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Today's AISC Live Webinar

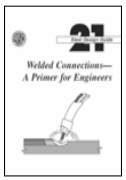
Welding - Special Applications

written and presented by

Duane K. Miller, Sc. D., P.E.
Manager, Engineering Services,
The Lincoln Electric Company,
Cleveland, OH.

4

Listen to the Steel!

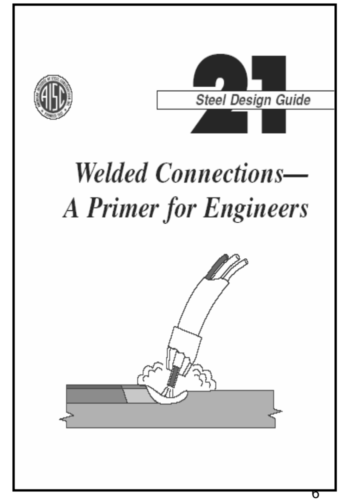


Special Welding Applications

5

Chapter 12

Special Welding Applications



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Special Welding Applications

- Extending Anchor Rod
- Welding Anchor Rod to Base Plates
- Welding on Coated Steels
- Welding Heavy Sections
- Welding Under High Restraint

7

Special Welding Applications

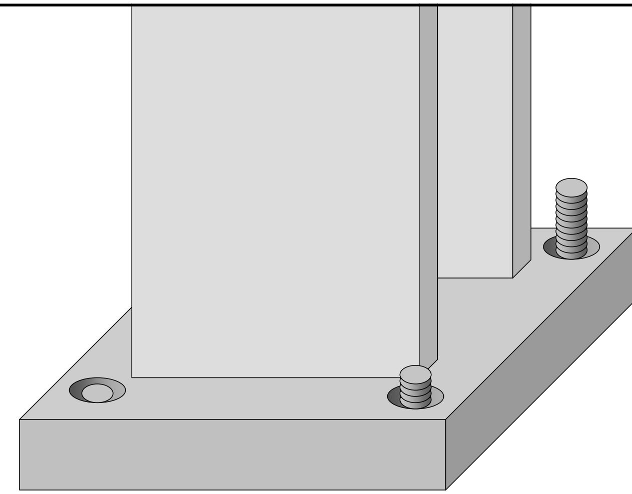
- Welding HSS
- Welding AESS
- Welding on Existing Structures
- Field Welding
- Heat Shrinking

8

Special Welding Applications

- **Extending Anchor Rod**
- Welding Anchor Rod to Base Plates
- Welding on Coated Steels
- Welding Heavy Sections
- Welding Under High Restraint

9



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Special Welding Applications

- Extending Anchor Rod
  - **Investigate Mechanical Options**
  - Investigate "Weldability"
  - Use Appropriate Detail

11

Special Welding Applications

- Extending Anchor Rod
  - Investigate Mechanical Options
  - **Investigate "Weldability"**
  - Use Appropriate Detail

12

AWS Standard Terms & Definitions (A3.0-94)

Weldability:

"The capacity of a material to be welded under the imposed fabrication conditions into a specific, suitably designed structure, and to perform satisfactorily in the intended service."

13

ASTM A6/A6M, Section X3

Weldability:

"A term that usually refers to the relative ease with which a metal can be welded using conventional practice."

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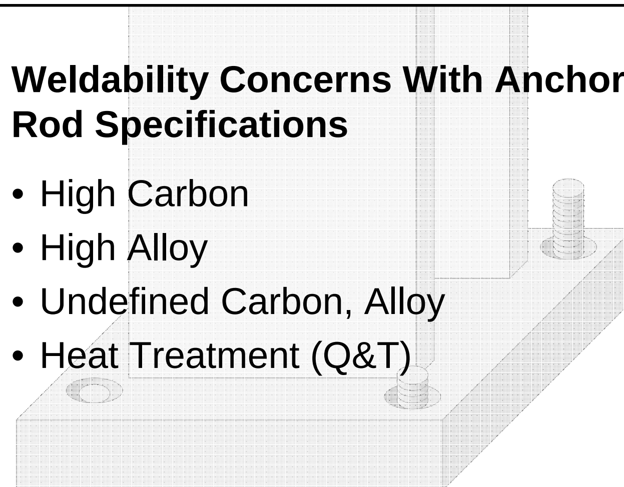
Weldability

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

15

Weldability Concerns With Anchor Rod Specifications



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

16

ASTM F1554

- **Three Grades: 36, 55, 105**

–

17

ASTM F1554
Grade 36

– Chemistry like that of ASTM A36
– Footnote: for rod diameters of up to ¾ in., the manganese content is "optional with the manufacturer, but shall be compatible with weldable steel."
– Grade 55 substituted for Grade 36 ("only Grade 55 is made today")

–

18

ASTM F1554

Grade 55, 105:

– Controls only on S and P
– Grade 55 can be ordered to Supplement S1 with limits on C, Mn, Si, P, S
– Also, two CE equations ("carbon" steel, "alloy" steel)

–

19

ASTM F1554
Grade 36:

– Chemistry indicates it should be readily weldable, but…..
– Confusion exists (mechanical properties or mechanicals plus composition)
– "Weldability only assured if Grade 55 is ordered in accordance with Supplement S1"
– Grade 55 supplied for Grade 36

20

ASTM F1554

Grade 36:

- Chemistry indicates it should be readily weldable, but…..
- Confusion exists (mechanical properties or mechanicals plus composition)
- "Weldability only assured if Grade 55 is ordered in accordance with Supplement S1"
- Grade 55 supplied for Grade 36

Therefore, investigate on a case-by-case basis

21

ASTM F1554

Grade 55:

- Essentially no limits on chemistry indicate it may not be readily weldable
- "Weldability only assured if ordered in accordance with Supplement S1"

22

ASTM F1554

Grade 55:

- Essentially no limits on chemistry indicate it may not be readily weldable
- "Weldability only assured if ordered in accordance with Supplement S1"

Therefore, investigate on a case-by-case basis

23

ASTM F1554

Grade 55:

- Essentially no limits on chemistry indicate it may not be readily weldable
- "Weldability only assured if ordered in accordance with Supplement S1"

24

ASTM F1554

Grade 55:

- Essentially no limits on chemistry indicate it may not be readily weldable
- "Weldability only assured if ordered in accordance with Supplement S1"

Therefore, investigate on a case-by-case basis

25

ASTM F1554

Grade 55 with Supplement S1:

26

ASTM F1554

Grade 55 with Supplement S1:

Good weldability should be assured.

27

ASTM F1554

Grade 105:

- Essentially no chemistry control
- High strength

28

ASTM F1554

Grade 105:

- Essentially no chemistry control
- High strength

Weldability likely to be poor.

29

Special Welding Applications

- Extending Anchor Rod
  - Investigate Mechanical Options
  - Investigate "Weldability"
  - **Use Appropriate Detail**

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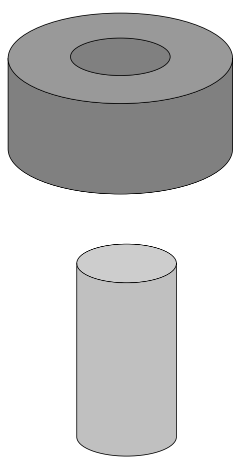

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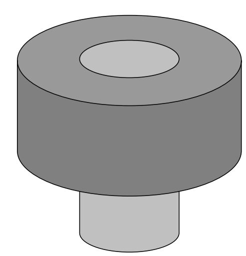

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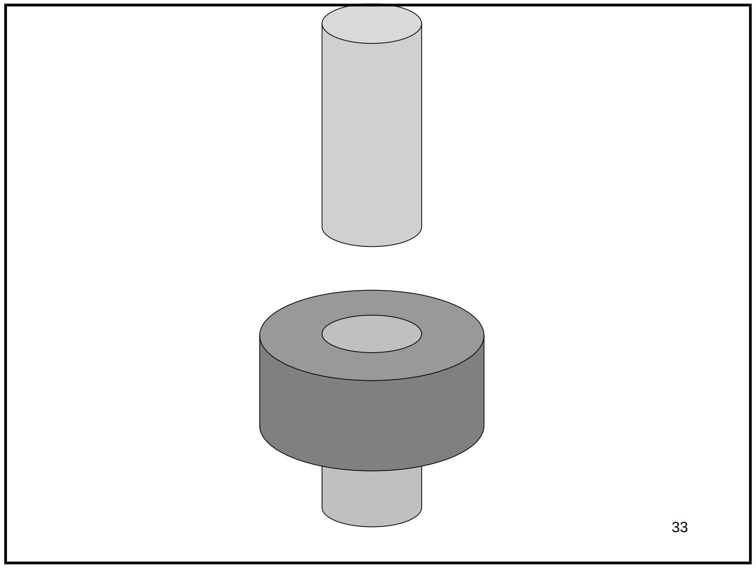
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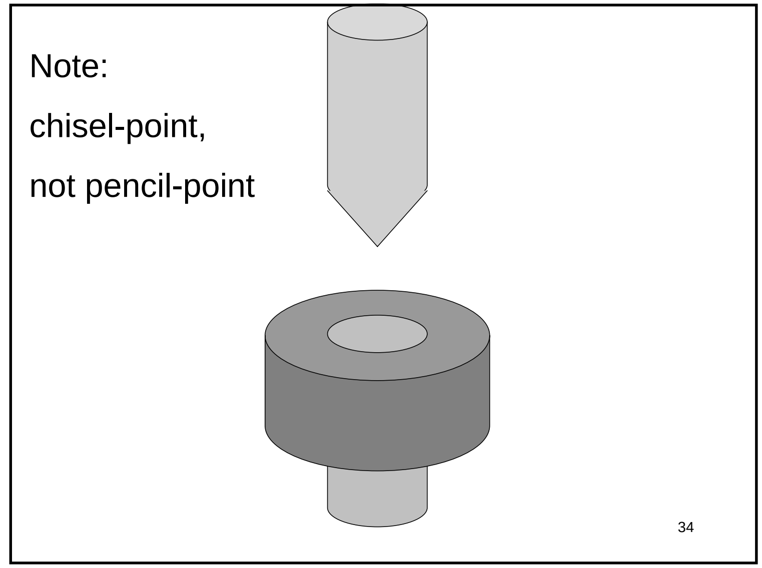
Note:
chisel-point,
not pencil-point
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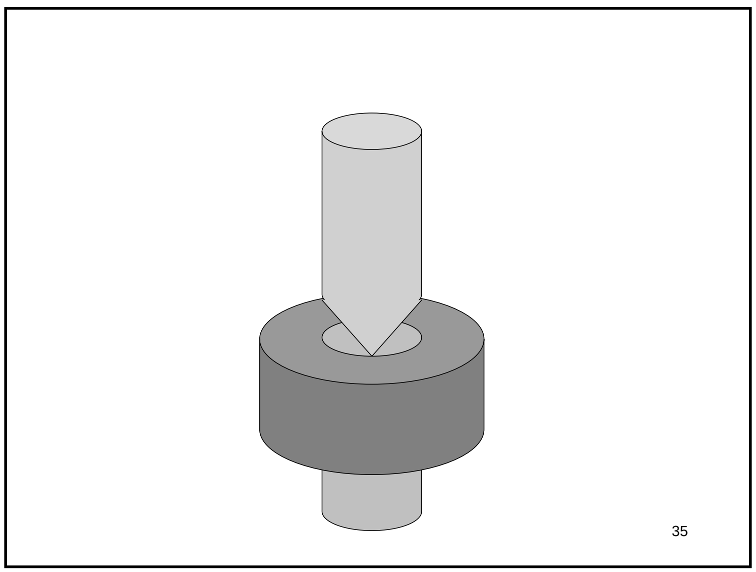
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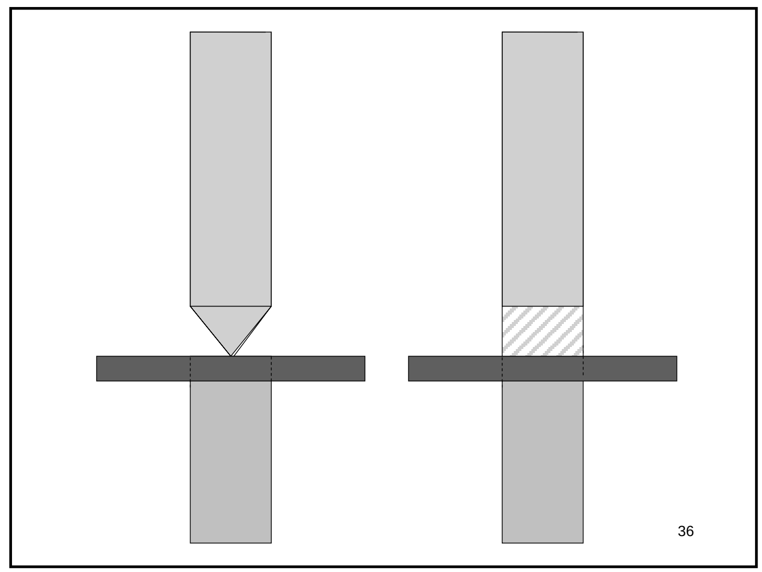
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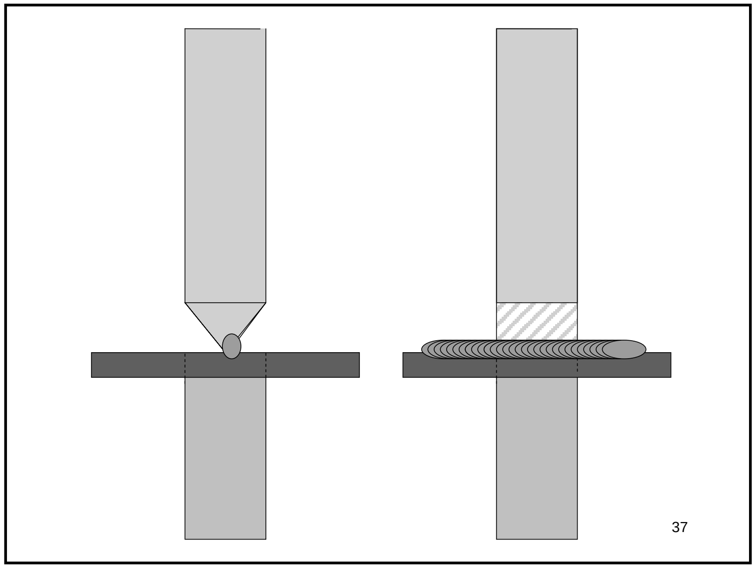
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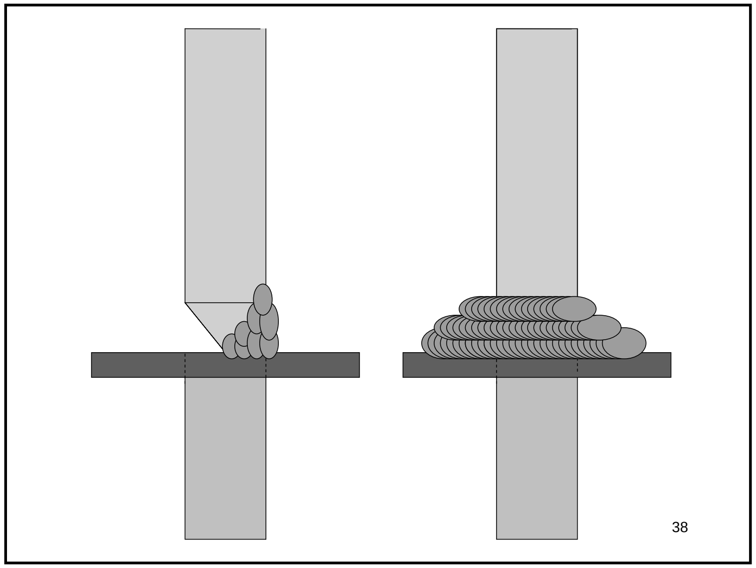
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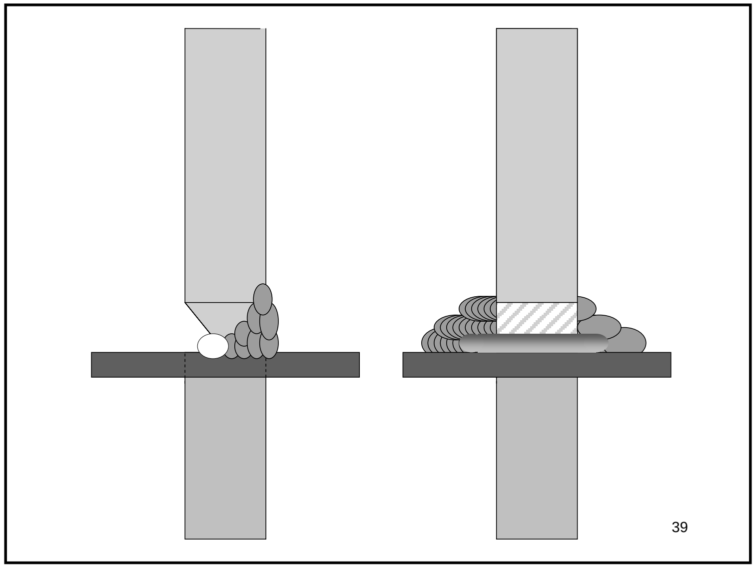
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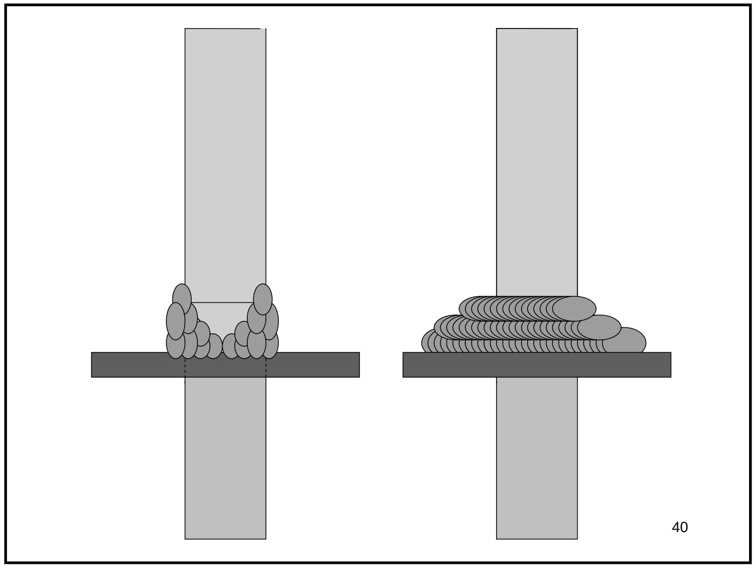
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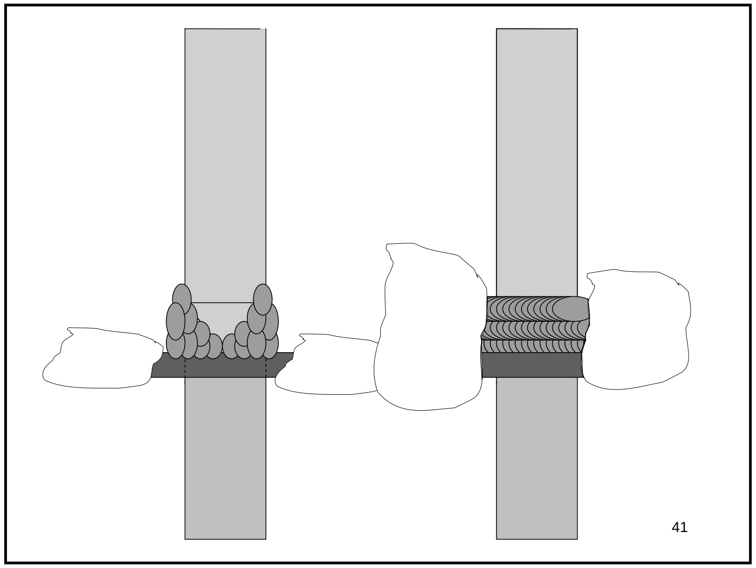
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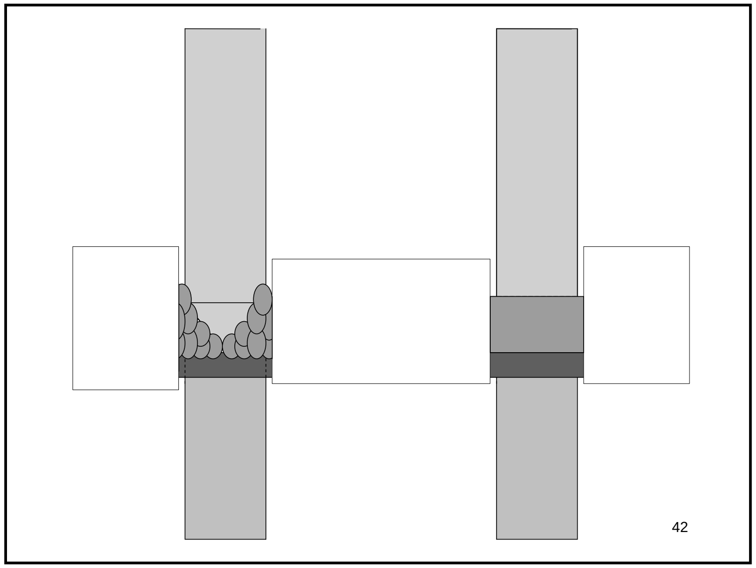
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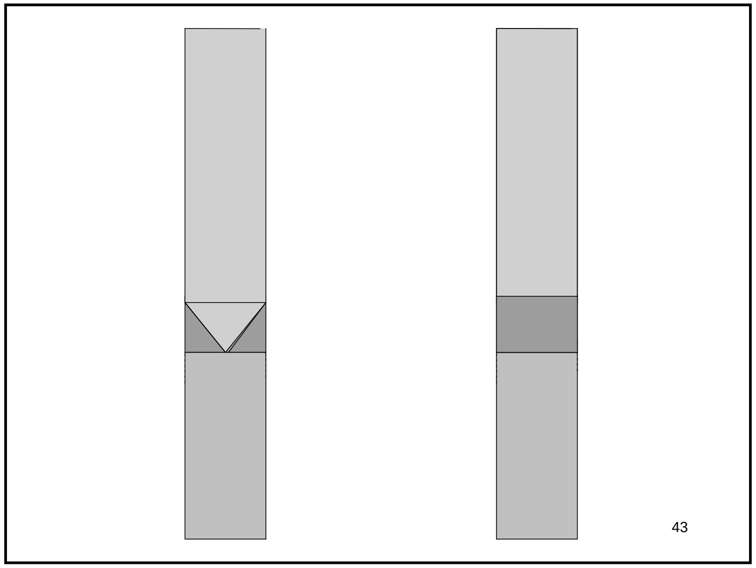
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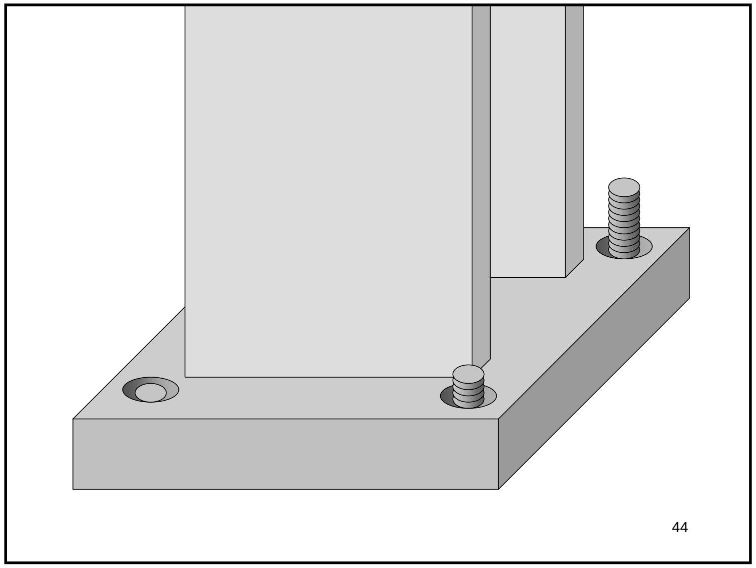
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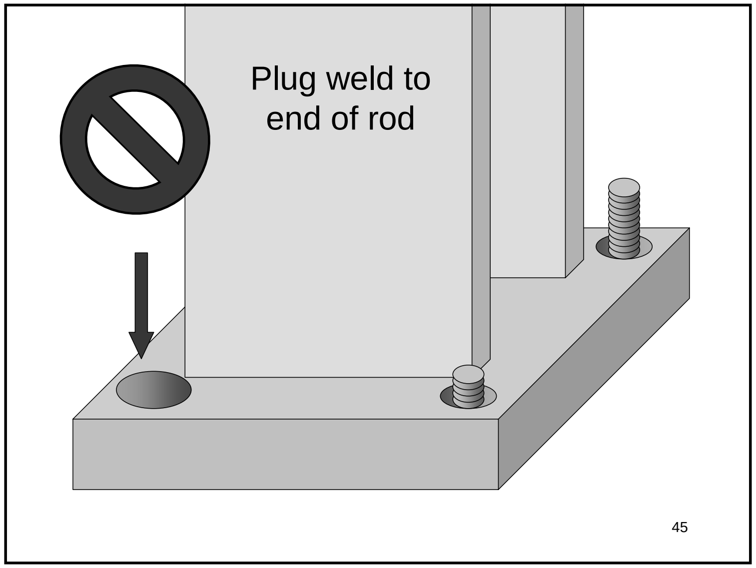

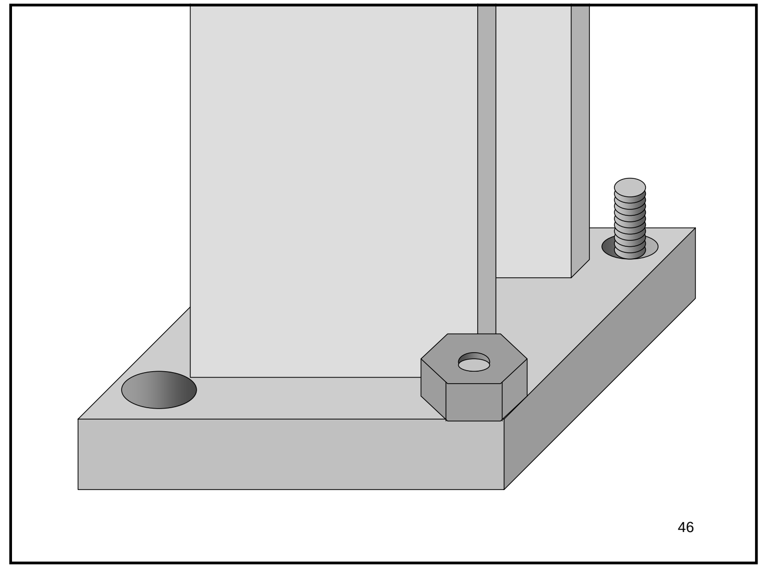

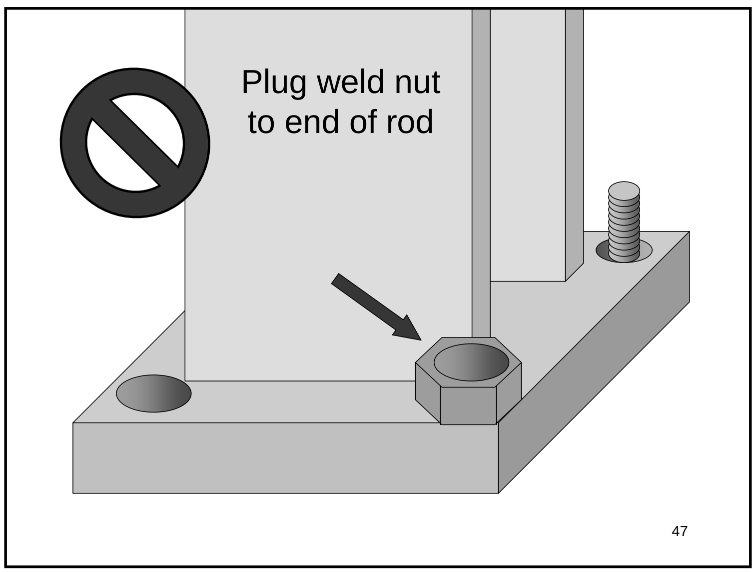

Special Welding Applications

- Extending Anchor Rod
- **Welding Anchor Rod to Base Plates**
- Welding on Coated Steels
- Welding Heavy Sections
- Welding Under High Restraint

