150

Summary

- Residual Stresses are Unavoidable and Not Calculated
- Virtual Assembly Field Spices on the Computer
 - Proven Technology Used in Other Industries
 - Provides a Digital Record of Fitup
- Design it Like You are Going to Build It
 - Avoid Short Lengths of Unique Plates
 - Space Welded Splice to Allow Slabbing of Welds
 - Size Field Pieces to Shipping Lengths
 - Ask the Fabricator About Any Questions




151



Good Design of Simple Bridge



152

A New Day Another Bridge







153

Polling Question 1

True or False:

Higher preheat temperatures are used in thicker plates to reduce the amount of energy input into the weld.



154

Polling Question 2

True or False:

Changing flange area by changing the flange width in the field section is preferred.



155

Questions?



156



Individual Webinar Registrants

CEU/PDH Certificates

Within 2 business days...

- You will receive an email on how to report 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!



There's always a solution in steel!

Individual Webinar Registrants

CEU/PDH Certificates

Within 2 business days...

- Reporting site (URL will be provided in the forthcoming email).
- Username: Same as AISC website username.
- Password: Same as AISC website password.



There's always a solution in steel!

8-Session Package Registrants CEU/PDH Certificates

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



There's always a solution in steel!

8-Session Package Registrants Course Resources

1. Log on to your AISC account and go to Course Resources.
<https://www.aisc.org/myaisc/course-resources/>
2. Locate your course.
3. Access handouts, videos, quizzes, quiz scores and attendance records.

AISC > MYAISC > COURSE RESOURCES > STEEL BRIDGE DESIGN

Steel Bridge Design

8-SESSION PACKAGE RESOURCES

Event	Date	Handouts	Video	Quiz	Attendance
R1: Introduction To Bridge Engineering	N/A	Handouts	View Passcode: R2N5141	Pass Score: 80	N/A
R2: Introduction and History of AASHTO Bridge Design	N/A	Handouts	Available 9/11/2017 5:00 PM EDT	Available 9/11/2017 5:00 PM EDT	N/A
R3: Steel Material Properties	N/A	Handouts	Available 9/11/2017 5:00 PM EDT	Available 9/11/2017 5:00 PM EDT	N/A
R4: Loads and Analysis	N/A	Handouts	Available 9/11/2017 5:00 PM EDT	Available 9/11/2017 5:00 PM EDT	N/A
L1: Steel Bridge Fabrication	Oct 12 2017 1:30PM EDT	Handouts	Available 10/14/2017 5:00PM EDT	Available 10/14/2017 5:00PM EDT	Pending
L2: Plate Girder Design and Stability	Oct 19 2017 1:30PM EDT	Handouts	Available 10/21/2017 5:00PM EDT	Available 10/21/2017 5:00PM EDT	Pending
L3: Effects of Curvature and Skew	Oct 26 2017 1:30PM EDT	Handouts	Available 10/28/2017 5:00PM EDT	Available 10/28/2017 5:00PM EDT	Pending
L4: Fatigue and Fracture	Nov 2 2017 1:30PM EDT	Handouts	Available 11/04/2017 5:00PM EDT	Available 11/04/2017 5:00PM EDT	Pending
Intro To Steel Bridge Design - Final Exam	Nov 23 2017 8:00AM EST			Available 11/25/2017 5:00PM EST	



There's always a solution in steel!



8-Session Package Registrants Videos and Quizzes

Videos

- For Sessions R1 – R4, find access to recordings starting September 11. Recording access expires on November 23.
- For Sessions L1 – L4, find access to recordings within two days after the live air date. Recording access expires three weeks after the live session.

Quizzes

- For Sessions R1 – R4, find access to quizzes starting September 11. Quizzes are due on November 23.
- For Sessions L1 – L4, find access to quizzes within two days after the live air date. Quizzes are due three weeks after the live session.
- A final exam will also be given.
- Quiz scores are displayed in the Course Resources table.



There's always a solution in steel!

8-Session Package Registrants Course Credit

Attendance and PDH Certificates

- For Sessions R1 – R4, you must pass the quiz to receive credit for the session.
- For Sessions L1 – L4, you have two options to receive credit for the session.
 - Option 1: Watch the session live. Credit for live attendance will be displayed in the Course Resources table within two days of the session.
 - Option 2: Watch the recording and pass the quiz.

EEU Certificates – Certificate of Completion

- In addition to PDH certificates earned for each individual session, an EEU (Equivalent Education Unit) certificate of completion will be issued for participants who complete the full course. Participants must pass at least 7 of 8 quizzes and the final exam to earn the EEU.

Distribution of Certificates

- All certificates (PDH and EEU) will be issued after the final session. Only the registrant will receive certificates for the course.



There's always a solution in steel!

There's always a solution in steel.

Thank You

Please give us your feedback!
Survey at conclusion of webinar.