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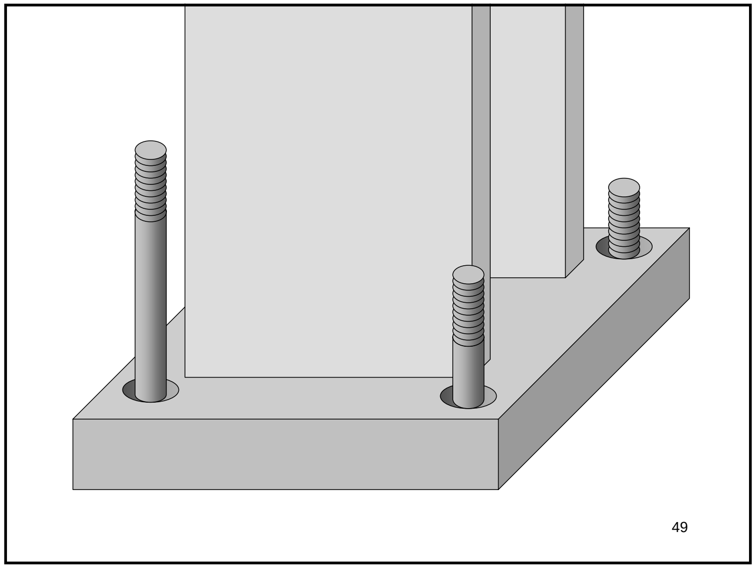

Special Welding Applications

- Welding Anchor Rod to Base Plates
  - **Investigate Mechanical Options**
  - Investigate "Weldability"
  - Use Appropriate Detail

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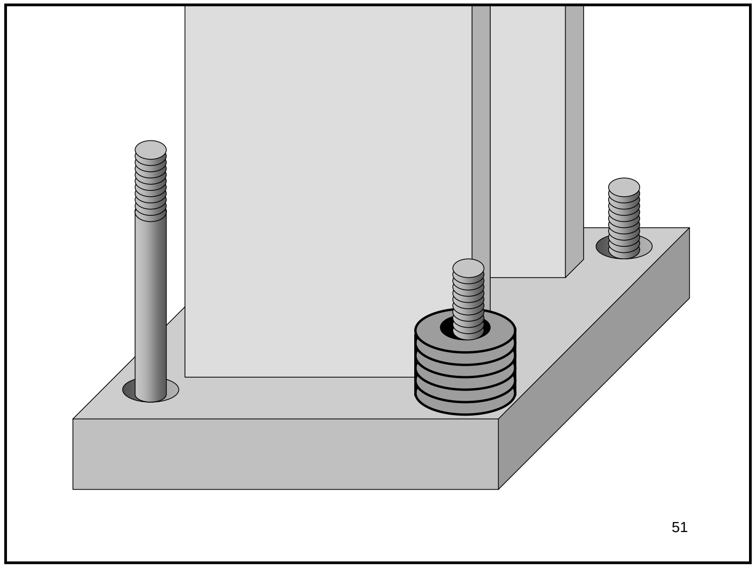
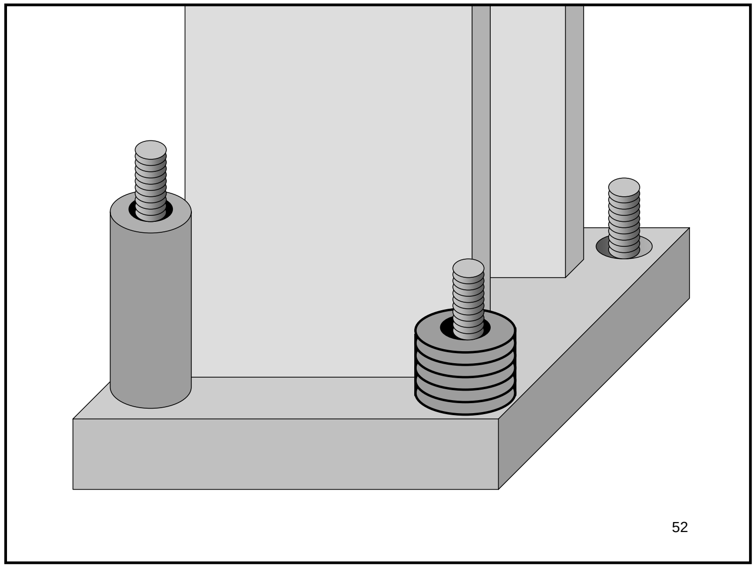
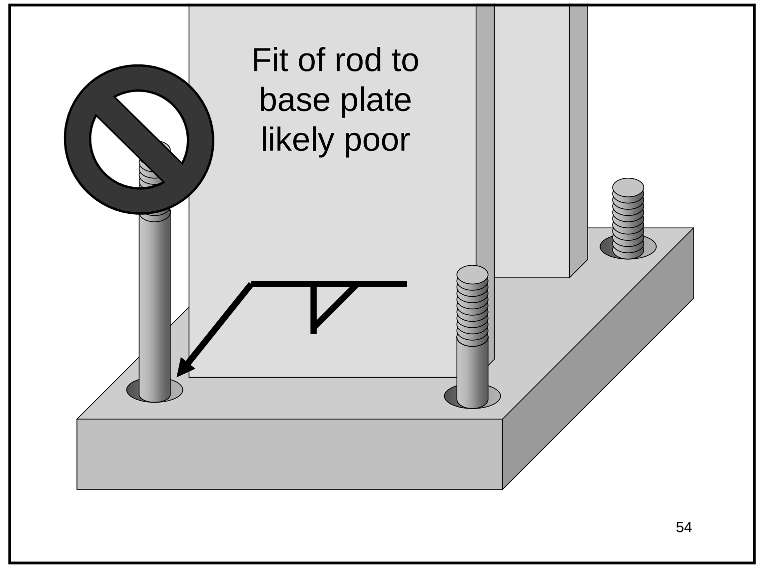


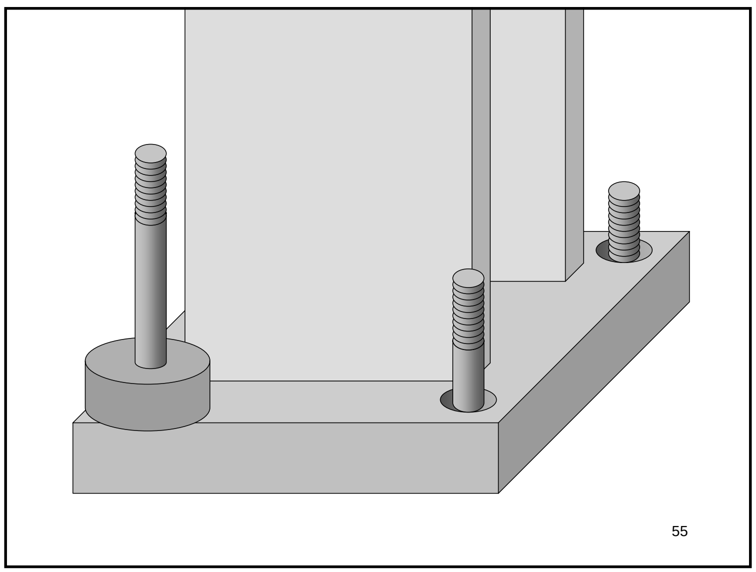


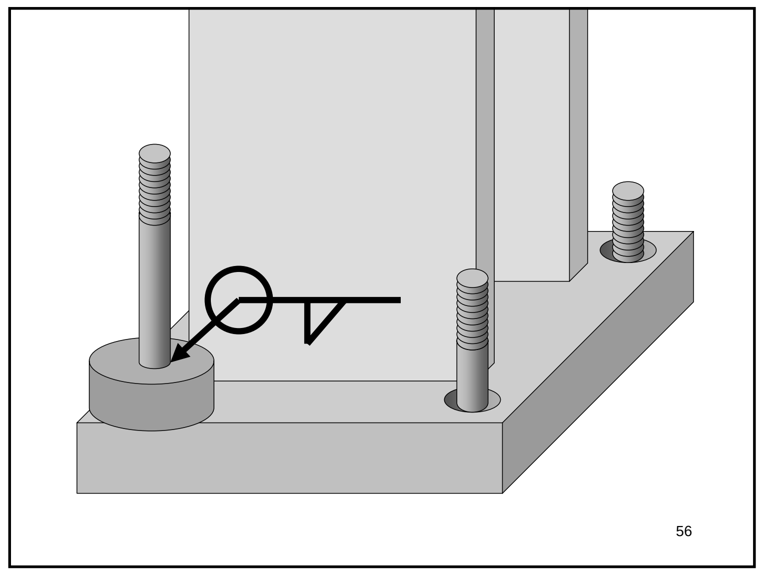
Special Welding Applications

- Welding Anchor Rod to Base Plates
  - Investigate Mechanical Options
  - **Investigate "Weldability"**
  - **Use Appropriate Detail**

53







Special Welding Applications

- Extending Anchor Rod
- Welding Anchor Rod to Base Plates
- **Welding on Coated Steels**
- Welding Heavy Sections
- Welding Under High Restraint

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Special Welding Applications

Welding on Coated Steels

Galvanized

Painted

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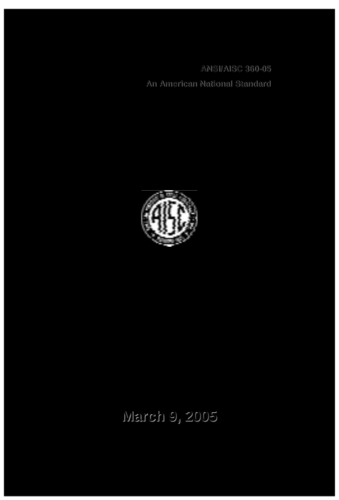

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Specification for Structural Steel Buildings

13th Edition

M3. SHOP PAINTING

5. Surfaces Adjacent to Field Welds

Unless otherwise specified in the design documents, surfaces within 2 in. (50 mm) of any field weld location shall be free of materials that would prevent proper welding or produce objectionable fumes during welding.

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Specification for Structural Steel Buildings
13th Edition

M4. ERECTION

5. Field Welding

Shop paint on surfaces adjacent to joints to be field welded shall be wire brushed if necessary to assure weld quality.

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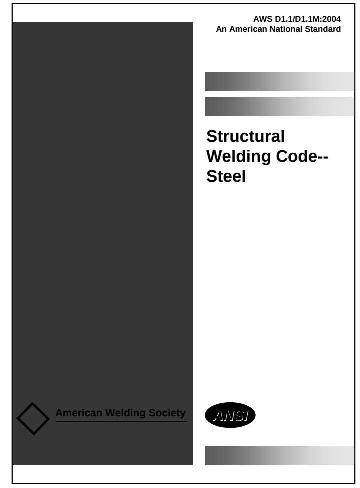

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AWS D1.1
Structural Welding Code—Steel

5.15 Preparation of Base Metal

Surfaces to be welded, and surfaces adjacent to a weld, shall also be free from loose or thick scale, slag, rust, moisture, grease, and other foreign material that would prevent proper welding or produce objectionable fumes.

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Common Elements

- Concern about fumes
- Concerns about inhibiting "proper welding"
- "Materials" broadly defined
- Outcome-based requirements

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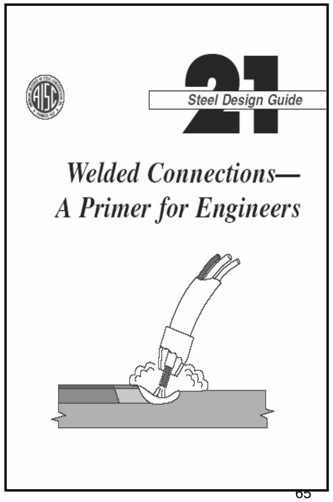
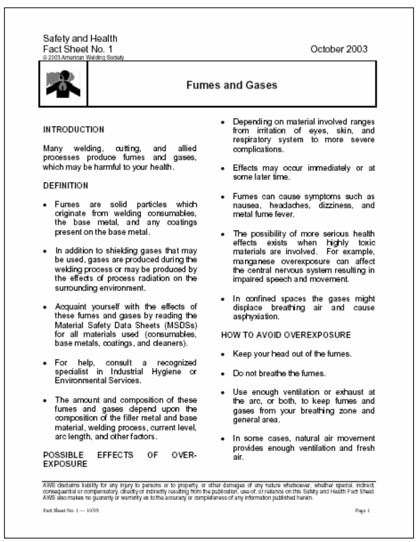
Chapter 15
Welding Safety



Welding Safety

- See ANSI Z49.1 *Safety in Welding, Cutting and Allied Processes*
- Available by free download from AWS

  www.aws.org/technical/facts
- "Fact Sheets" from AWS, also available as free download



Safety and Health
Fact Sheet No. 1

October 2003

Fumes and Gases

INTRODUCTION

Many welding, cutting, and allied processes produce fumes and gases, which may be harmful to your health.

DEFINITION

- Fumes are solid particles which originate from welding consumables, the base metal, and any coatings present on the base metal.
- In addition to shielding gases that may be used, gases are produced during the welding process or may be produced by the effects of process radiation on the surrounding environment.
- Acquaint yourself with the effects of these fumes and gases by reading the Material Safety Data Sheets (MSDSs) for all materials used (consumables, base metals, coatings, and cleaners).
- For help, consult a recognized specialist in Industrial Hygiene or Environmental Services.
- The amount and composition of these fumes and gases depend upon the composition of the filler metal and base material, welding process, current level, arc length, and other factors.

POSSIBLE EFFECTS OF OVER-EXPOSURE

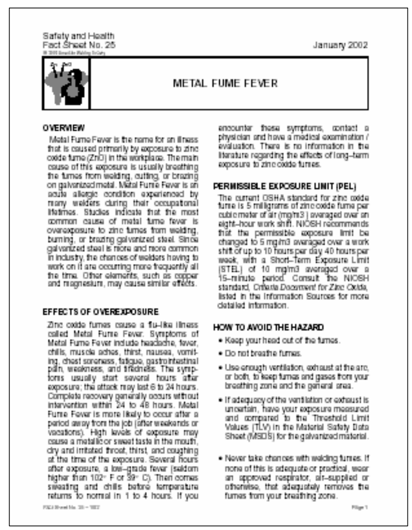
- Depending on material involved ranges from irritation of eyes, skin, and respiratory system to more severe complications.
- Effects may occur immediately or at some later time.
- Fumes can cause symptoms such as nausea, headaches, dizziness, and metal fume fever.
- The possibility of more serious health effects exists when highly toxic materials are involved. For example, manganese overexposure can affect the central nervous system resulting in impaired speech and movement.
- In confined spaces the gases might displace breathing air and cause asphyxiation.

HOW TO AVOID OVEREXPOSURE

- Keep your head out of the fumes.
- Do not breathe the fumes.
- Use enough ventilation or exhaust at the arc, or both, to keep fumes and gases from your breathing zone and general area.
- In some cases, natural air movement provides enough ventilation and fresh air.

Fact Sheet No. 1 — 10/03

Page 1



Safety and Health
Fact Sheet No. 25

January 2002

METAL FUME FEVER

OVERVIEW

Metal Fume Fever is the name for an illness that is caused primarily by exposure to zinc oxide fume (ZnO) in the workplace. The main cause of this exposure is usually breathing the fumes from welding, cutting, or brazing on galvanized metal. Metal Fume Fever is an acute allergic condition experienced by many welders during their occupational lifetimes. Studies indicate that the most common cause of metal fume fever is overexposure to zinc fumes from welding, burning, or brazing galvanized steel. Since galvanized steel is more and more common in industry, the chances of welders having to work on it are occurring more frequently all the time. Other elements, such as copper and magnesium, may cause similar effects.

EFFECTS OF OVEREXPOSURE

Zinc oxide fumes cause a flu-like illness called Metal Fume Fever. Symptoms of Metal Fume Fever include headache, fever, chills, muscle aches, thirst, nausea, vomiting, chest soreness, fatigue, gastrointestinal pain, weakness, and tiredness. The symptoms usually start several hours after exposure; the attack may last 6 to 24 hours. Complete recovery generally occurs without intervention within 24 to 48 hours. Metal Fume Fever is more likely to occur after a period away from the job (after weekends or vacations). High levels of exposure may cause a metallic or sweet taste in the mouth, dry and irritated throat, thirst, and coughing at the time of the exposure. Several hours after exposure, a low-grade fever (seldom higher than 102° F or 39° C). Then comes sweating and chills before temperature returns to normal in 1 to 4 hours. If you encounter these symptoms, contact a physician and have a medical examination / evaluation. There is no information in the literature regarding the effects of long-term exposure to zinc oxide fumes.

PERMISSIBLE EXPOSURE LIMIT (PEL)

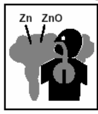
The current OSHA standard for zinc oxide fume is 5 milligrams of zinc oxide fume per cubic meter of air (mg/m3) averaged over an eight-hour work shift. NIOSH recommends that the permissible exposure limit be changed to 5 mg/m3 averaged over a work shift of up to 10 hours per day 40 hours per week, with a Short-Term Exposure Limit (STEL) of 10 mg/m3 averaged over a 15-minute period. Consult the NIOSH standard, *Criteria Document for Zinc Oxide*, listed in the Information Sources for more detailed information.

HOW TO AVOID THE HAZARD

- Keep your head out of the fumes.
- Do not breathe fumes.
- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area.
- If adequacy of the ventilation or exhaust is uncertain, have your exposure measured and compared to the Threshold Limit Values (TLV) in the Material Safety Data Sheet (MSDS) for the galvanized material.
- Never take chances with welding fumes. If none of this is adequate or practical, wear an approved respirator, air-supplied or otherwise, that adequately removes the fumes from your breathing zone.

Page 1

Safety and Health
Fact Sheet No. 25 January 2002



METAL FUME FEVER

OVERVIEW

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encounter these symptoms, contact a physician and have a medical examination / evaluation. There is no information in the literature regarding the effects of long–term exposure to zinc oxide fumes.

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The current OSHA standard for zinc oxide fume is 5 milligrams of zinc oxide fume per cubic meter of air (mg/m3) averaged over an eight–hour work shift. NIOSH recommends that the permissible exposure limit be changed to 5 mg/m3 averaged over a work shift of up to 10 hours per day, 40 hours per week, with a Short–Term Exposure Limit (STEL) of 10 mg/m3 averaged over a 15–minute period. Consult the NIOSH standard, *Criteria Document for Zinc Oxide,*

Safety and Health Fact Sheet No. 25 Metal Fume Fever

- Overview
- Effects of Overexposure
- Permissible Exposure Limit (PEL)
- How to Avoid the Hazard
- Respirators
- Monitoring and Measuremetnt Procedures
- Information Sources
- Summary

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OVERVIEW

Metal Fume Fever is the name for an illness that is caused primarily by exposure to zinc oxide fume (ZnO) in the workplace. The main cause of this exposure is usually breathing the fumes from welding, cutting, or brazing on galvanized metal. Metal Fume Fever is an acute allergic condition experienced by many welders during their occupational lifetimes. Studies indicate that the most

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HOW TO AVOID THE HAZARD

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- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area.
- If adequacy of the ventilation or exhaust is uncertain, have your exposure measured and compared to the Threshold Limit Values (TLV) in the Material Safety Data Sheet (MSDS) for the galvanized material.

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Quality Concerns

- Fusion
- Porosity
- Cracking

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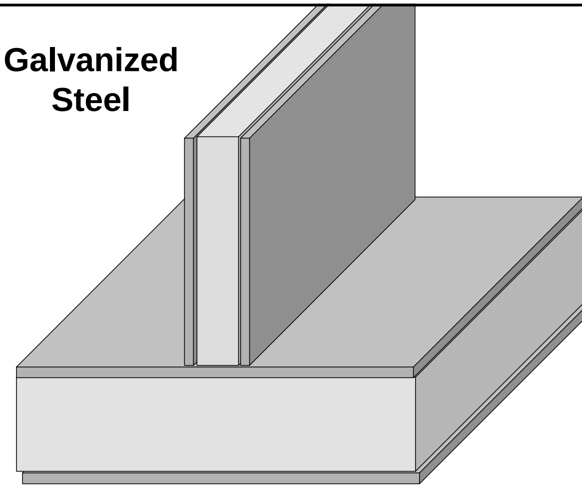
Galvanized Steel



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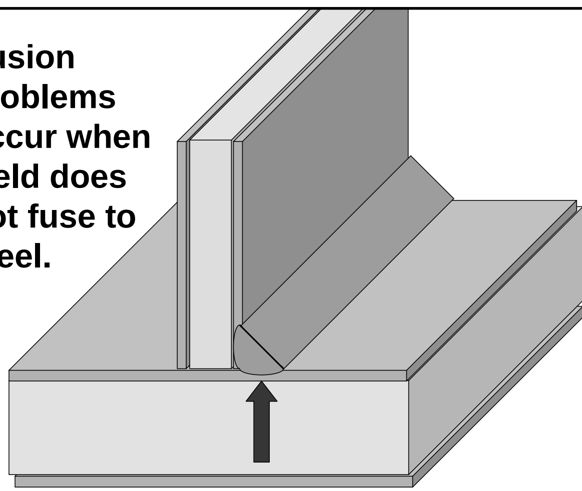
Fusion problems occur when weld does not fuse to steel.



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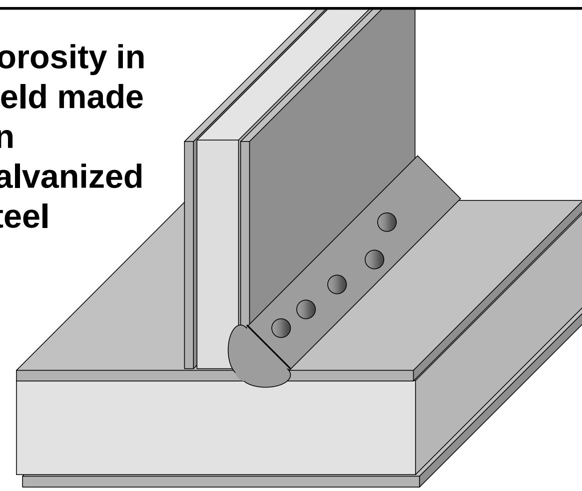
Porosity in weld made on galvanized steel



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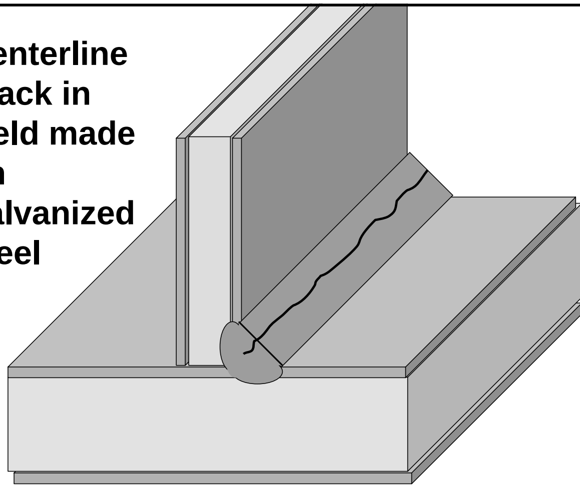
Centerline crack in weld made on galvanized steel



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AWS D19.0-72 Welding Zinc-Coated Steel

Factors affecting cracking tendencies on galvanized steel

- The silicon content of the weld metal
- The degree of penetration of the weld beyond the root
- The thickness of the base metal (which affects restraint)
- The coating weight of the zinc (a function of the coating thickness)
- The microstructure of the zinc coating, which is related to the base metal composition and the silicon content in particular

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For critical applications

- Qualify WPS by test
- Limitations of Table 4.5 may not be adequate
- Closely replicate field conditions
- Test thickest coating condition

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Special Welding Applications

- Extending Anchor Rod
- Welding Anchor Rod to Base Plates
- Welding on Coated Steels
- **Welding Heavy Sections**
- Welding Under High Restraint

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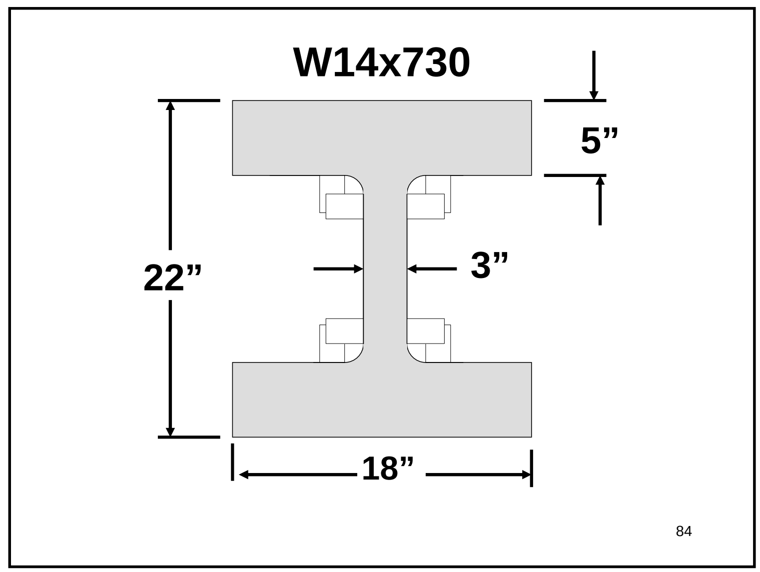
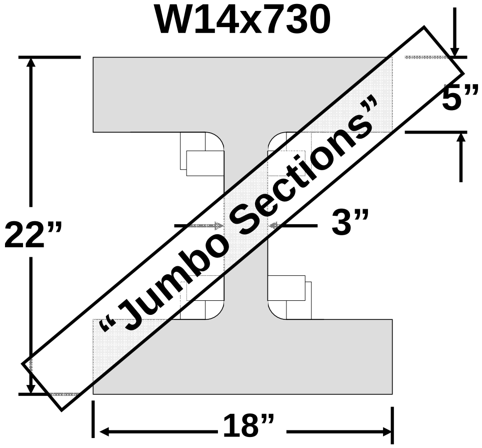
EEL.PAI
ATKA.FLA.


PAI
ATK


PAI
ATK


W14x730
5”
3”
22”
18”
84

W14x730



85

Heavier Sections

- Larger Welds
- More Shrinkage
- Increased Stress

86

Heavier Sections

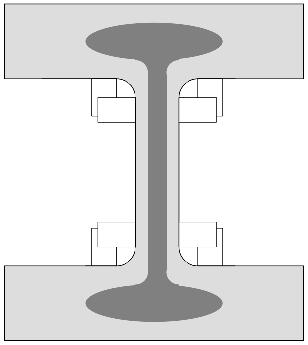
- More Restraint
- More Triaxiality
- Less Ductiliy

87

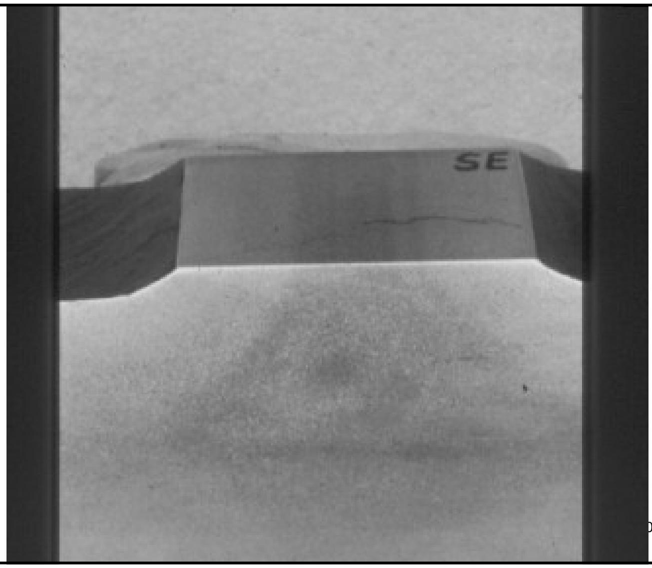
Heavier Sections

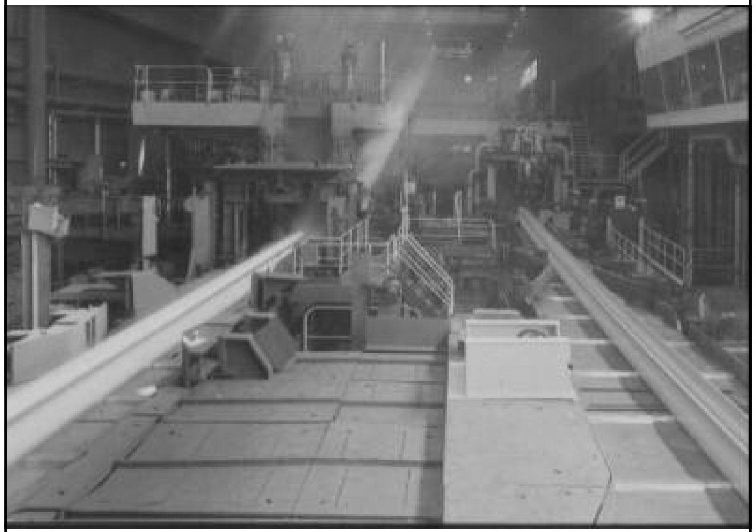
- Less Rolling
- Slower Cooling
- Lower Toughness

88



89

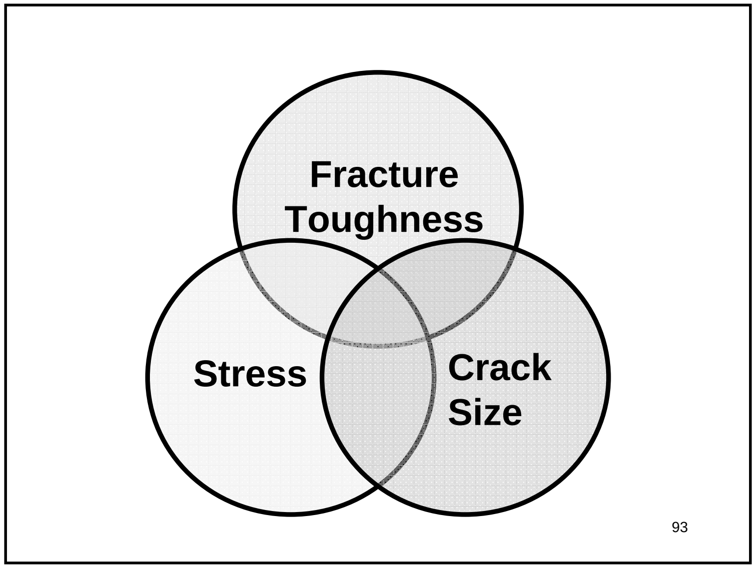


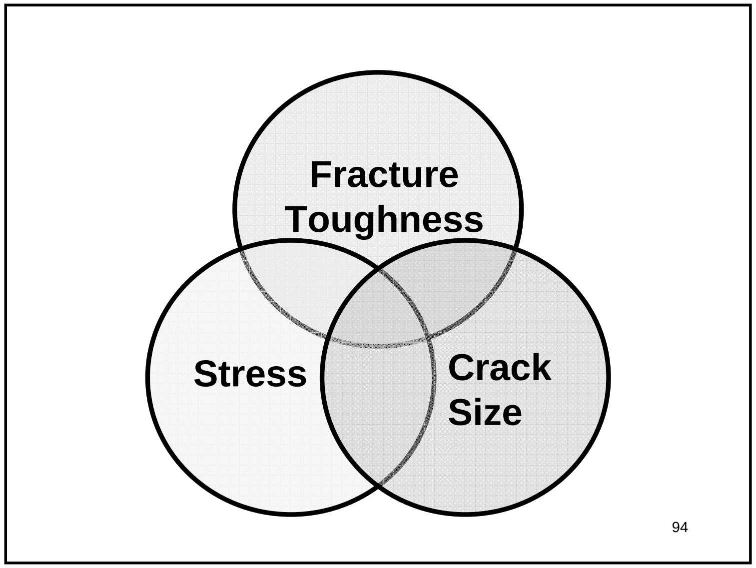


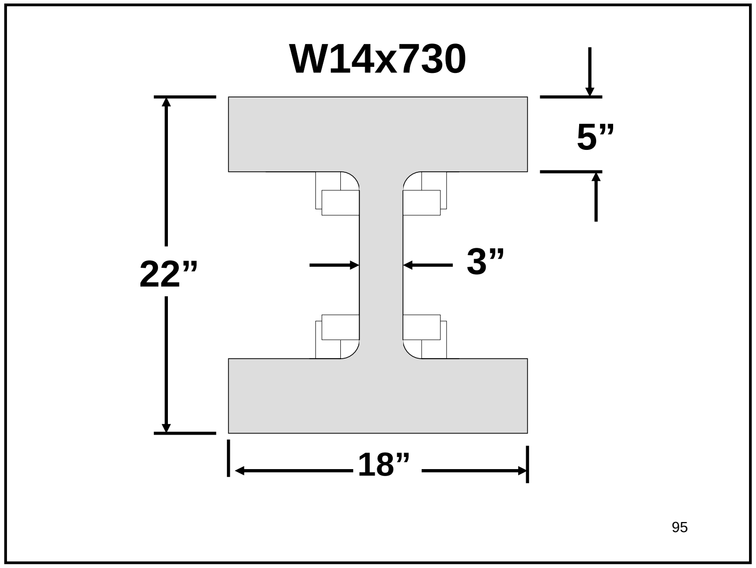
Greater Cracking Tendencies

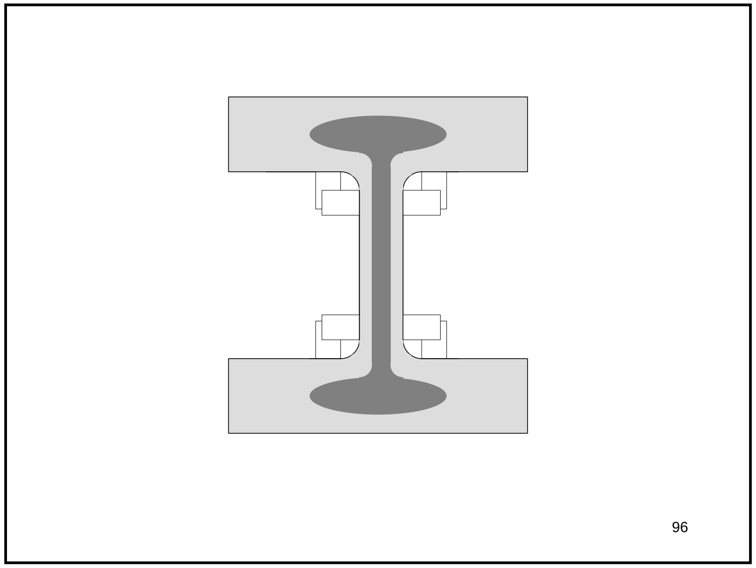
Heavier Sections

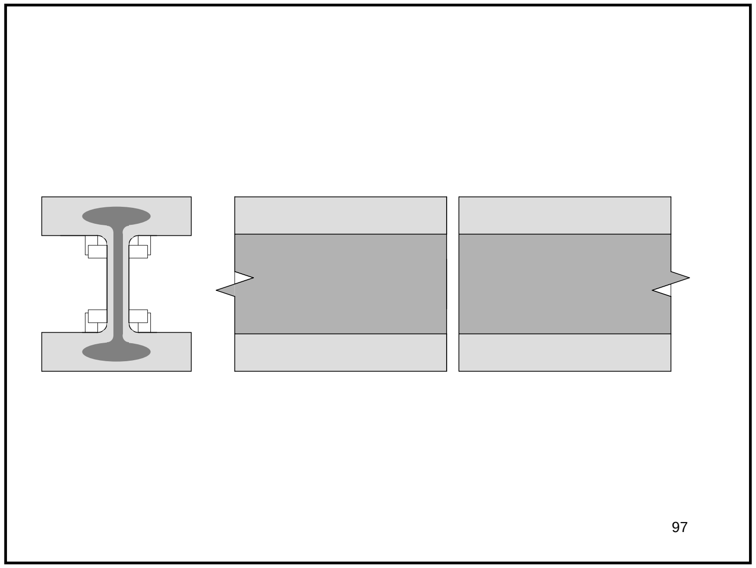
92

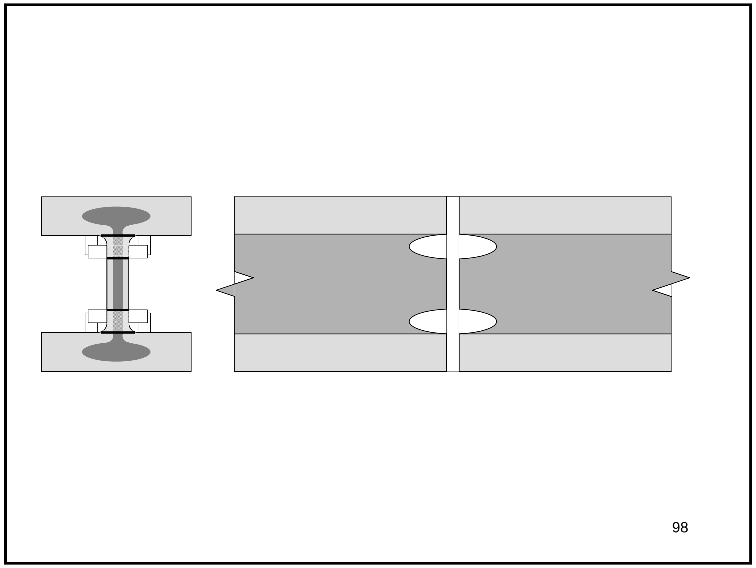

Fracture
Toughness
Stress
Crack
Size
93


Fracture
Toughness
Stress
Crack
Size
94


W14x730
5”
3”
22”
18”
95


96


97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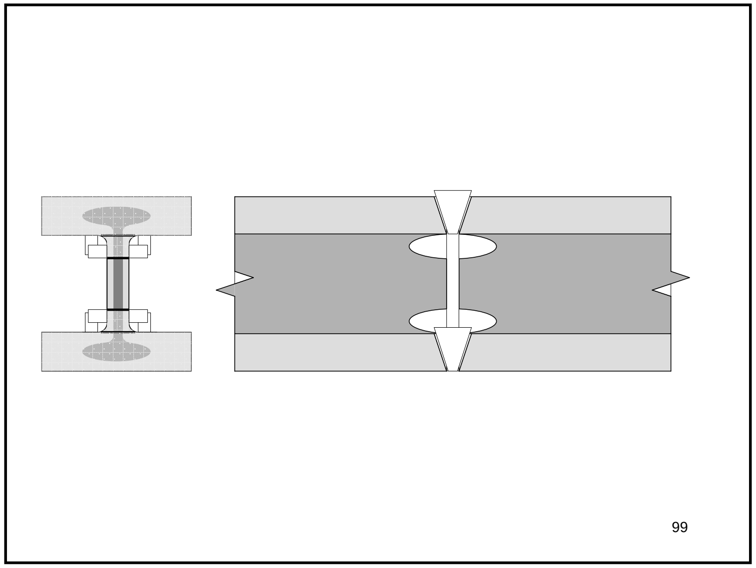
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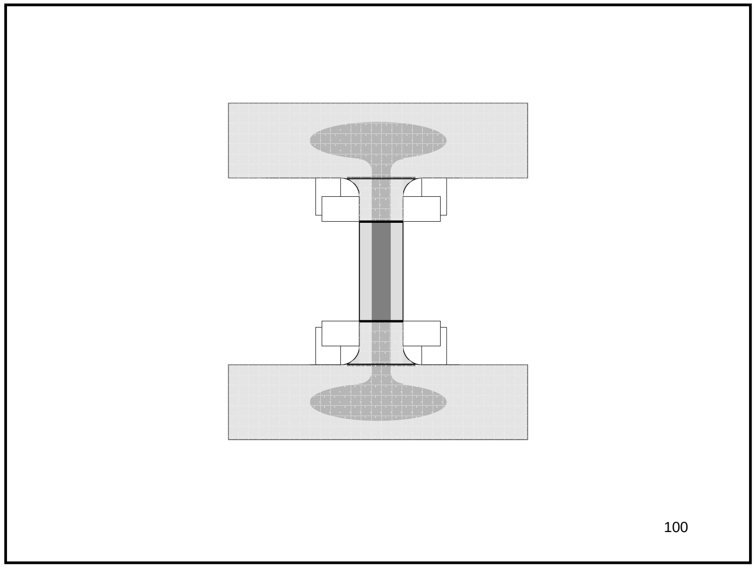
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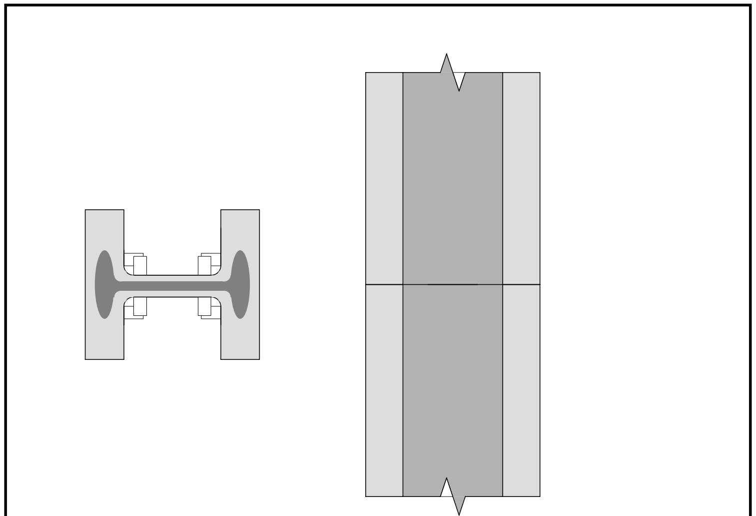
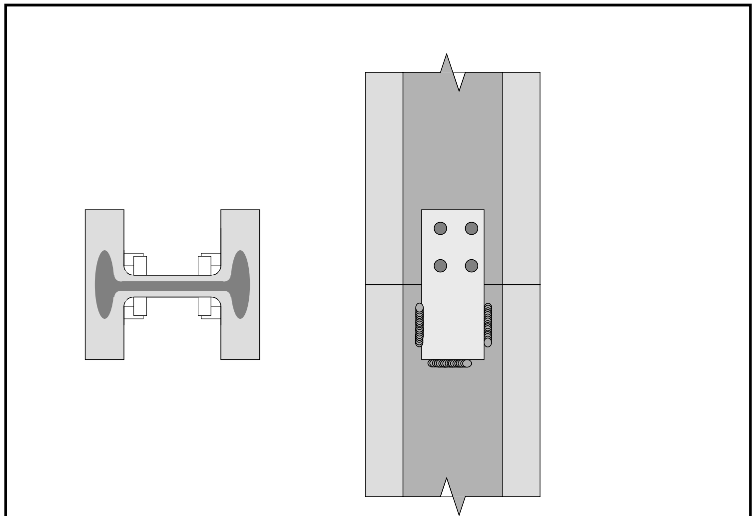
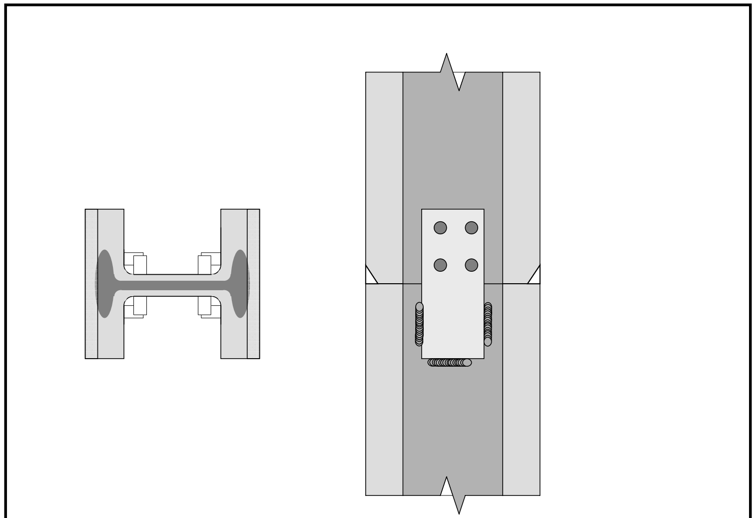


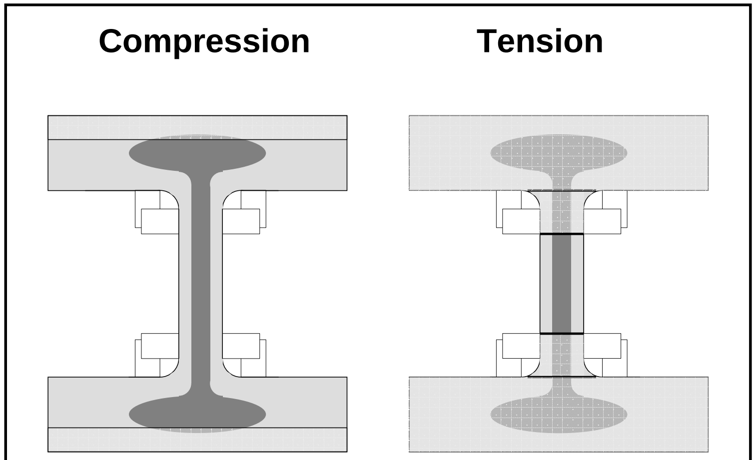
101



102

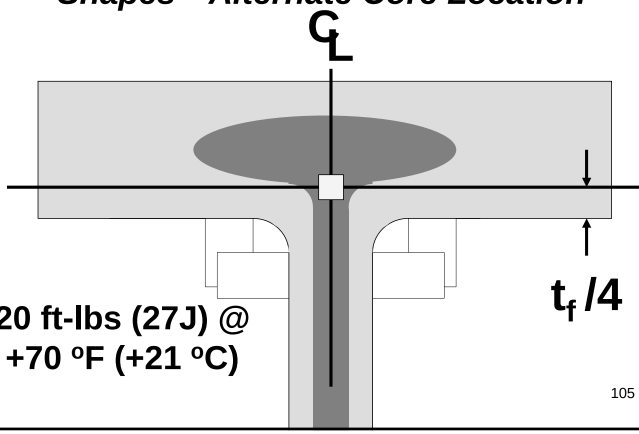


103



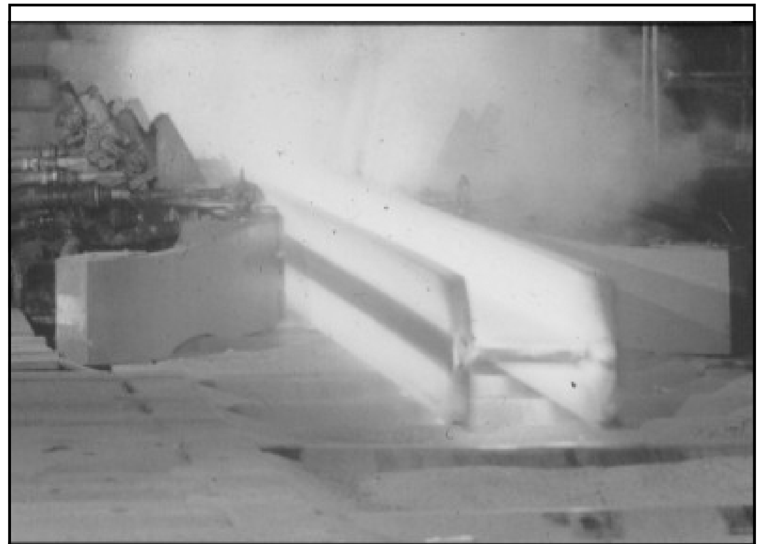
104

ASTM A6, Supplementary Requirement S30
Charpy V-Notch Impact Tests for Structural Shapes—Alternate Core Location

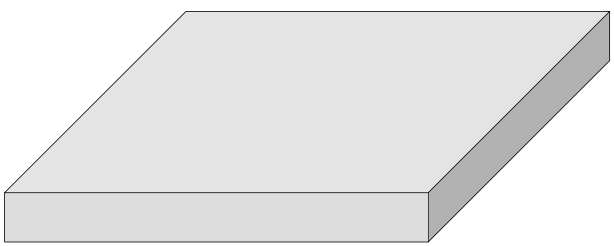


20 ft-lbs (27J) @
+70 ºF (+21 ºC)

105



ASTM A6, Supplementary Requirement S5
Charpy V-Notch Impact Test



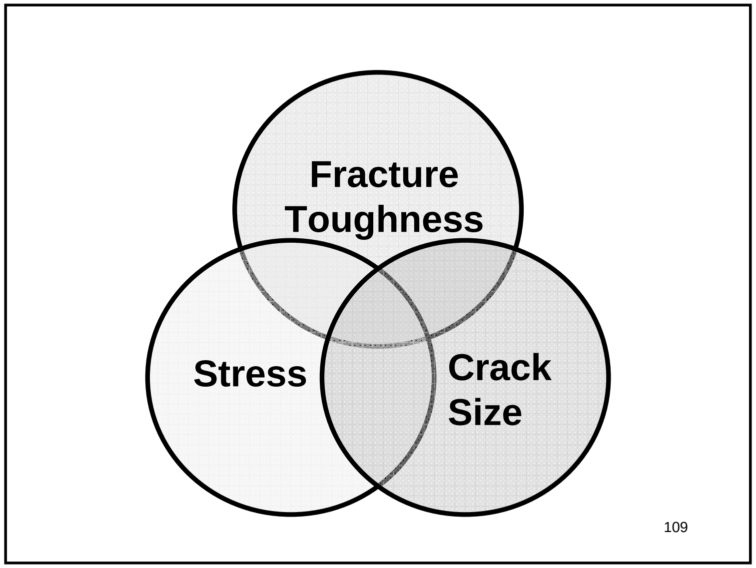
20 ft-lbs (27J) @
+70 ºF (+21 ºC)

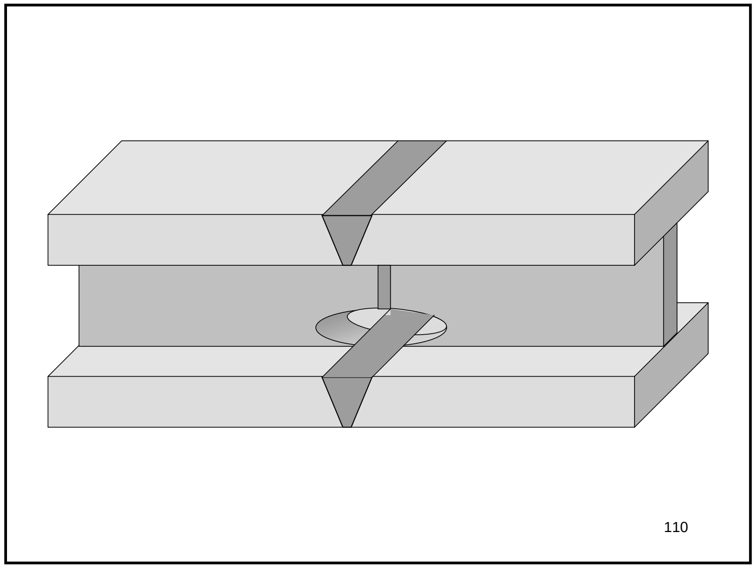
107

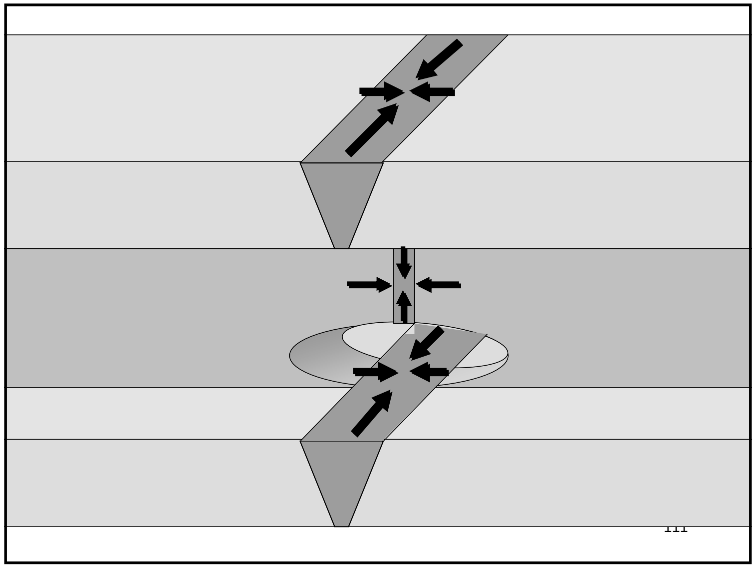
J3.6 Filler Metal Requirements

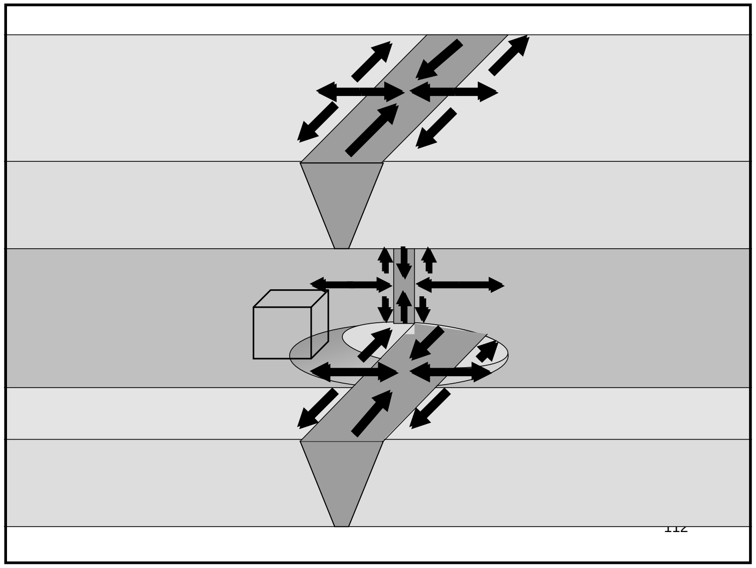
20 ft-lbs (27J) @
+40 ºF (+4 ºC)

108


Fracture
Toughness
Stress
Crack
Size
109

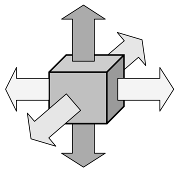

110





Longitudinal shrinkage of web weld

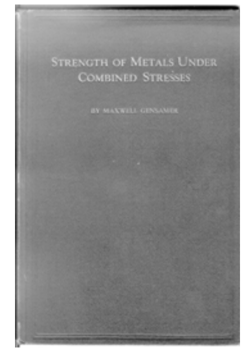
Longitudinal shrinkage of flange welds



Transverse shrinkage of welds

113

STRENGTH OF METALS UNDER COMBINED STRESSES

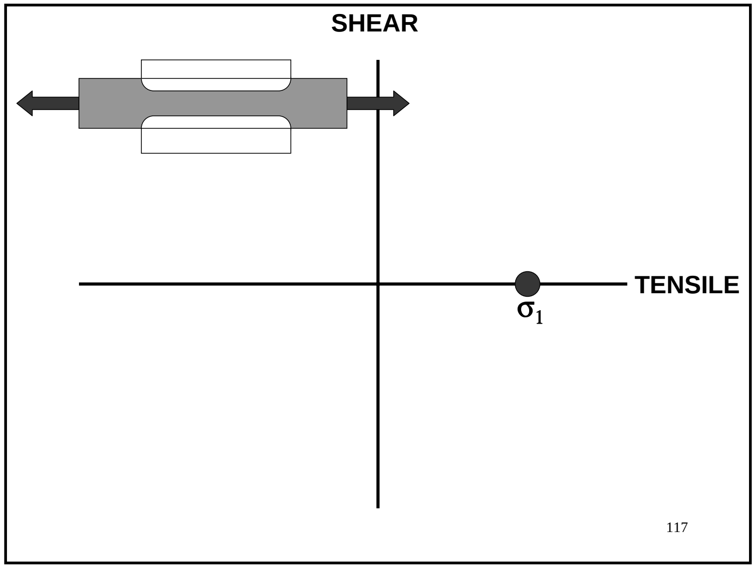


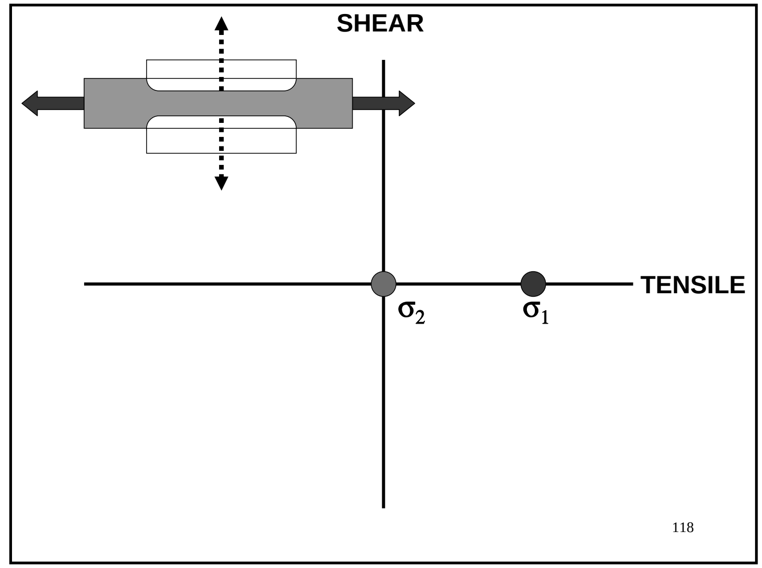
114

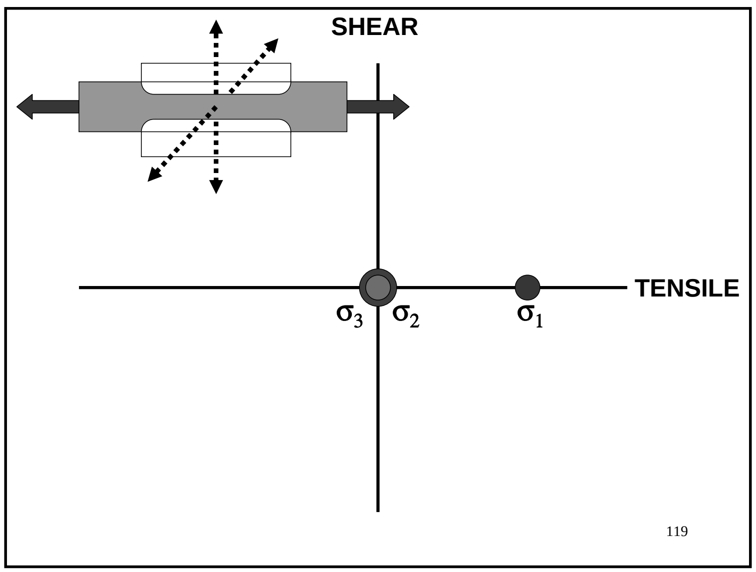
"This is an important concept and needs to be emphasized: no shear stress, no plastic deformation or flow."

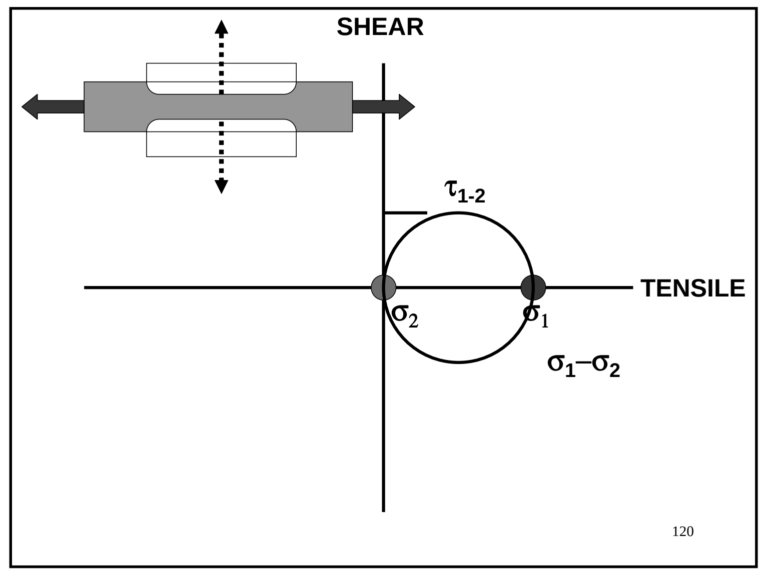
Maxwell Gensamer
1941

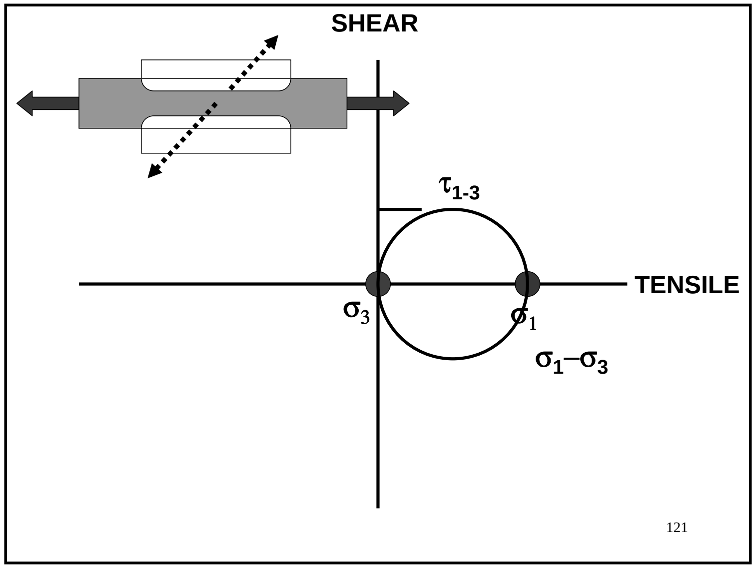
115

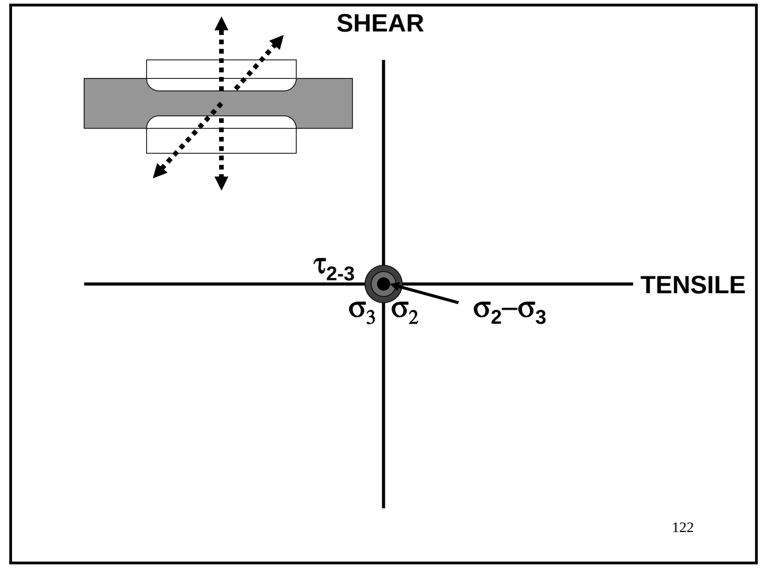

SHEAR
TENSILE
σ1
117

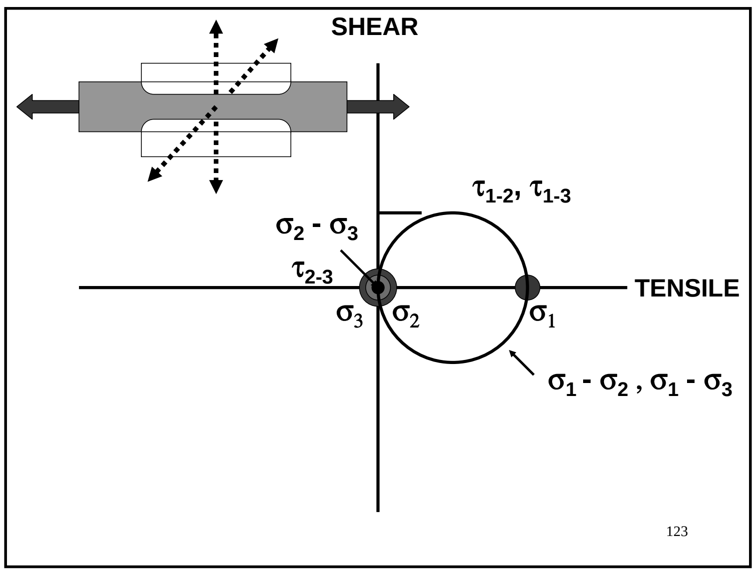

SHEAR
TENSILE
σ2
σ1
118

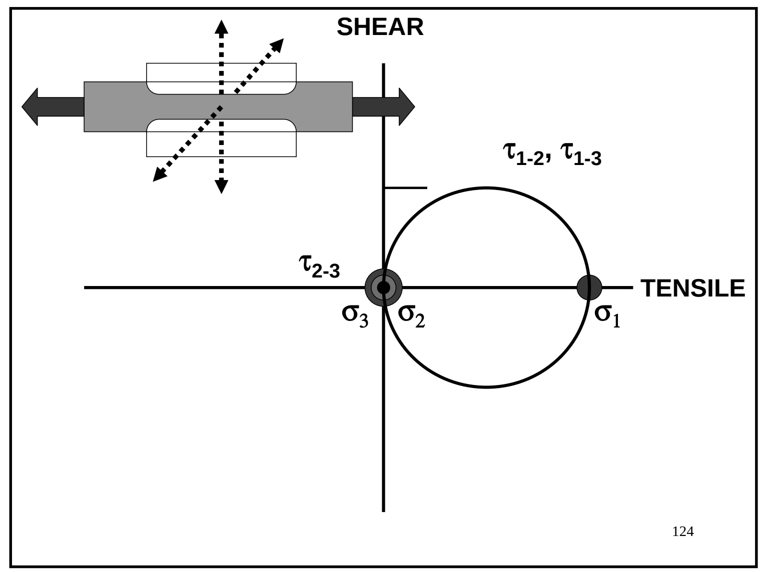

SHEAR
TENSILE
σ3
σ2
σ1
119

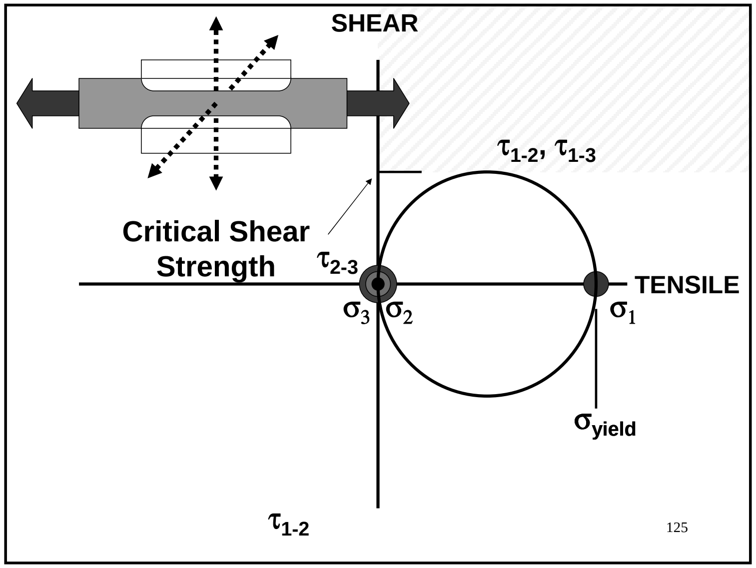

SHEAR
τ1-2
TENSILE
σ2
σ1
σ1–σ2
120

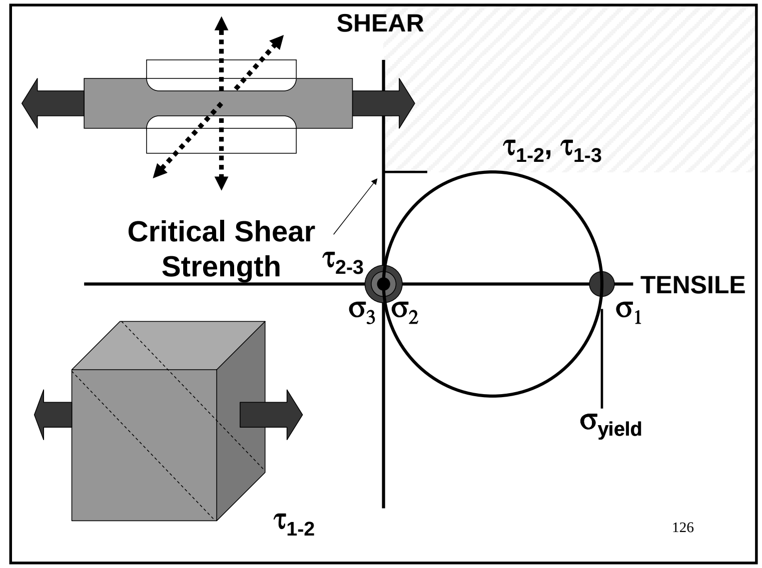

SHEAR
τ_{1-3}
TENSILE
σ_3
σ_1
$\sigma_1 - \sigma_3$
121

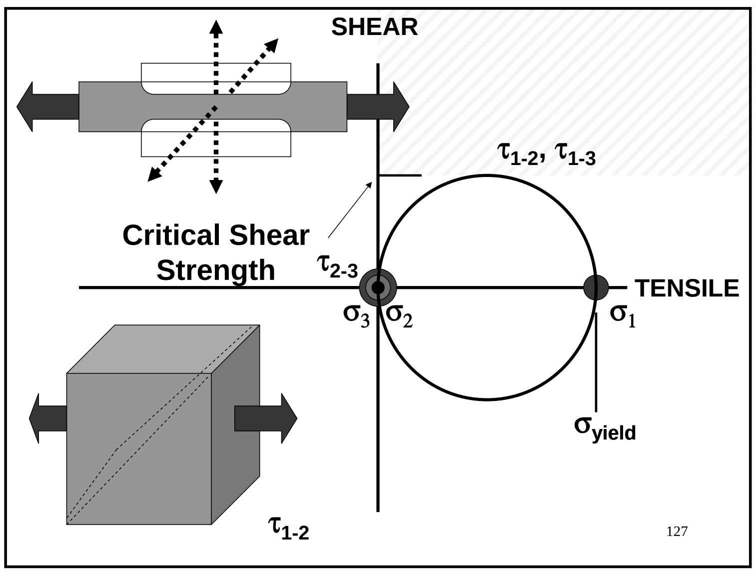

SHEAR
τ_{2-3}
TENSILE
σ_3 σ_2
$\sigma_2 - \sigma_3$
122

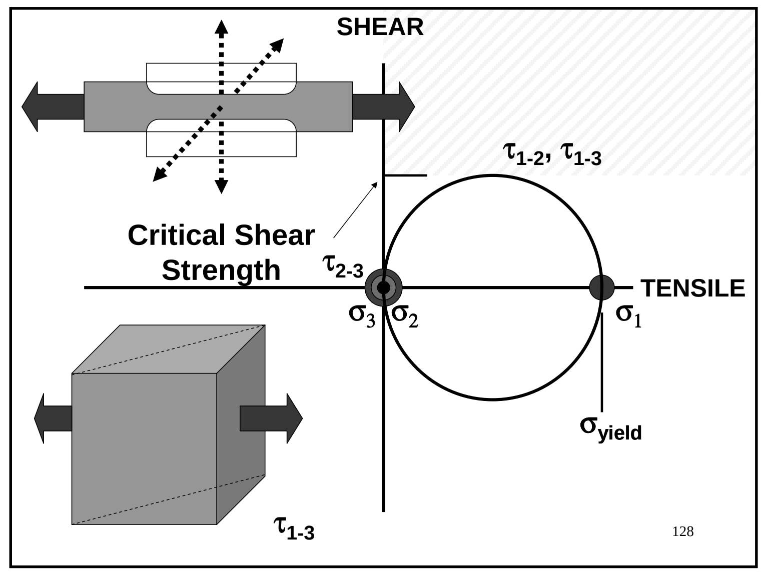

SHEAR
τ_{1-2}, τ_{1-3}
σ_2 - σ_3
τ_{2-3}
TENSILE
σ_3 σ_2 σ_1
σ_1 - σ_2 , σ_1 - σ_3
123

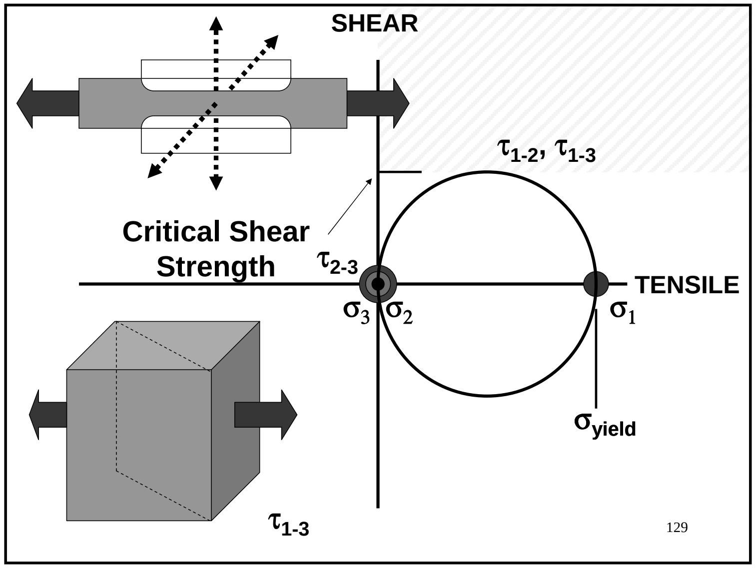

SHEAR
τ_{1-2}, τ_{1-3}
τ_{2-3}
TENSILE
σ_3 σ_2 σ_1
124

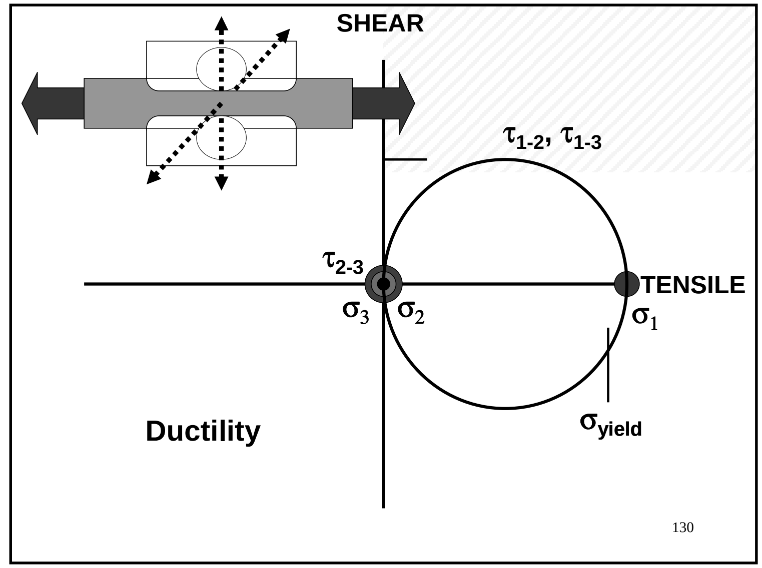

SHEAR
$\tau_{1\text{-}2}$, $\tau_{1\text{-}3}$
Critical Shear Strength
$\tau_{2\text{-}3}$
TENSILE
σ_3 σ_2
σ_1
σ_{yield}
$\tau_{1\text{-}2}$
125

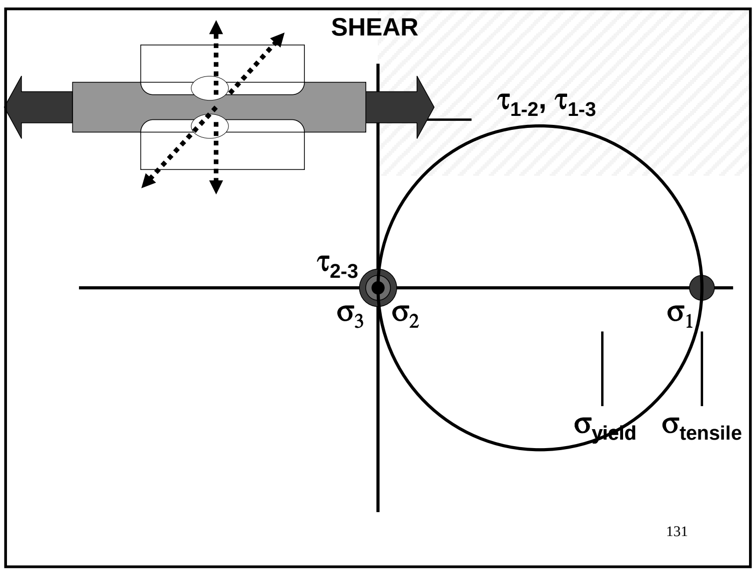

SHEAR
$\tau_{1\text{-}2}$, $\tau_{1\text{-}3}$
Critical Shear Strength
$\tau_{2\text{-}3}$
TENSILE
σ_3 σ_2
σ_1
σ_{yield}
$\tau_{1\text{-}2}$
126

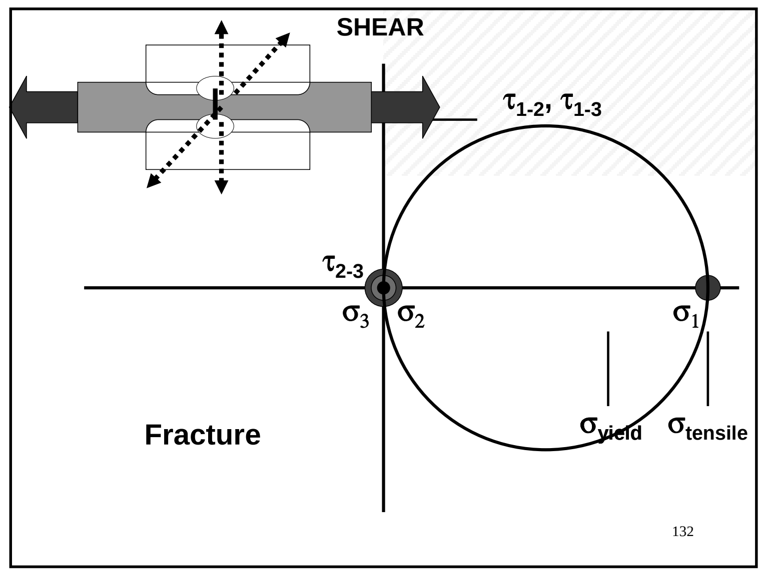

SHEAR
$\tau_{1\text{-}2}$, $\tau_{1\text{-}3}$
Critical Shear Strength
$\tau_{2\text{-}3}$
TENSILE
σ_3 σ_2
σ_1
σ_{yield}
$\tau_{1\text{-}2}$
127

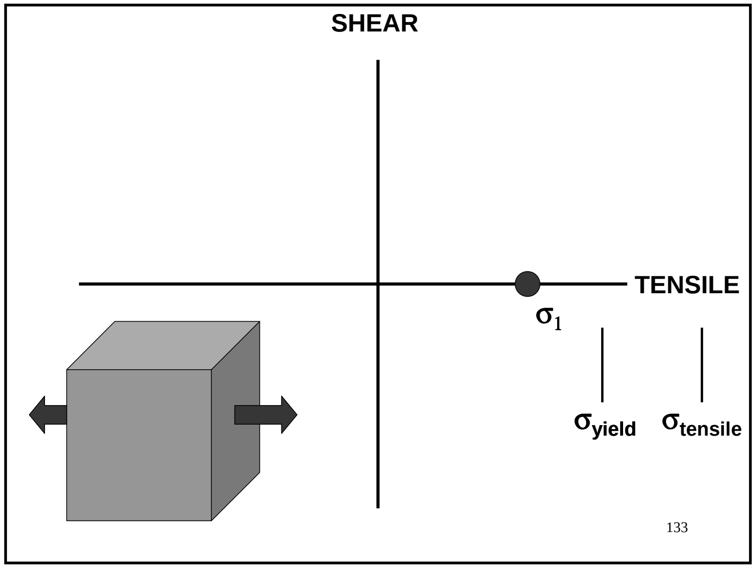

SHEAR
$\tau_{1\text{-}2}$, $\tau_{1\text{-}3}$
Critical Shear Strength
$\tau_{2\text{-}3}$
TENSILE
σ_3 σ_2
σ_1
σ_{yield}
$\tau_{1\text{-}3}$
128

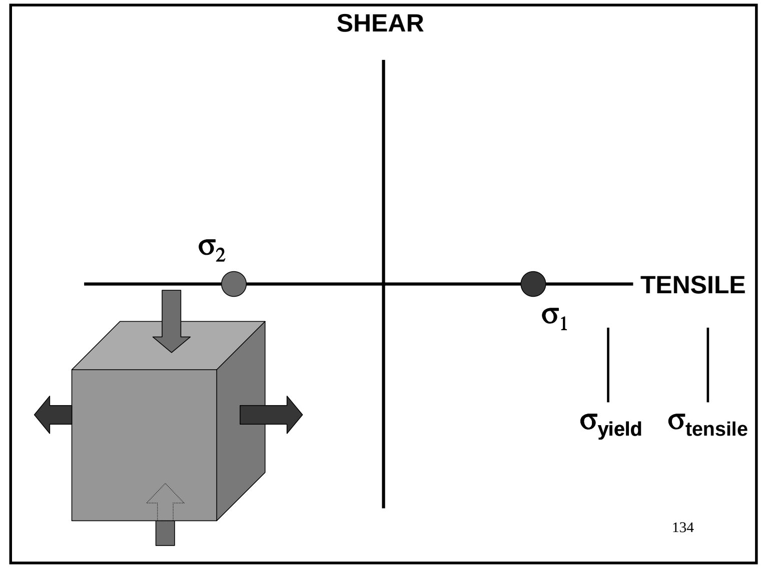

SHEAR
τ_{1-2}, τ_{1-3}
Critical Shear Strength
τ_{2-3}
TENSILE
σ_3 σ_2
σ_1
σ_{yield}
τ_{1-3}
129

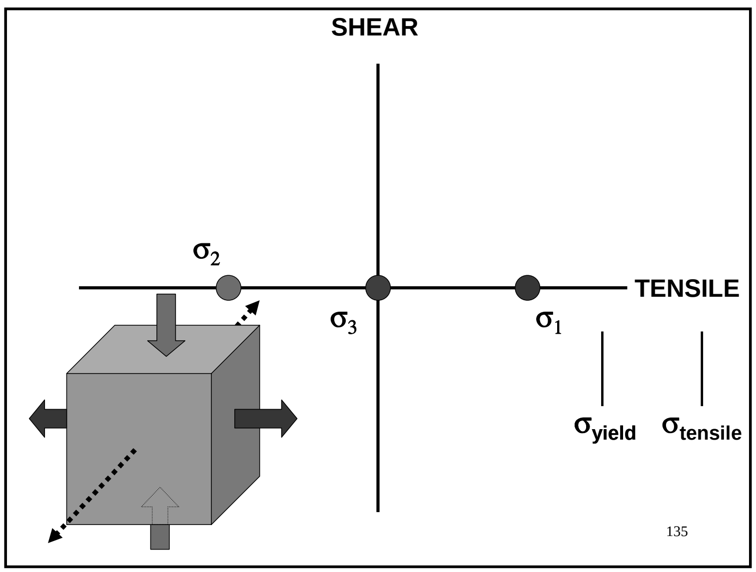

SHEAR
τ_{1-2}, τ_{1-3}
τ_{2-3}
TENSILE
σ_3 σ_2
σ_1
Ductility
σ_{yield}
130

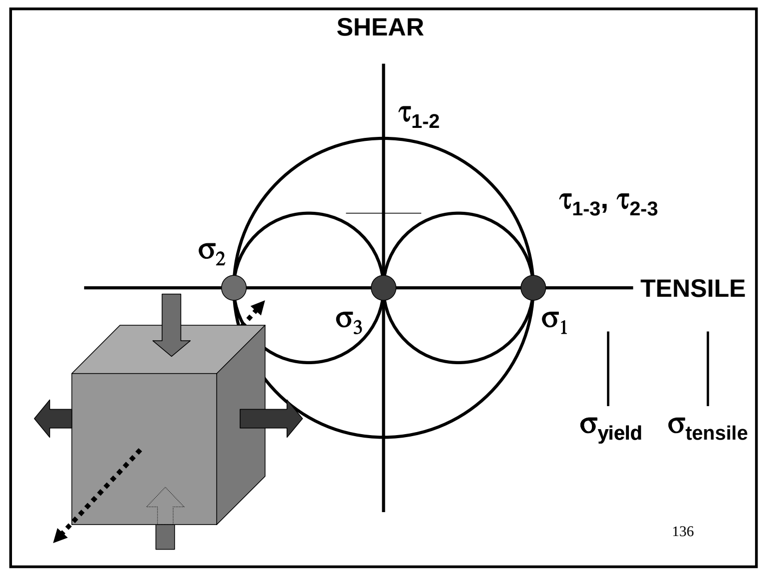

SHEAR
τ_{1-2}, τ_{1-3}
τ_{2-3}
σ_3 σ_2
σ_1
σ_{yield} $\sigma_{tensile}$
131

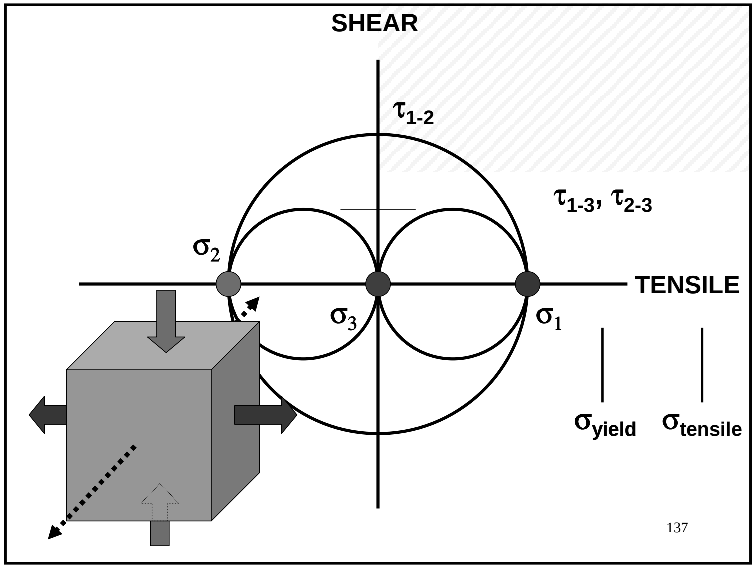

SHEAR
τ_{1-2}, τ_{1-3}
τ_{2-3}
σ_3 σ_2
σ_1
Fracture
σ_{yield} $\sigma_{tensile}$
132

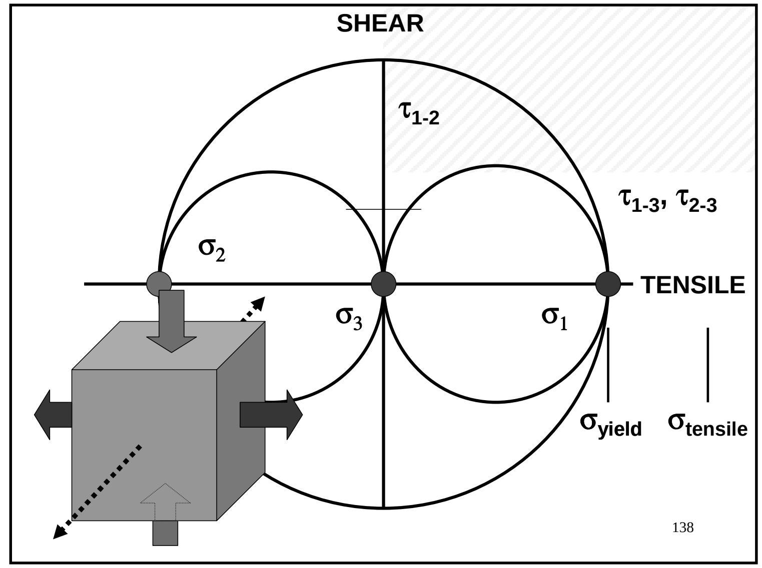

SHEAR
TENSILE
σ1
σyield
σtensile
133

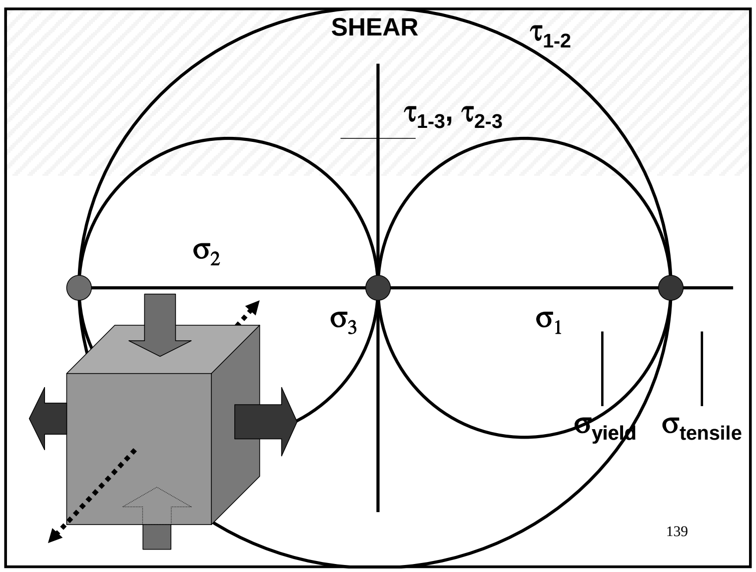

SHEAR
σ2
TENSILE
σ1
σyield
σtensile
134

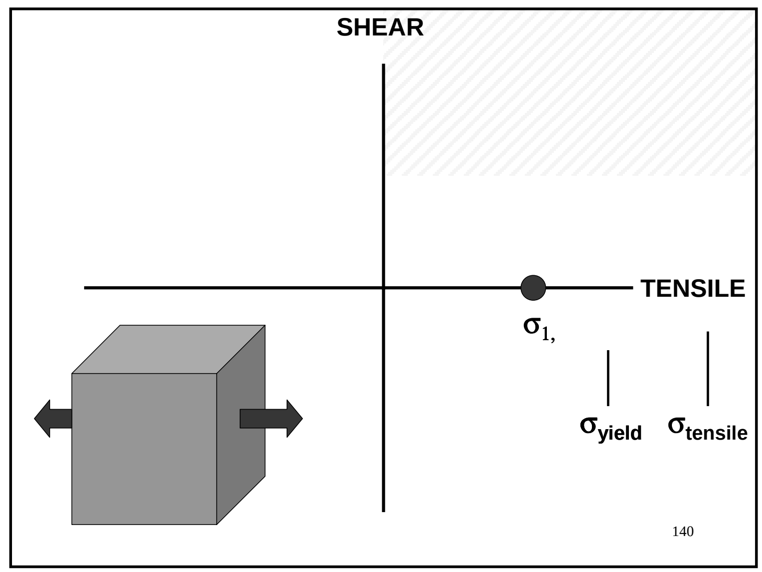

SHEAR
σ2
TENSILE
σ3
σ1
σyield
σtensile
135

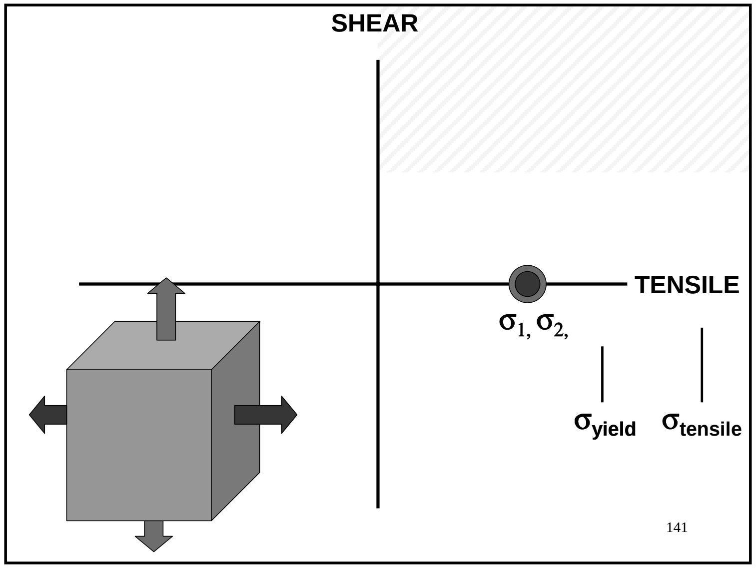

SHEAR
τ1-2
τ1-3, τ2-3
σ2
TENSILE
σ3
σ1
σyield
σtensile
136

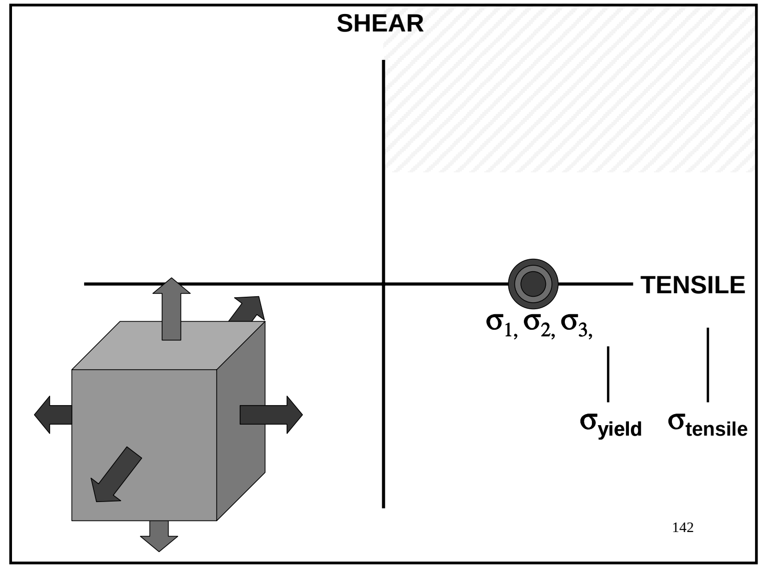

SHEAR
τ_{1-2}
τ_{1-3}, τ_{2-3}
σ_2
TENSILE
σ_3
σ_1
σ_{yield}
$\sigma_{tensile}$
137

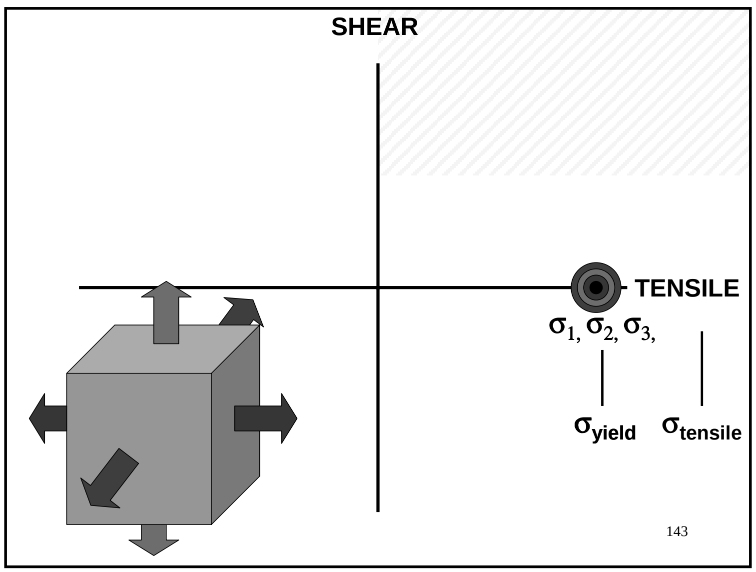

SHEAR
τ_{1-2}
τ_{1-3}, τ_{2-3}
σ_2
TENSILE
σ_3
σ_1
σ_{yield}
$\sigma_{tensile}$
138

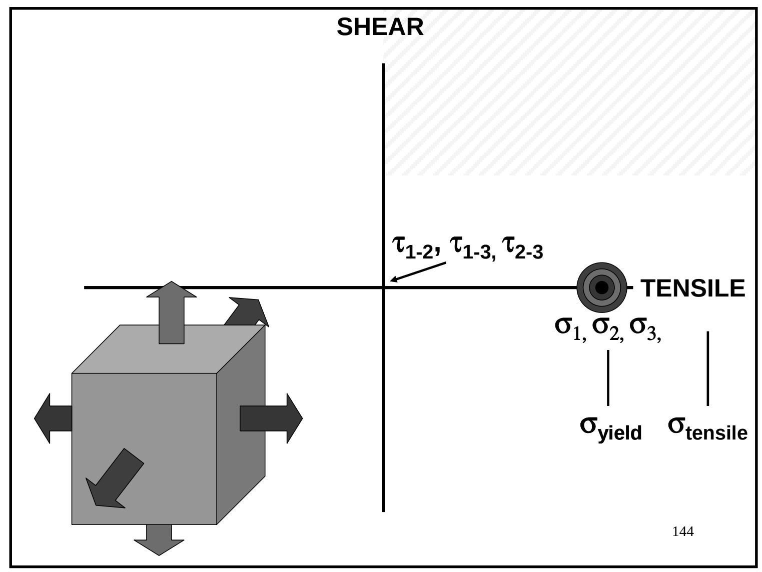

SHEAR
τ_{1-2}
τ_{1-3}, τ_{2-3}
σ_2
σ_3
σ_1
σ_{yield}
$\sigma_{tensile}$
139

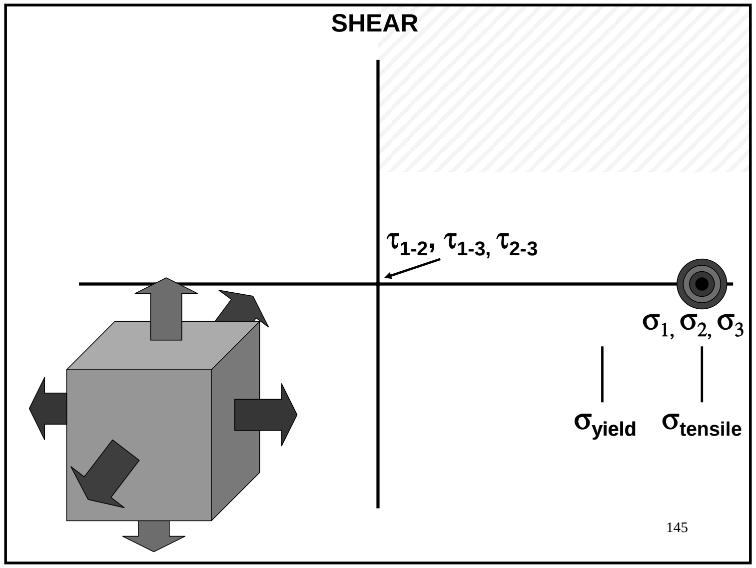

SHEAR
TENSILE
σ_1,
σ_{yield}
$\sigma_{tensile}$
140

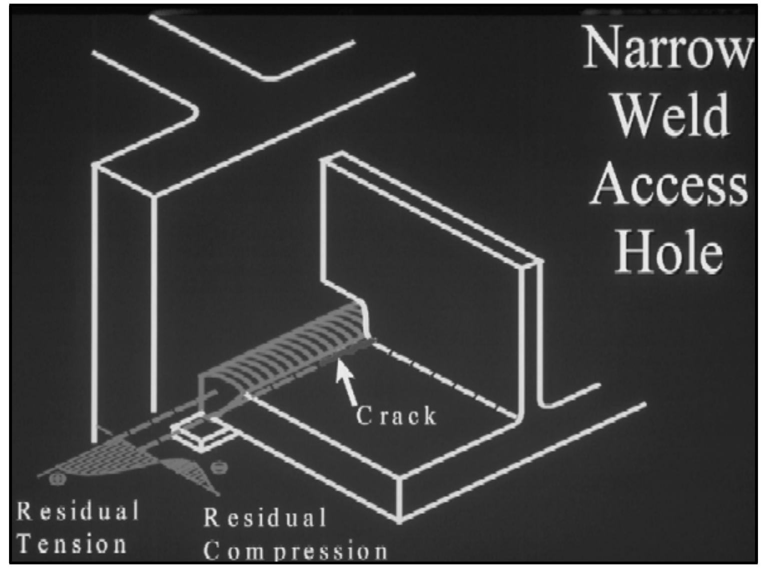

SHEAR
TENSILE
σ1, σ2,
σyield
σtensile
141

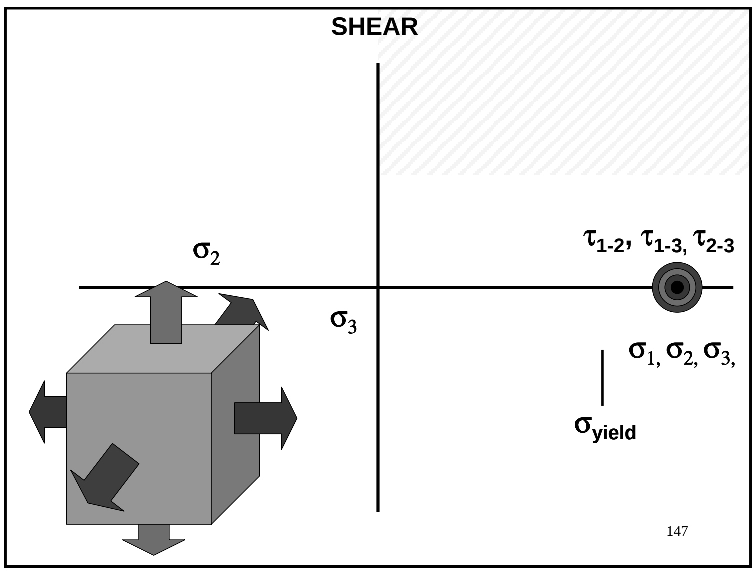

SHEAR
TENSILE
σ1, σ2, σ3,
σyield
σtensile
142


SHEAR
TENSILE
σ1, σ2, σ3,
σyield
σtensile
143

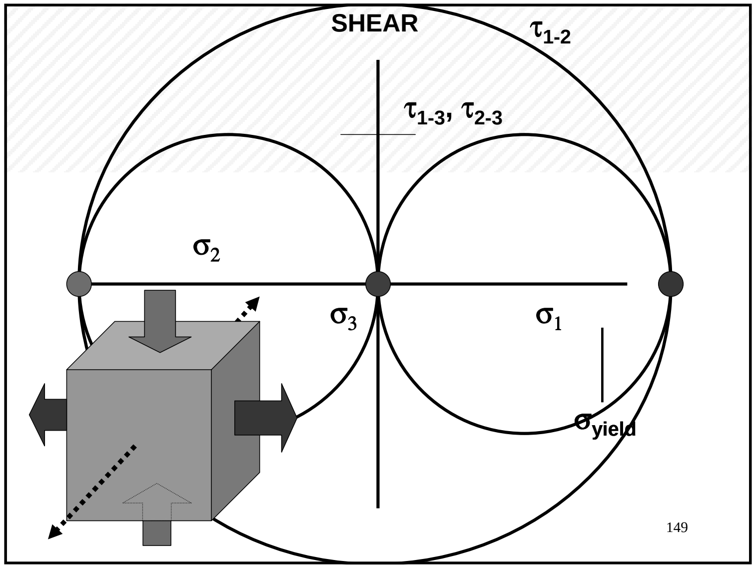

SHEAR
τ1-2, τ1-3, τ2-3
TENSILE
σ1, σ2, σ3,
σyield
σtensile
144

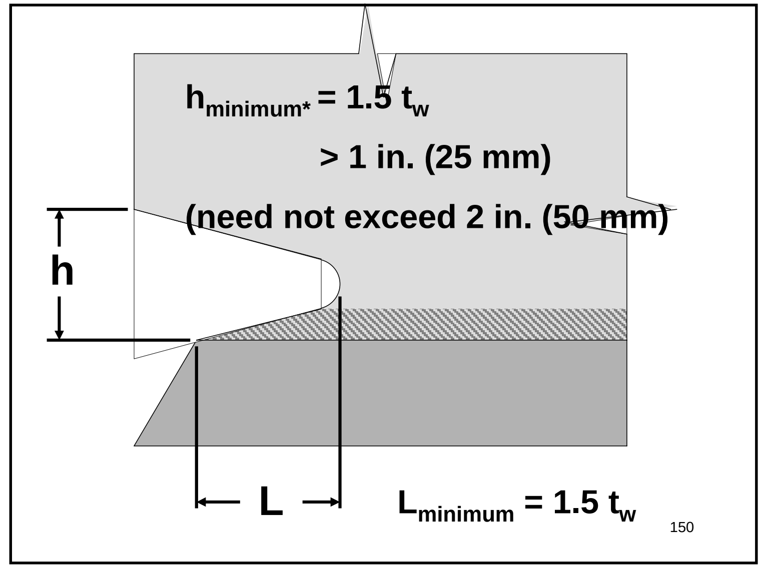

SHEAR
$\tau_{1-2}, \tau_{1-3}, \tau_{2-3}$
$\sigma_1, \sigma_2, \sigma_3$
σ_{yield}
$\sigma_{tensile}$
145

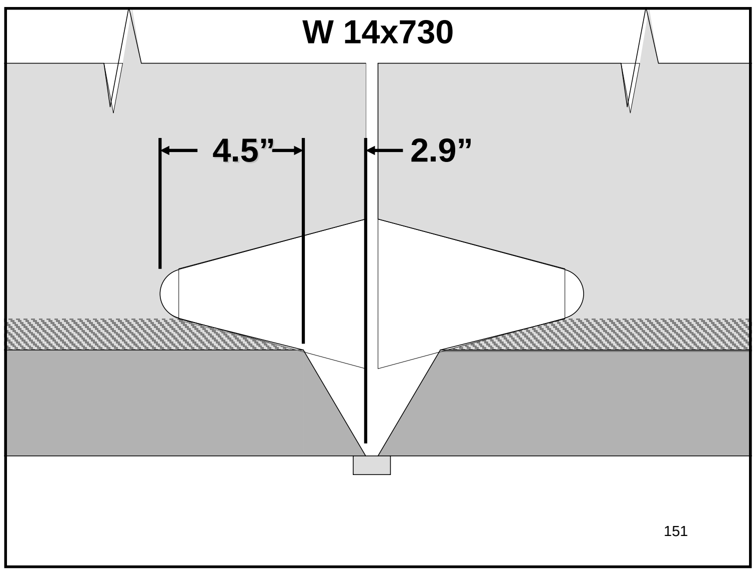

Narrow Weld Access Hole
Crack
Residual Tension
Residual Compression

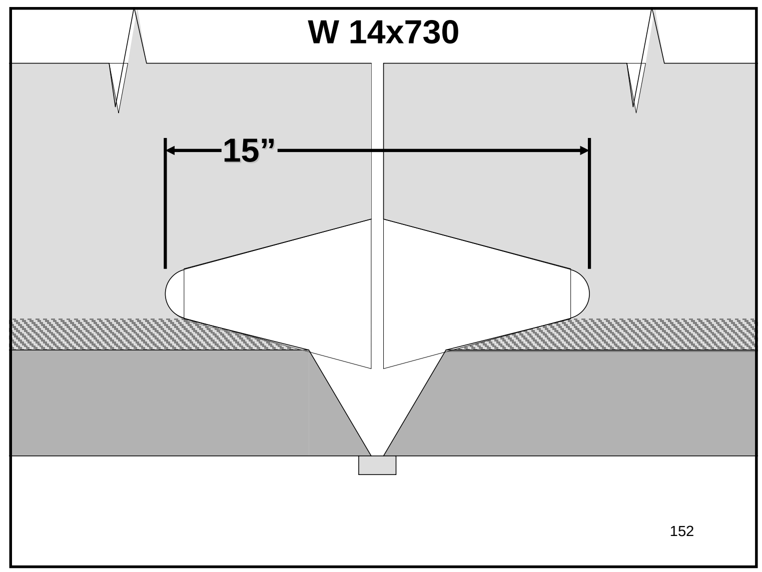

SHEAR
σ_2
σ_3
$\tau_{1-2}, \tau_{1-3}, \tau_{2-3}$
$\sigma_1, \sigma_2, \sigma_3,$
σ_{yield}
147

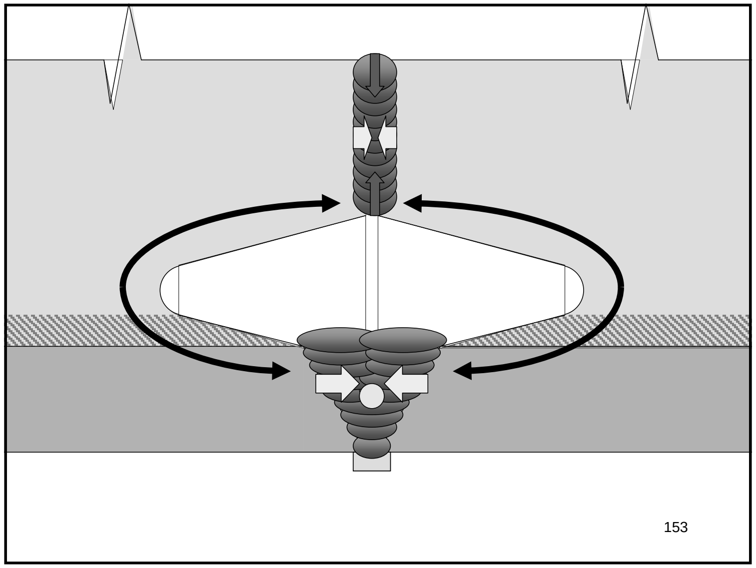

Wide Weld Access Hole
Residual Tension
Residual Compression

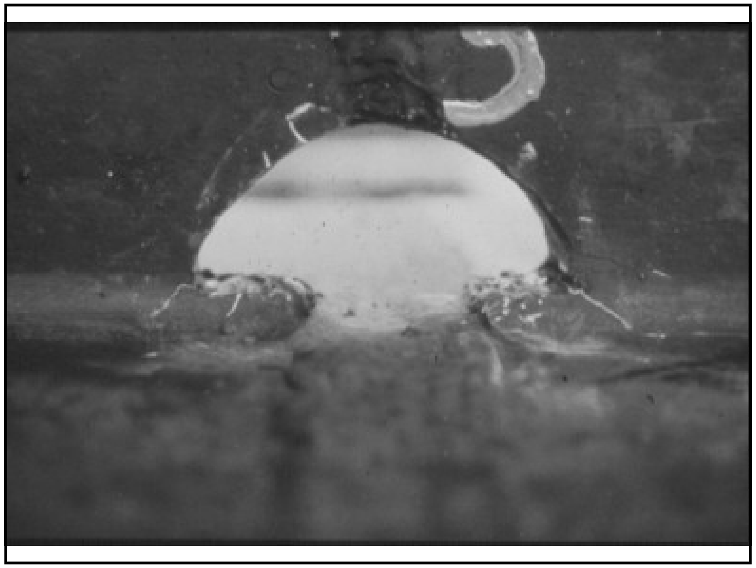

SHEAR
τ_{1-2}
τ_{1-3}, τ_{2-3}
σ_2
σ_3
σ_1
σ_{yield}
149

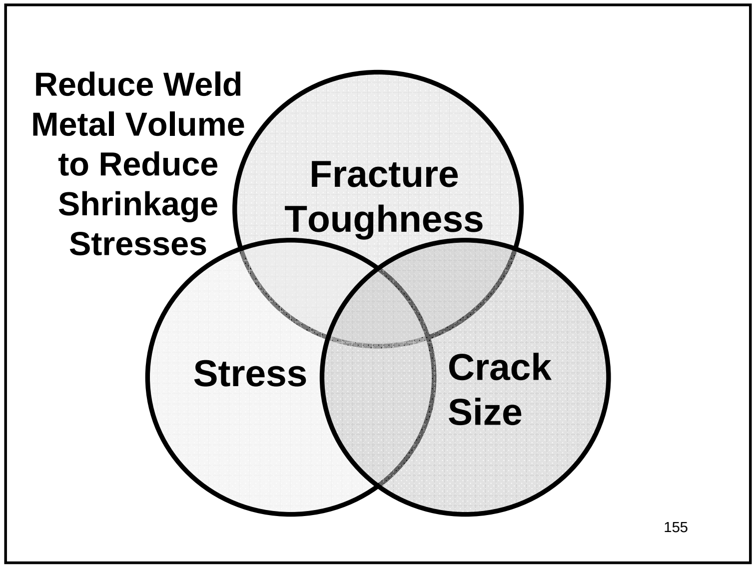

$h_{minimum*}$ = 1.5 t_w
> 1 in. (25 mm)
(need not exceed 2 in. (50 mm)
h
L
$L_{minimum}$ = 1.5 t_w
150

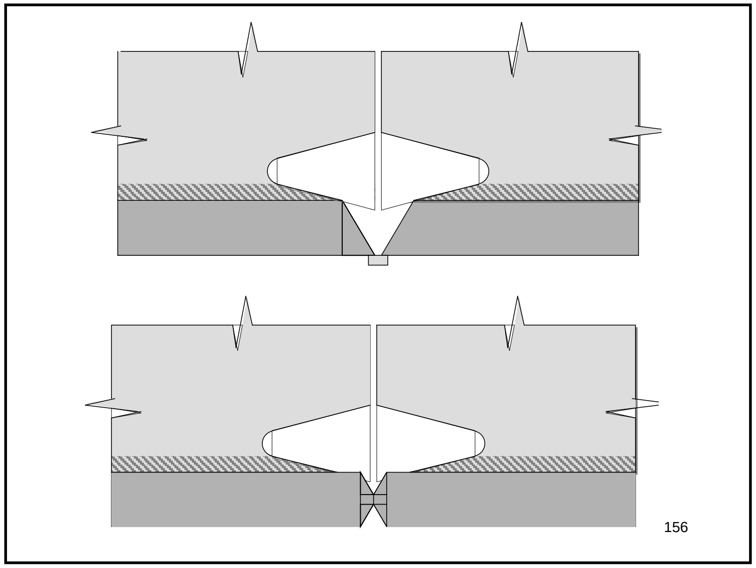

W 14x730
4.5”
2.9”
151

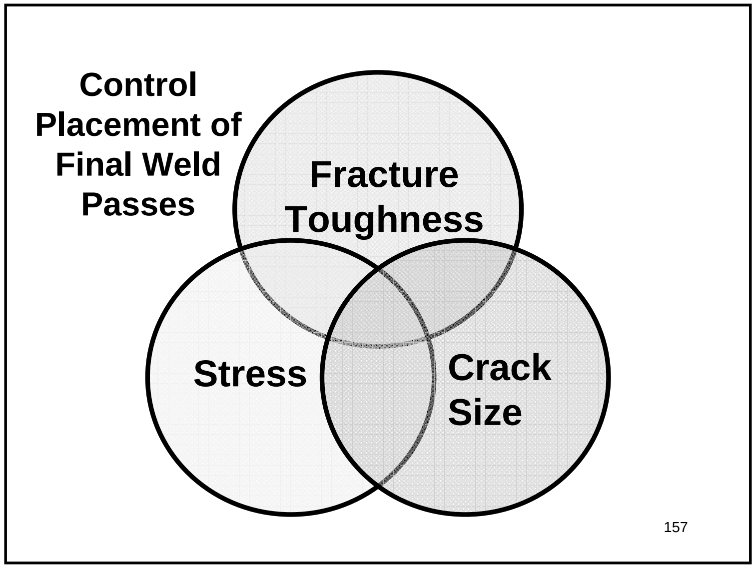

W 14x730
15”
152

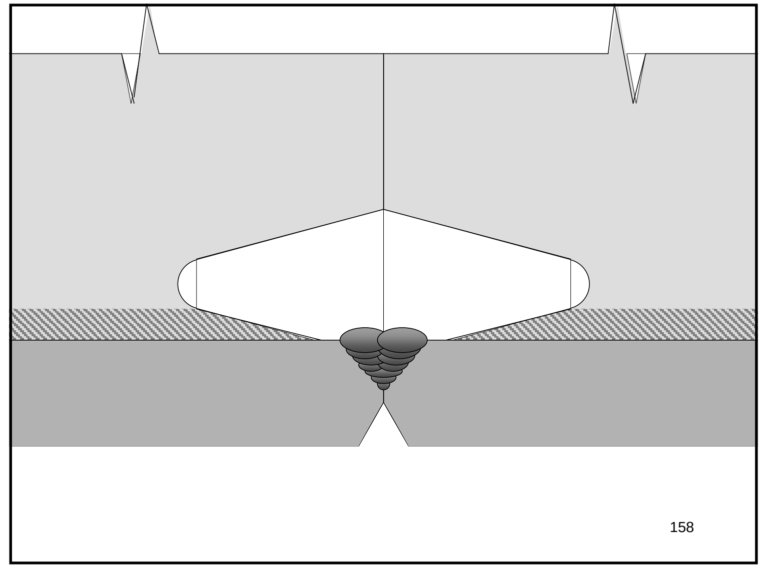

153

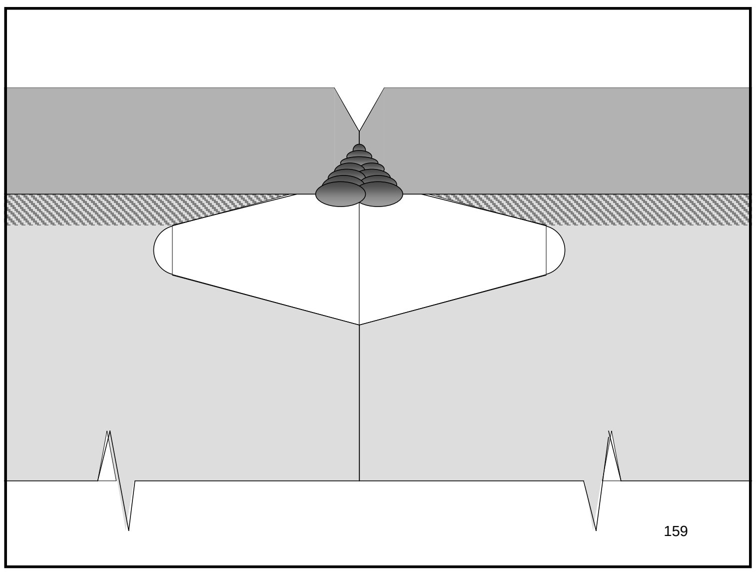


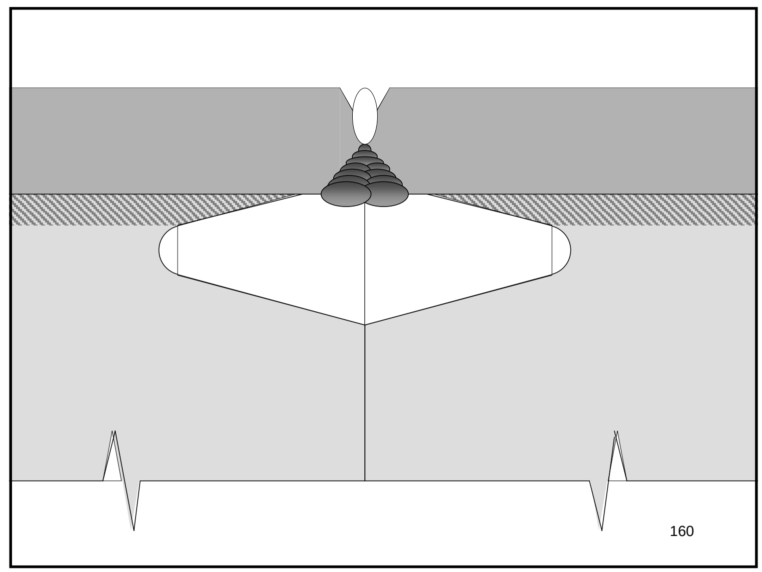

Reduce Weld Metal Volume to Reduce Shrinkage Stresses
Fracture Toughness
Stress
Crack Size
155

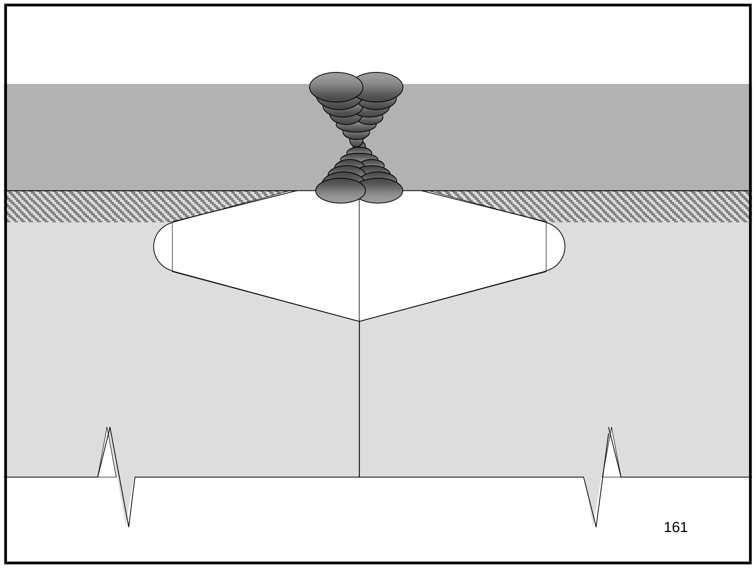

156

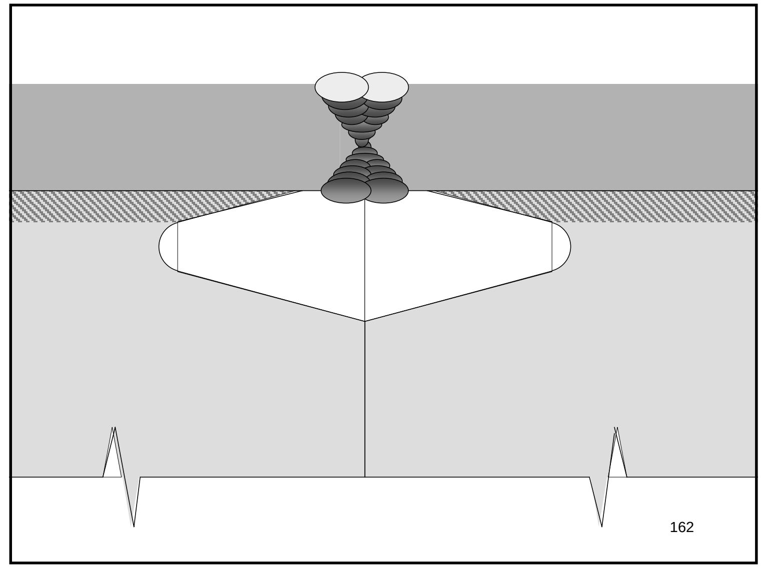

Control
Placement of
Final Weld
Passes
Fracture
Toughness
Stress
Crack
Size
157

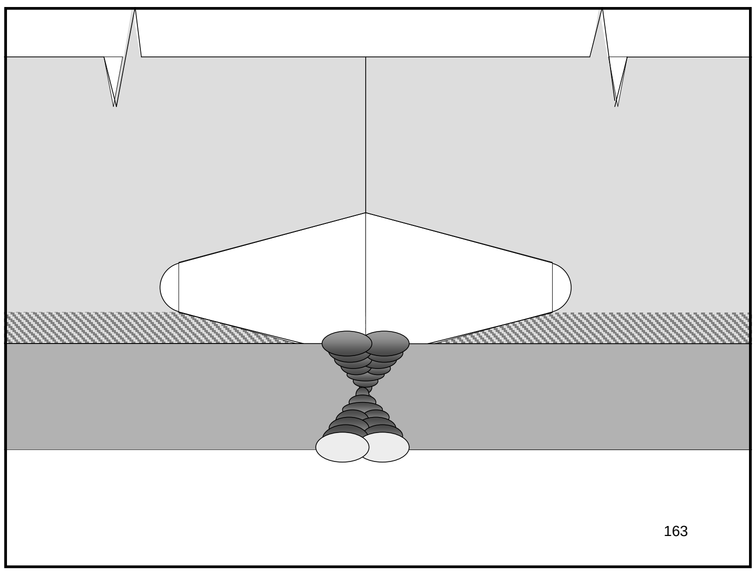

158

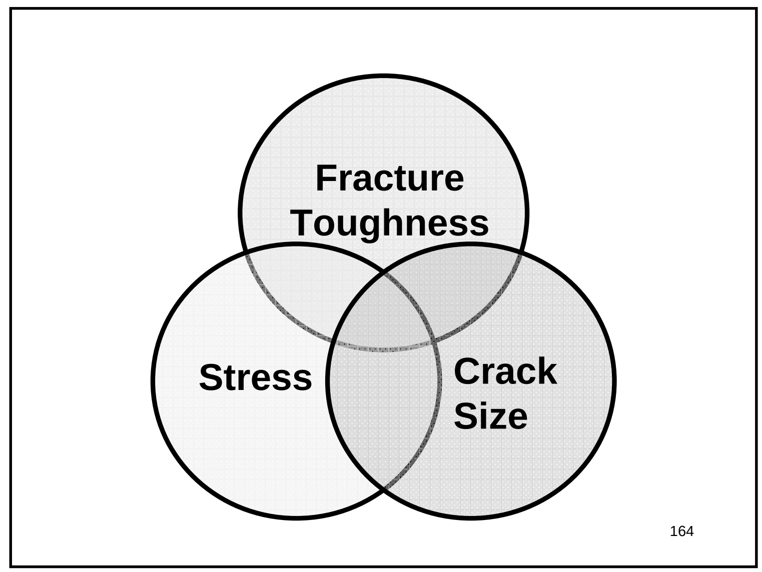

159

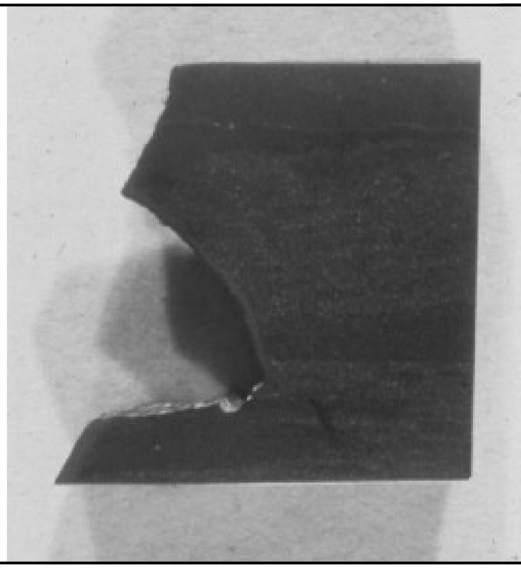

160


161

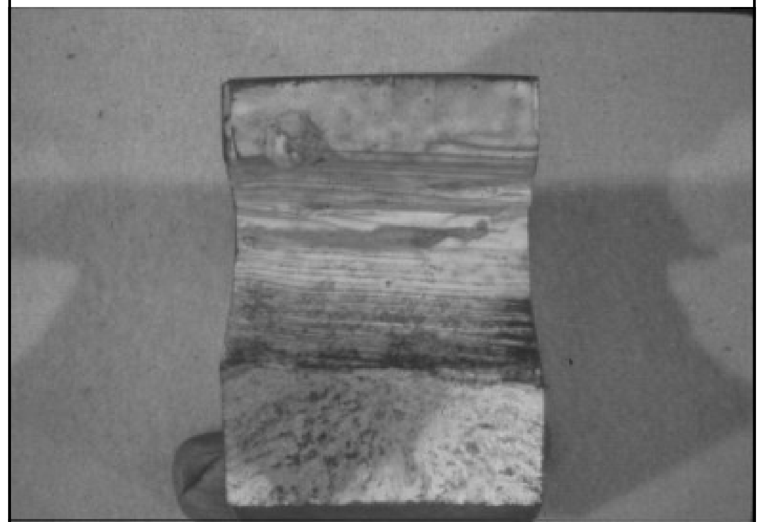

162

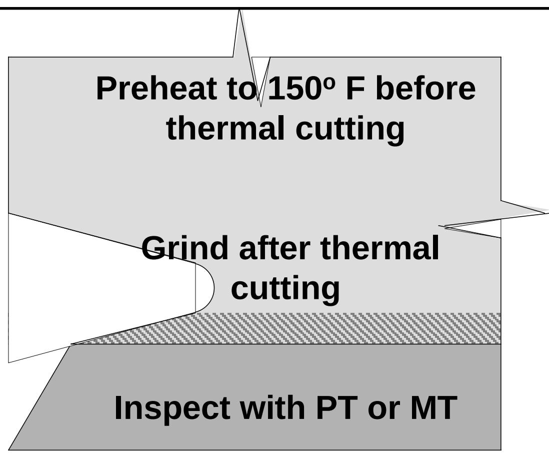

163


Fracture Toughness
Stress
Crack Size
164

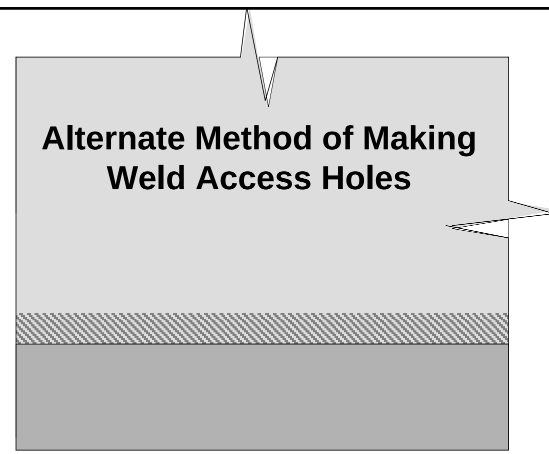


165

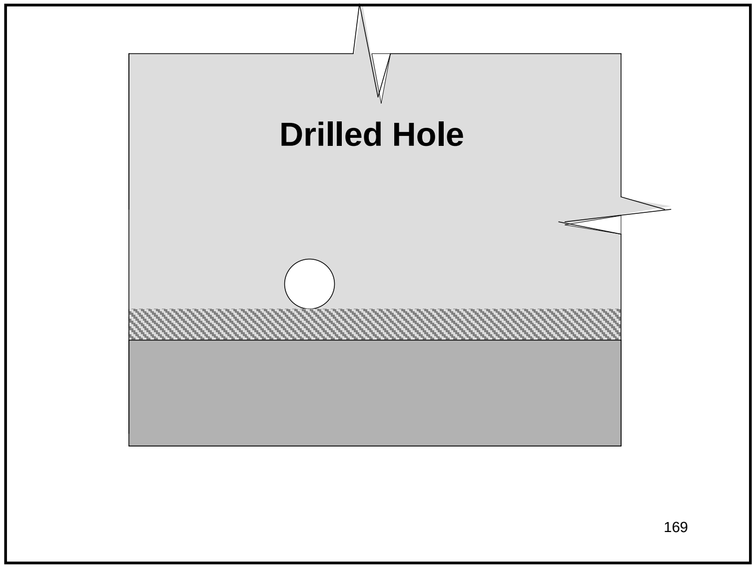


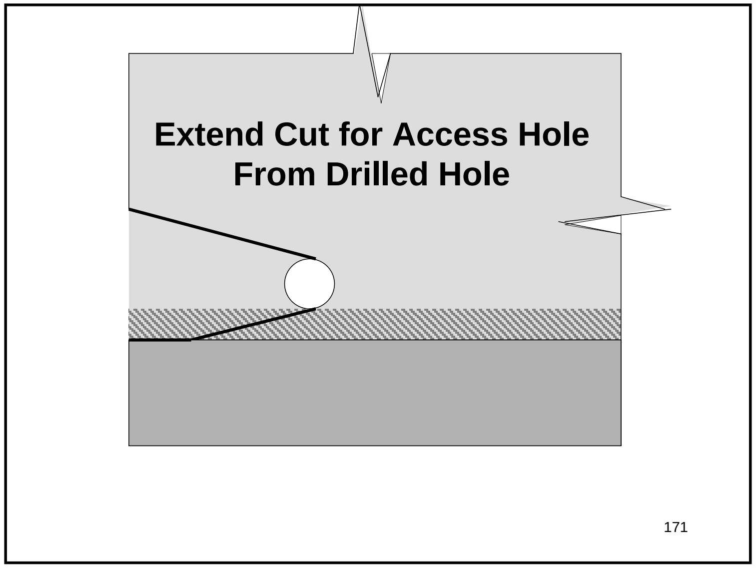

Preheat to 150º F before thermal cutting
Grind after thermal cutting
Inspect with PT or MT

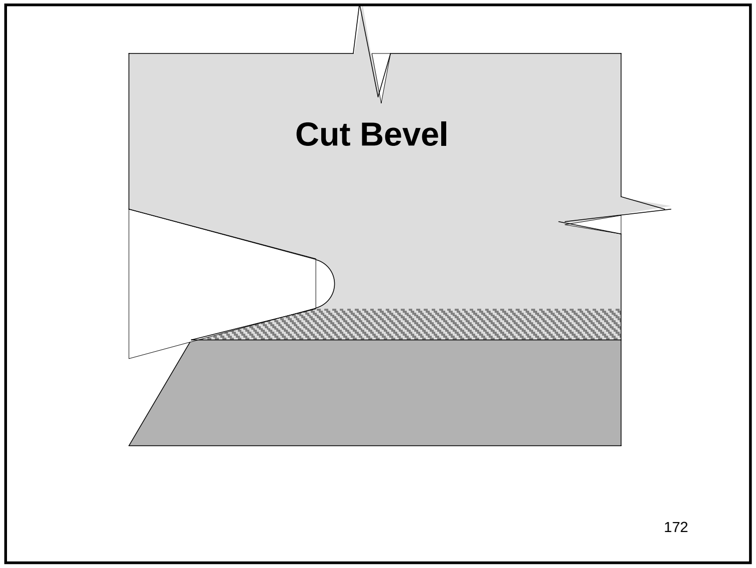
167

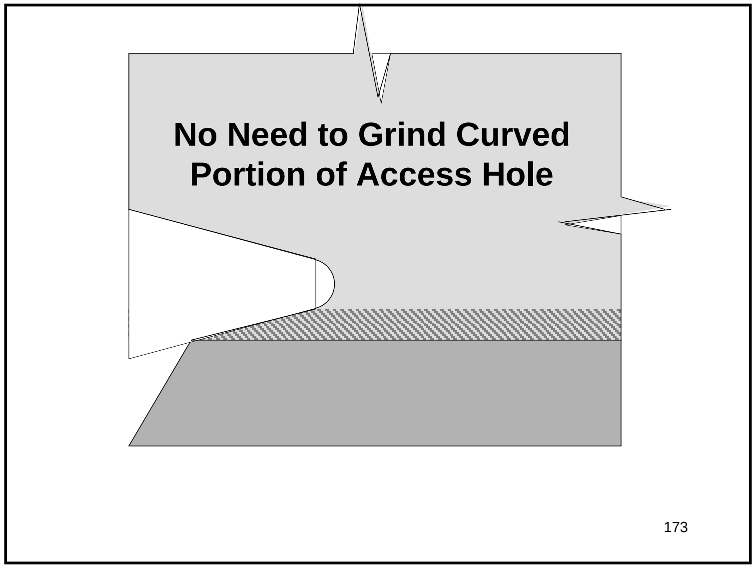

Alternate Method of Making Weld Access Holes

168


Drilled Hole
169


Extend Cut for Access Hole
From Drilled Hole
171


Cut Bevel
172


No Need to Grind Curved Portion of Access Hole
173

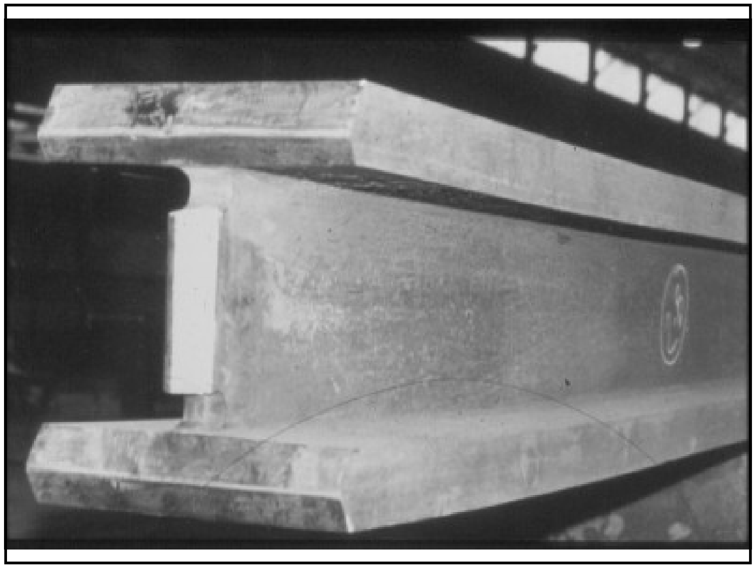



PLATE 19

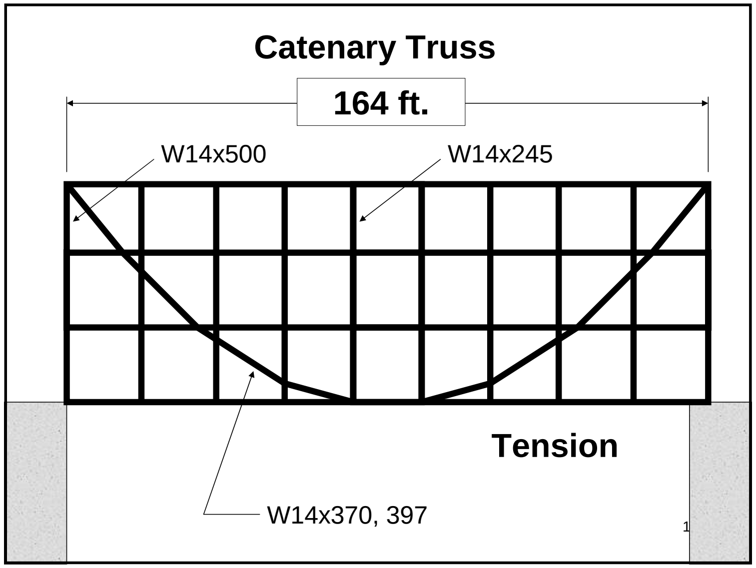
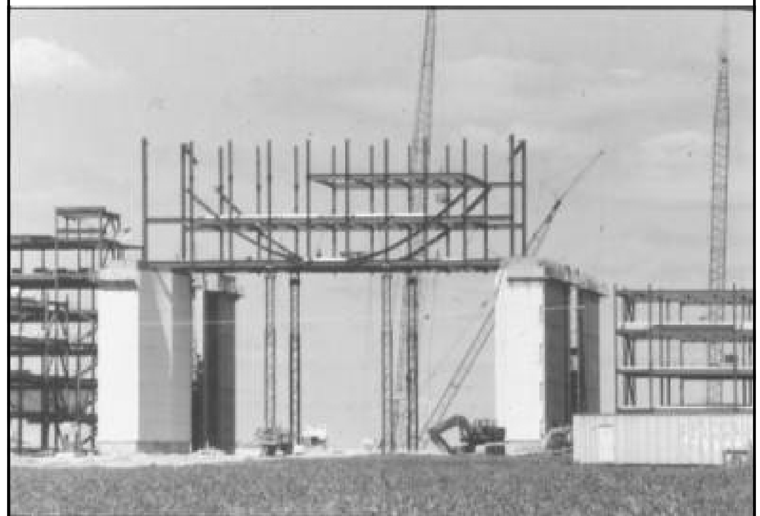
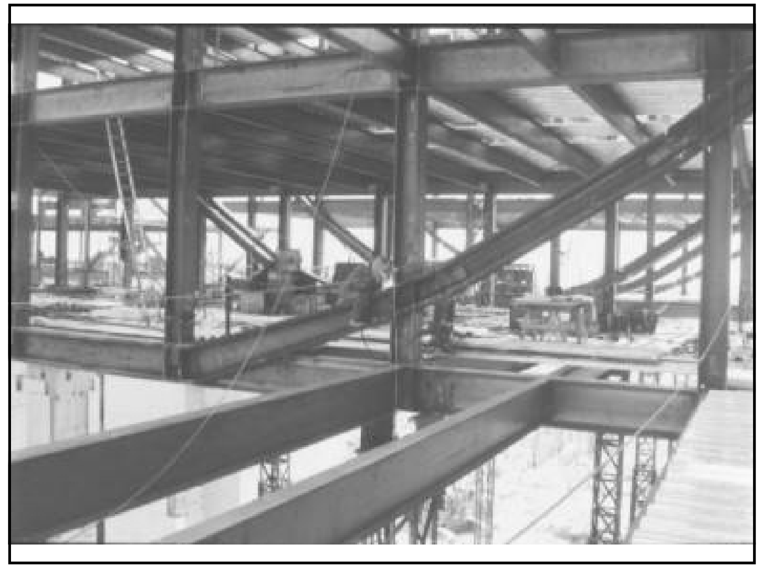

Catenary Truss
164 ft.
W14x500
W14x245
Tension
W14x370, 397


PLATE 11





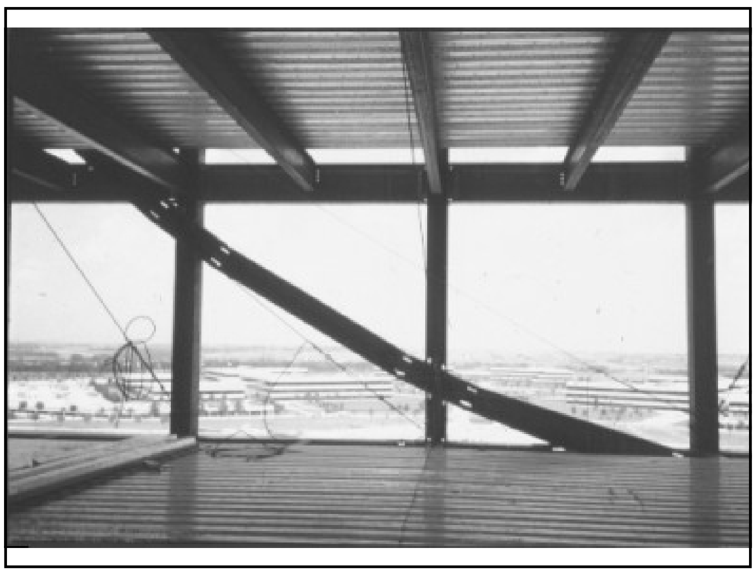



PLATE 18

Special Welding Applications

- Extending Anchor Rod
- Welding Anchor Rod to Base Plates
- Welding on Coated Steels
- Welding Heavy Sections
- **Welding Under High Restraint**

186

Welding Under High Restraint

Increase Fracture Resistance
Reduce Shrinkage Stresses
Reduce Restraint

187

Welding Under High Restraint

- Increase Fracture Resistance
  - Avoid cracks and notches
    - Smooth transitions
    - Ground flame cut and rough surfaces
    - Ream punched holes
  - Use materials with defined notch toughness
  - Increase preheat levels

188

Welding Under High Restraint

Reduce Shrinkage Stresses
- Specify the smallest weld size possible
- For a given weld size, select details that will require the least amount of weld metal
- Control fitup
- Don't overweld
- Limit weld reinforcement
- For a given weld size, make the weld in the fewest number of weld passes
- For double-sided joints requiring backgouging, limit the backgouging to only that which is required

189

Welding Under High Restraint

Reduce Shrinkage Stresses (continued)
- Use filler metal with the lowest strength level possible
- In general, but not always, use higher levels of preheat, and heat a greater volume of weld metal
- Limit weld penetration
- Complete highly restrained weldments without interruption
- When around-the-clock welding is impossible, maintain around-the-clock interpass temperature control
- Plan the welding to ensure the assembly will need to be welded only once

190

Welding Under High Restraint

- Reduce Restraint
  - When possible, fabricate small subassemblies, and then join subassemblies into the final assembly
  - Weld components expected to have the greatest shrinkage first, then weld the members with less anticipated shrinkage
  - Weld the most rigid components first, saving the more flexible components for welding later
  - When possible, sequence the welding of various joints so that the shrinkage movement of the parts is all toward a relatively fixed central location

191

Welding Under High Restraint

- Reduce Restraint (continued)
  - For individual joints, balance shrinkage on opposite sides of the member, when possible
  - Slight gaps of 1/32–1/16 in. help accommodate shrinkage. Soft steel spacer wires in between members can help in this regard
  - Increasing the preheat, and increasing the volume of material preheated, can sometimes assist, particularly when transverse cracking is being experienced and the joint can be expanded thermally before welding
  - Preset members before welding and allow them to move during welding

192

Special Welding Applications

- **Welding HSS**
- Welding AESS
- Welding on Existing Structures
- Field Welding
- Heat Shrinking

193

Special Welding Applications

- Welding HSS
  - Connections and HSS member size

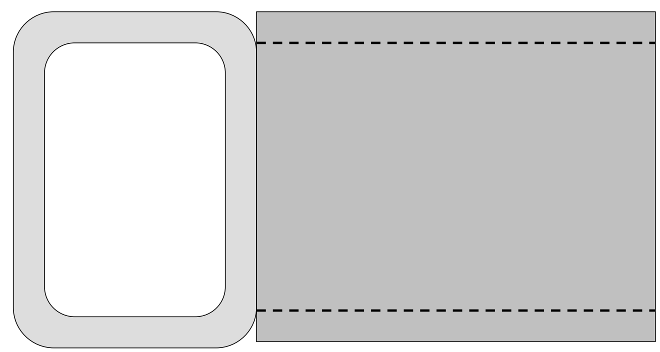
194

Special Welding Applications

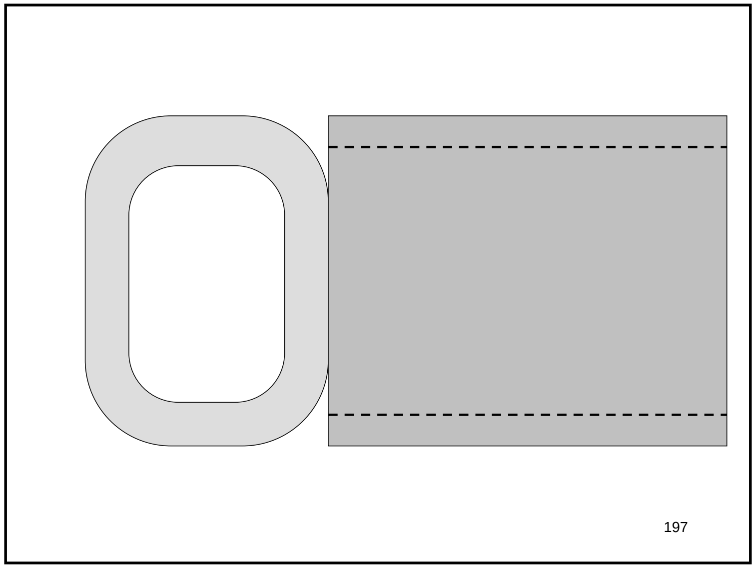
- Welding HSS
  - Connections and HSS member size
  - Overall configuration

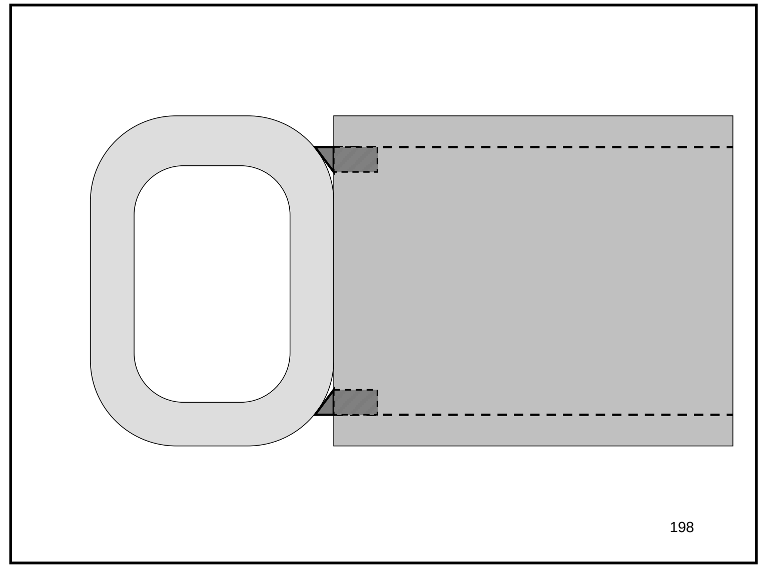
195

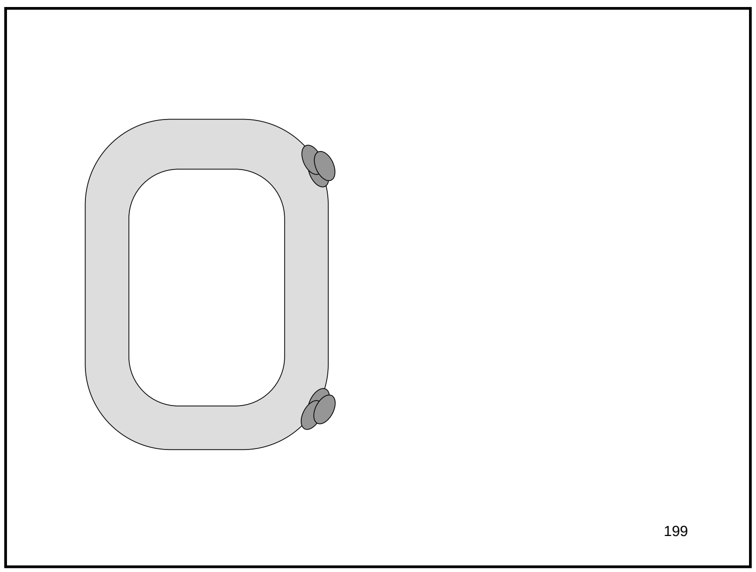
Matched Connection

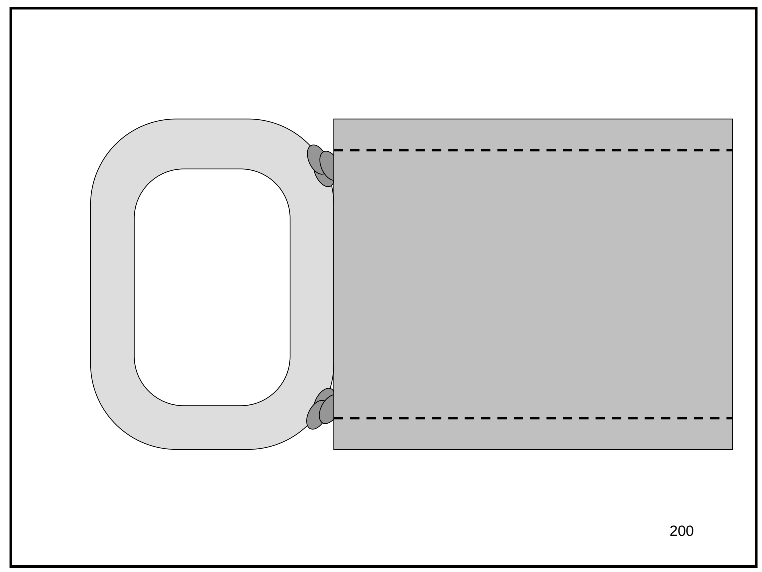


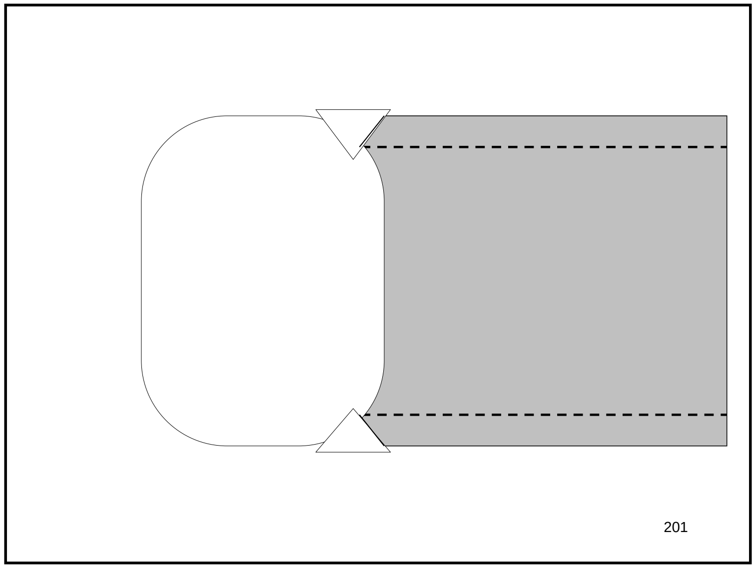
196

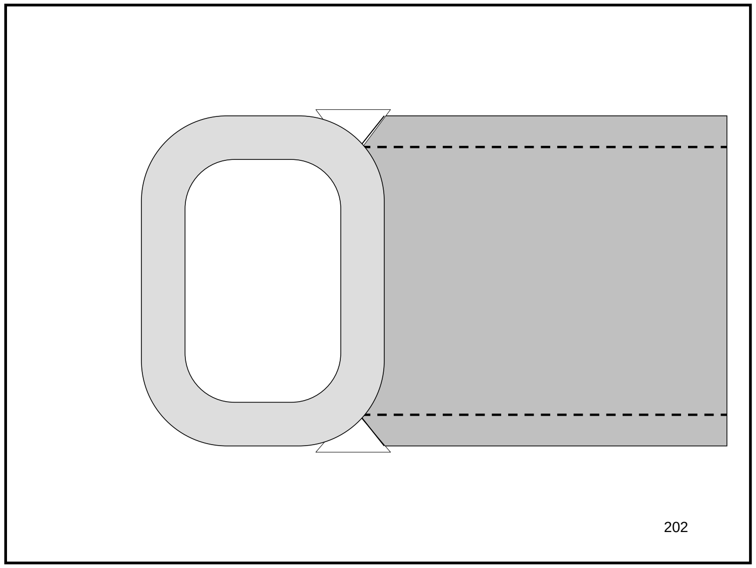

197

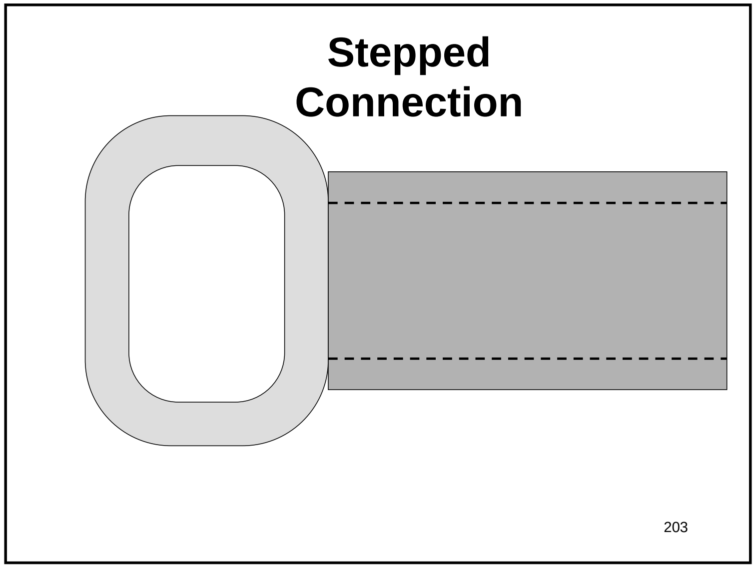

198

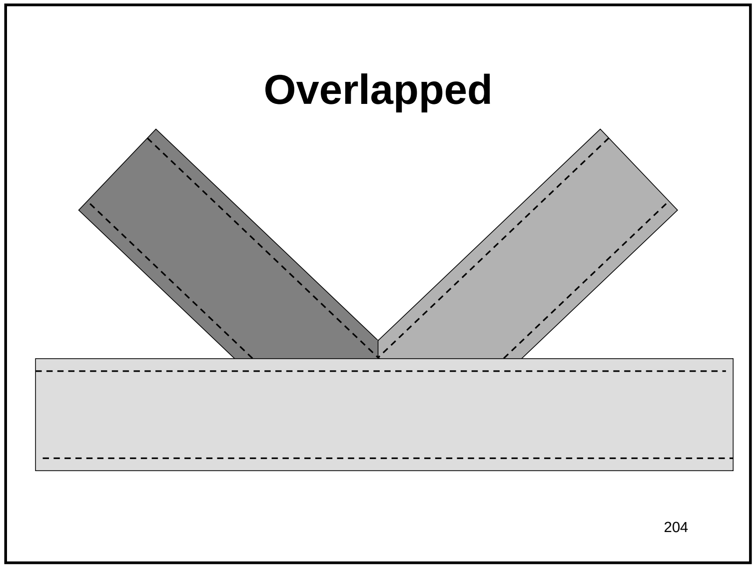

199


200

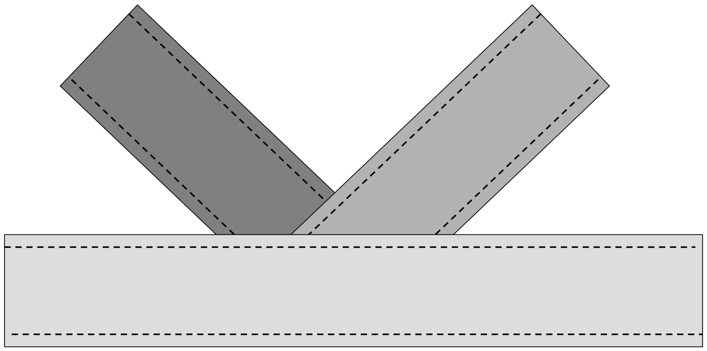

201


202


Stepped
Connection
203

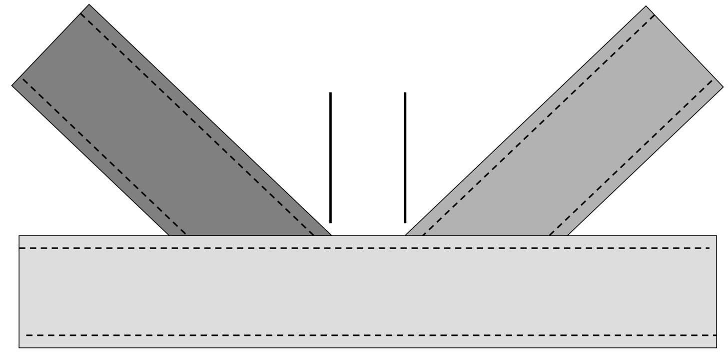

Overlapped
204

Overlapped



205

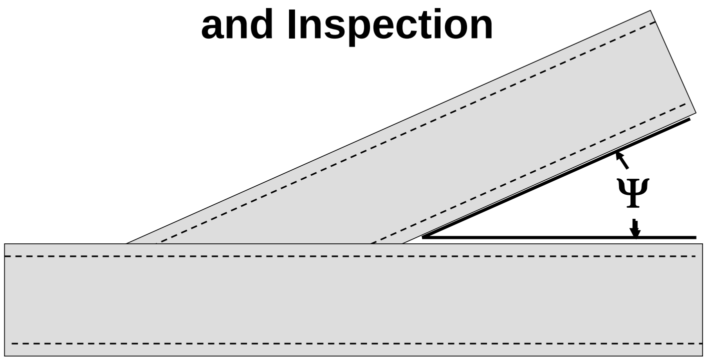
Gapped



Preferred

206

Provide Access for Welding and Inspection



$\Psi = 30^{o}$ minimum

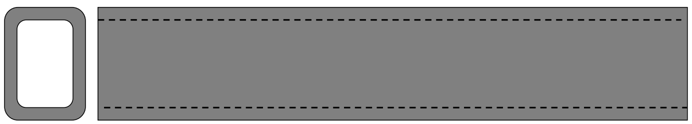
207

Special Welding Applications

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

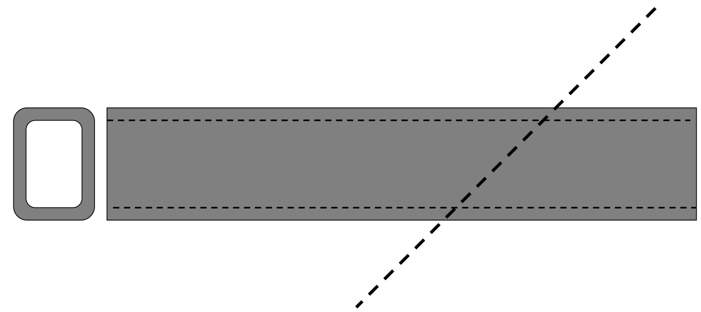
208

Box HSS



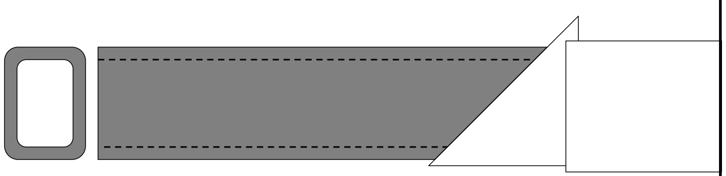
209

Box HSS



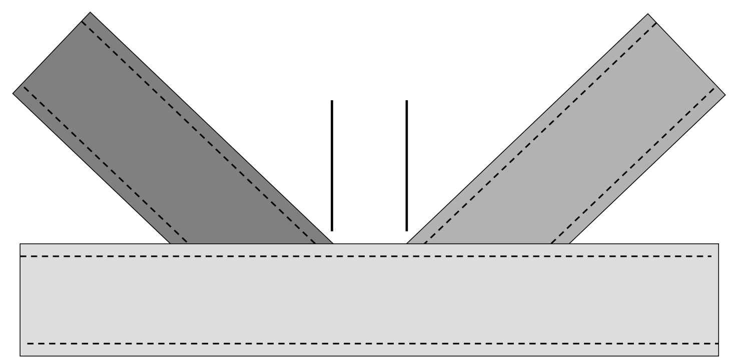
210

Box HSS



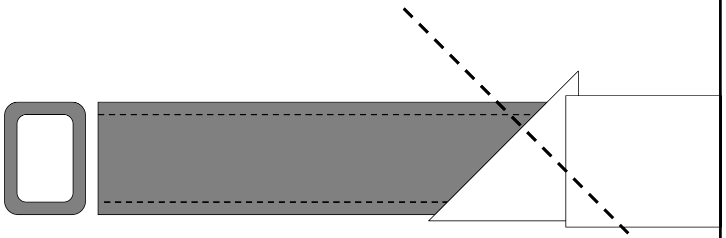
211

Gapped



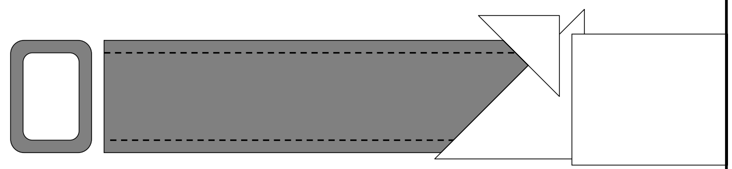
212

Box HSS



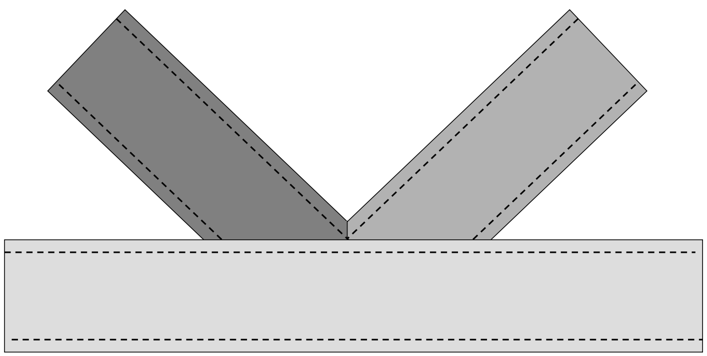
213

Box HSS



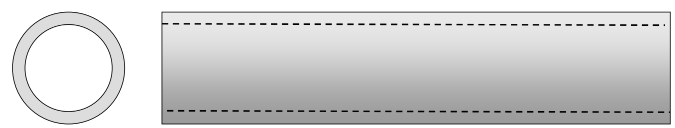
214

Overlapped



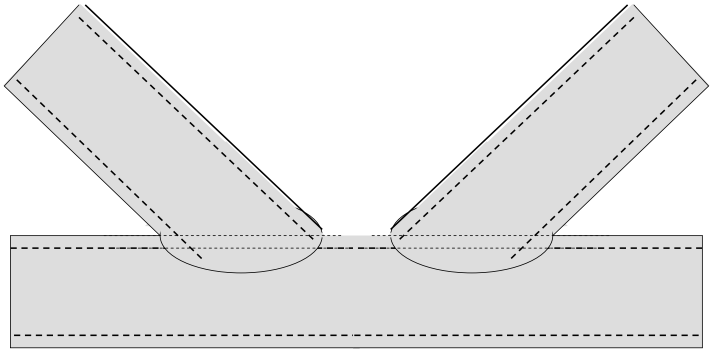
215

Round HSS



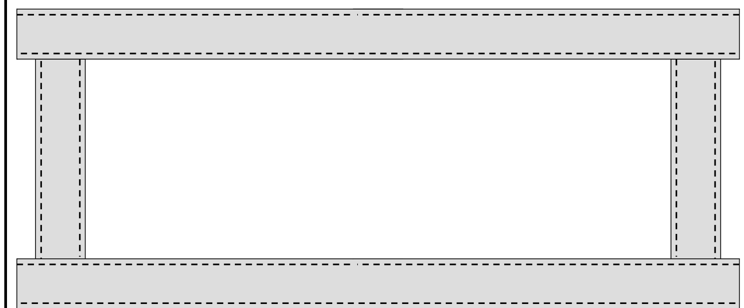
216

Round HSS



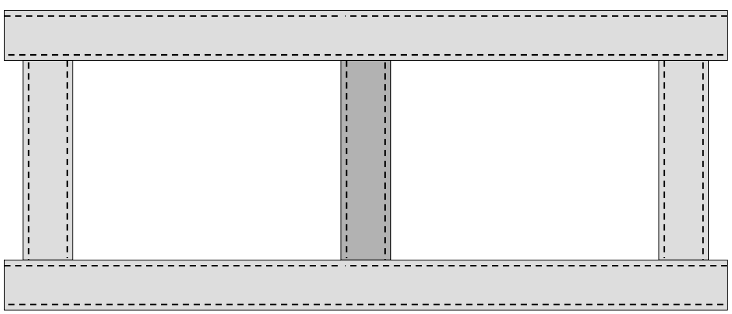
217

Box HSS



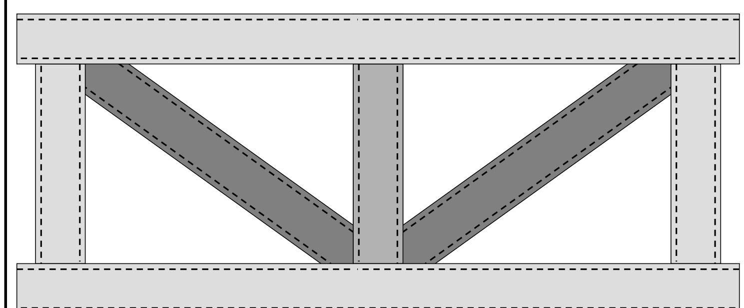
218

Box HSS



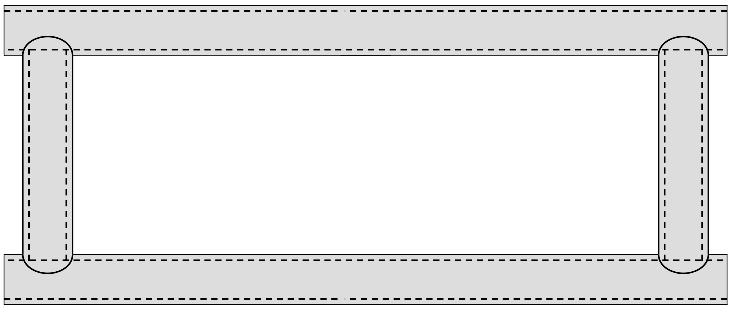
219

Box HSS



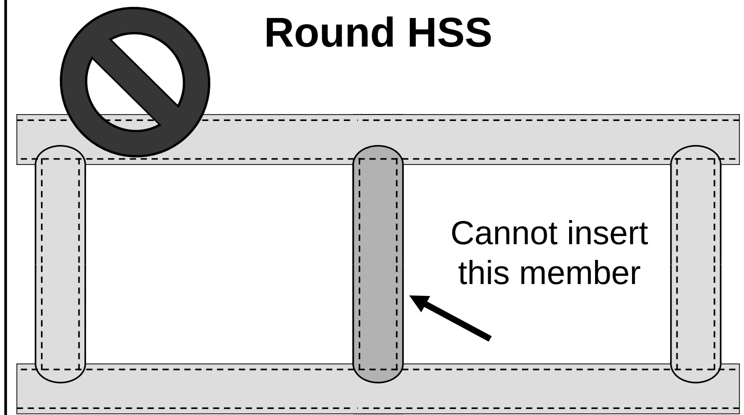
220

Round HSS



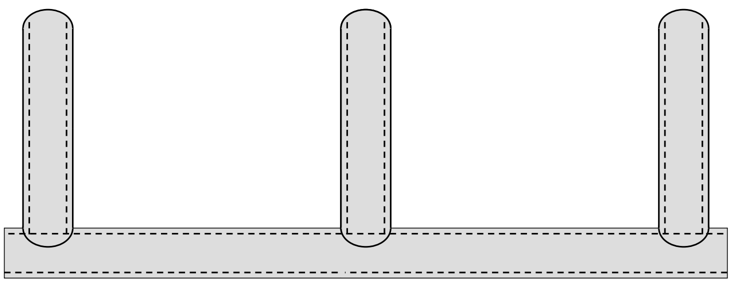
221

Round HSS



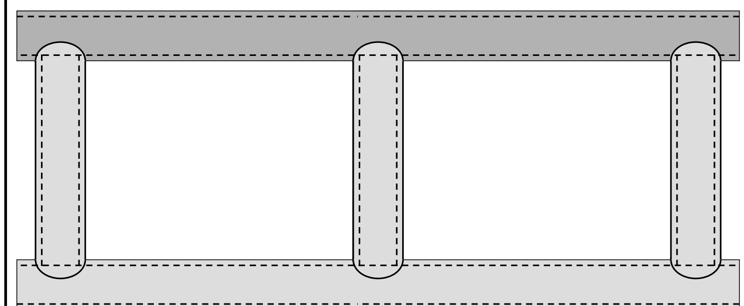
222

Round HSS



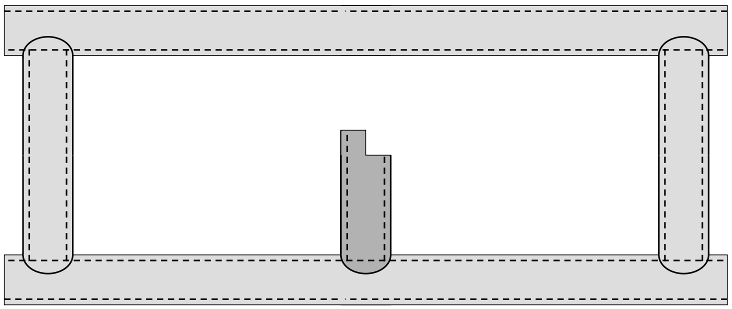
223

Round HSS



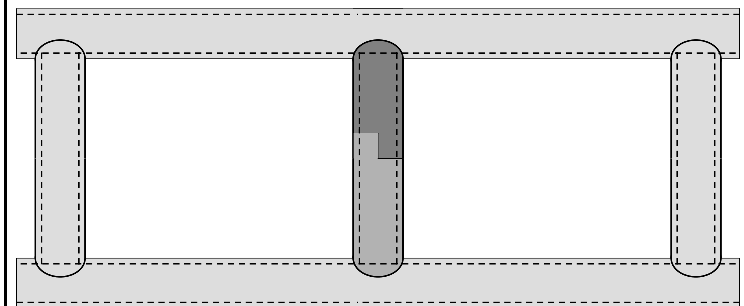
224

Round HSS



225

Round HSS



226

Special Welding Applications

- Welding HSS
- **Welding AESS**
- Welding on Existing Structures
- Field Welding
- Heat Shrinking

227

230

231

3

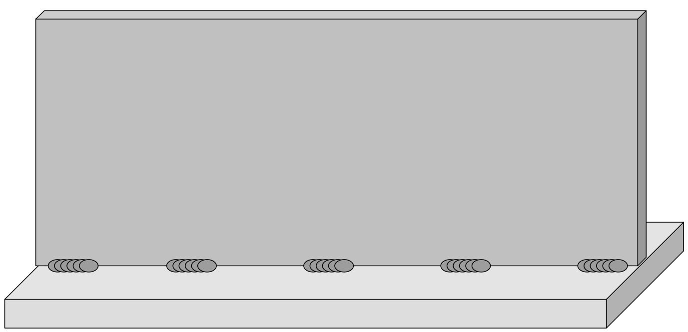
Special Welding Applications

Welding AESS

- **Use of Mock-ups**
- **Visual Inspection from the observer's distance and perspective**
- **Note requirements on drawings**
- **Technical issues**

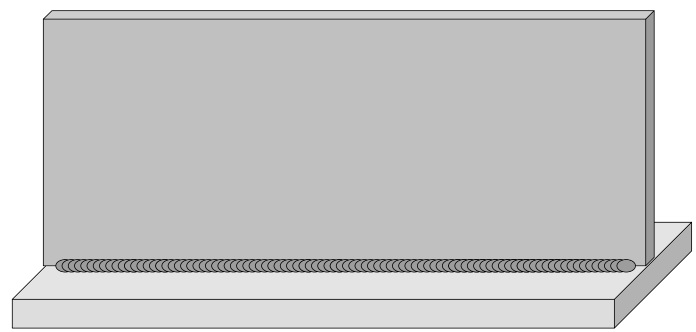
234

Required for strength

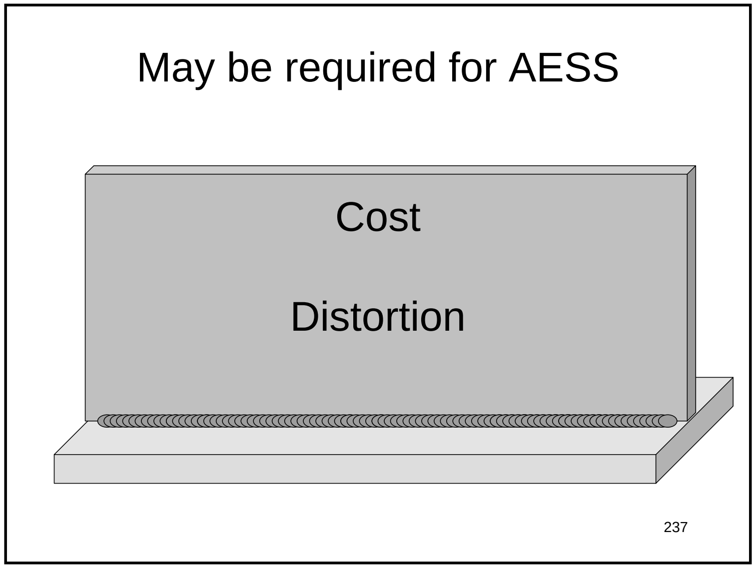


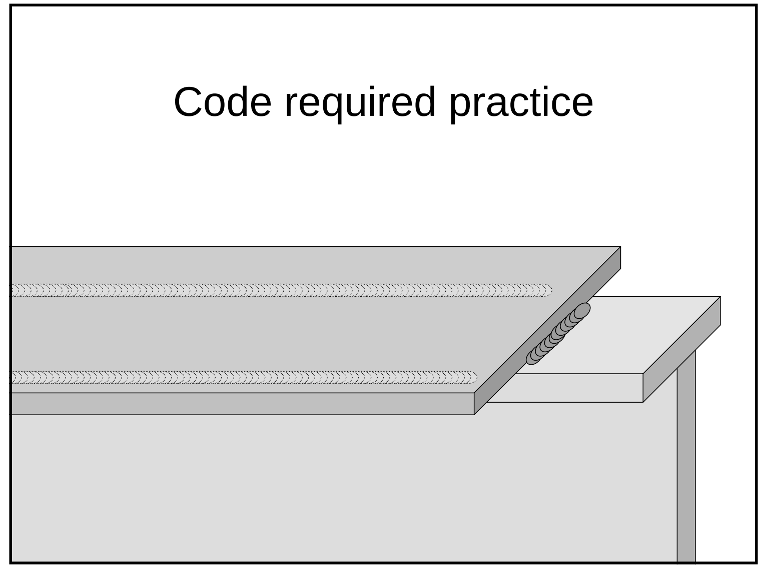
235

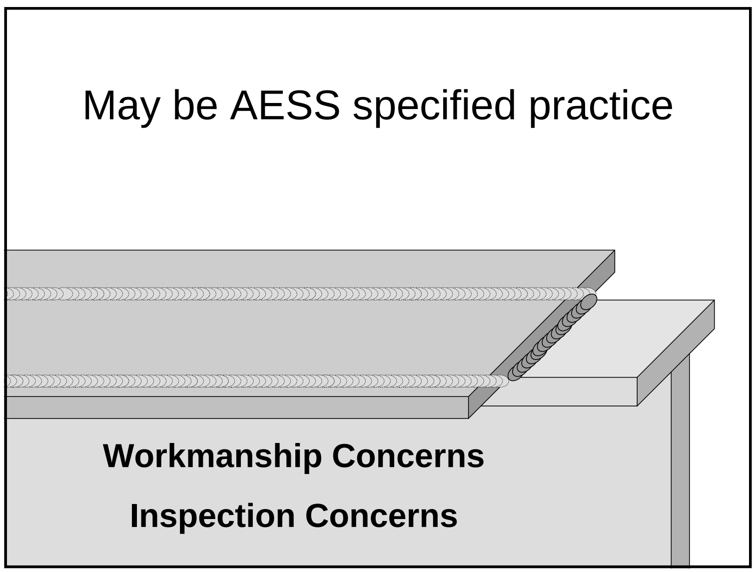
May be required for AESS

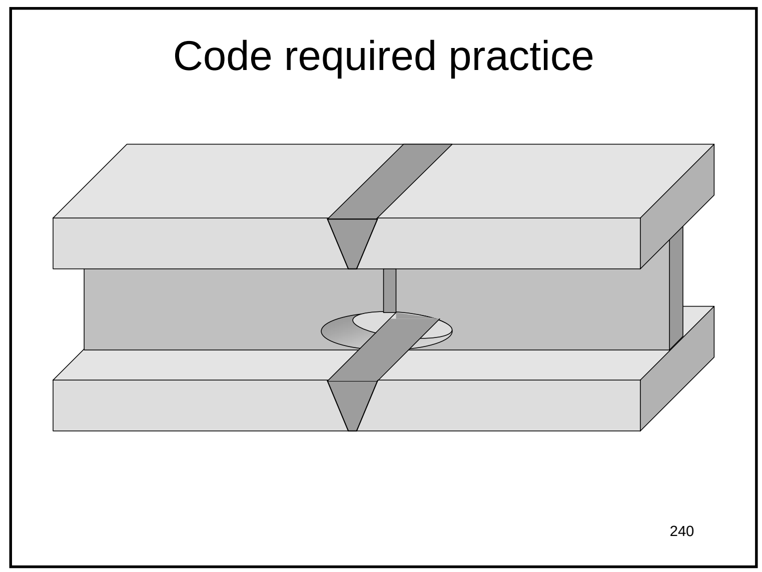


236

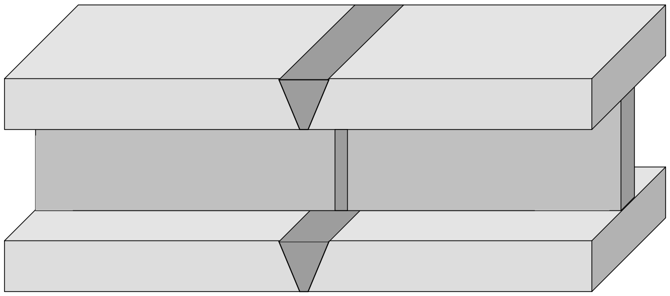

May be required for AESS
Cost
Distortion
237


Code required practice


May be AESS specified practice
Workmanship Concerns
Inspection Concerns


Code required practice
240

May be AESS specified practice



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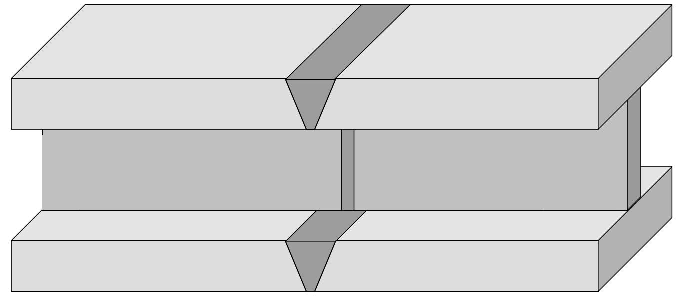
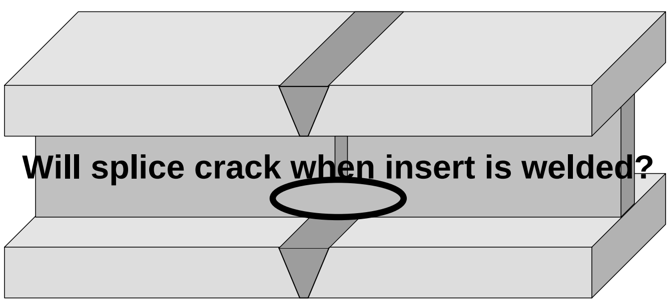
May be AESS specified practice



How can flange CJP groove weld be made?

242

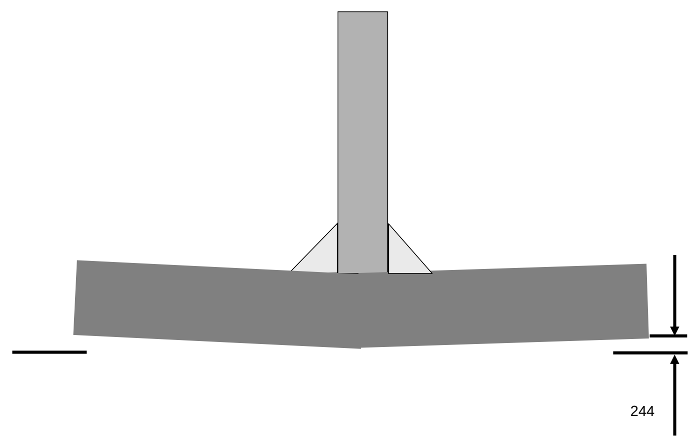
May be AESS specified practice



Will splice crack when insert is welded?

243

Acceptable D1.1 distortion



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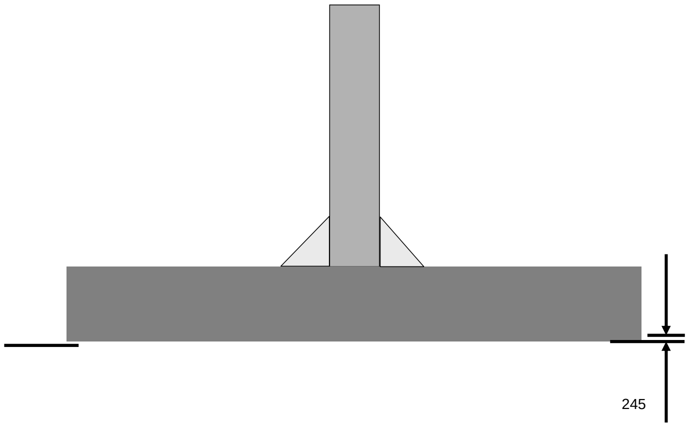
May be AESS Specified Tolerance



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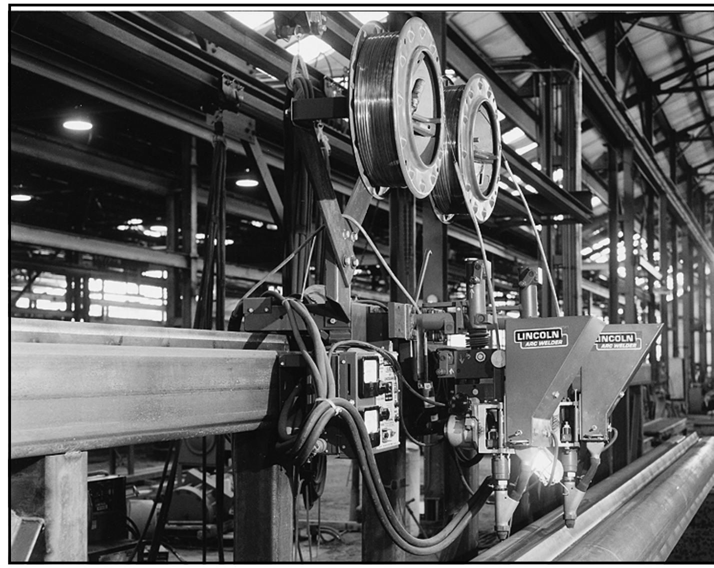
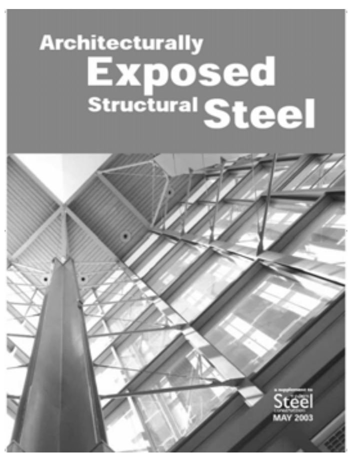


Free Download from AISC

http://www.aisc.org/store/p-1500-architecturally-exposed-structural-steel.aspx



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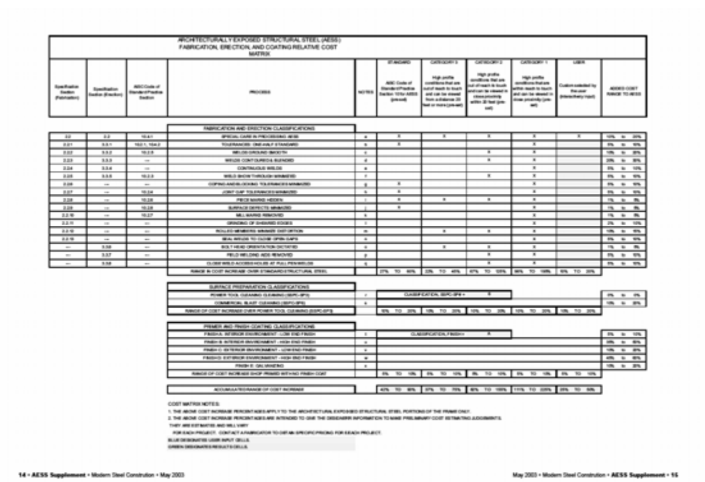


248

Special Welding Applications

- Welding HSS
- Welding AESS
- **Welding on Existing Structures**
- Field Welding
- Heat Shrinking

249

Special Welding Applications

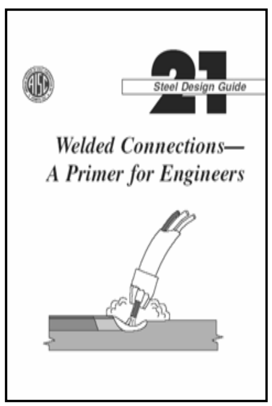
Welding on Existing Structures

- **Historic Steels**
- **Welding Under Load**
- **Fire**
- **Cold Worked/Strain Aging**

250

Chapter 4 Metallurgical Issues

- **Historic (Obsolete) Steels**
  - **ASTM A9**
  - **ASTM A7**
  - **ASTM A373**
  - **ASTM A242**



251

Welding on Existing Structures

- **Check weldability of steel (especially if riveted)**

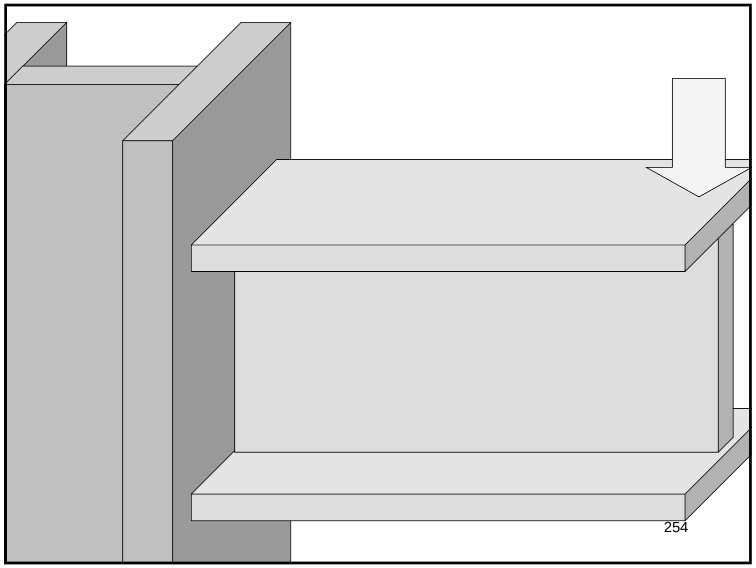
252

Special Welding Applications

Welding on Existing Structures

- Historic Steels
- **Welding Under Load**
- Fire
- Cold Worked/Strain Aging

253



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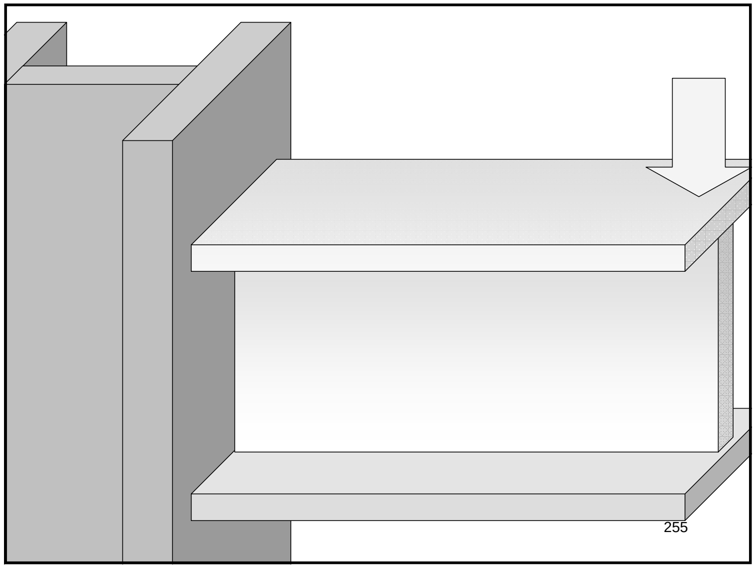

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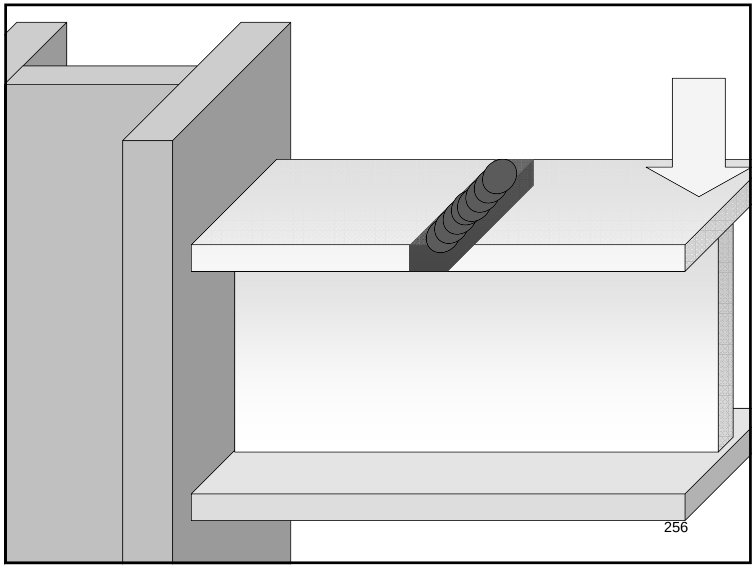

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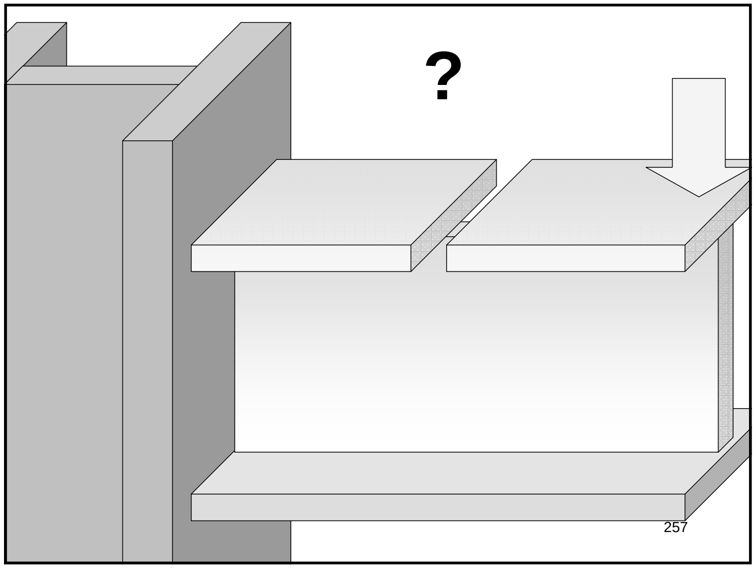
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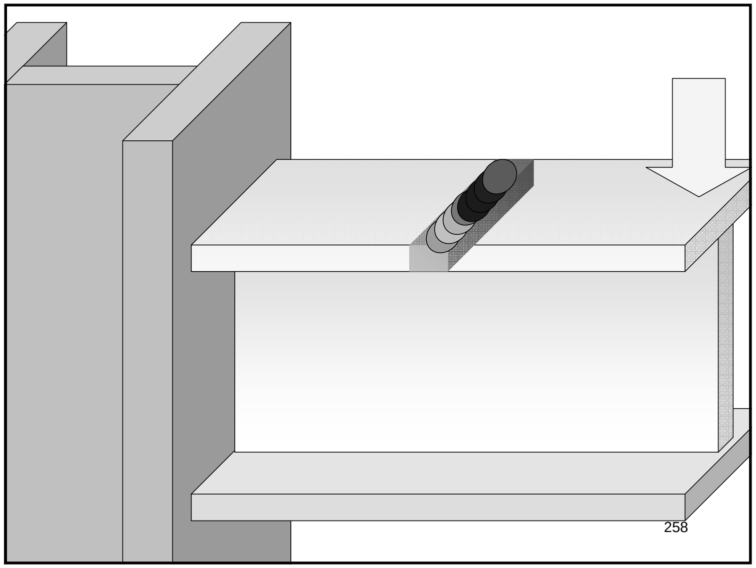
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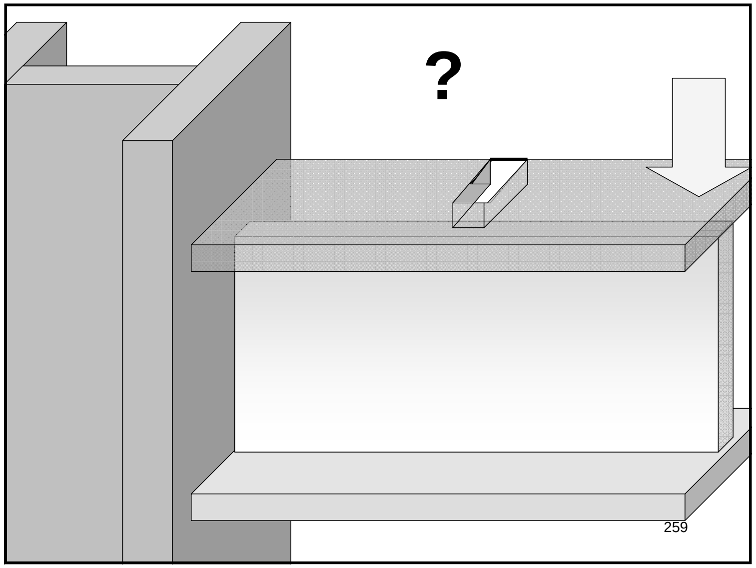
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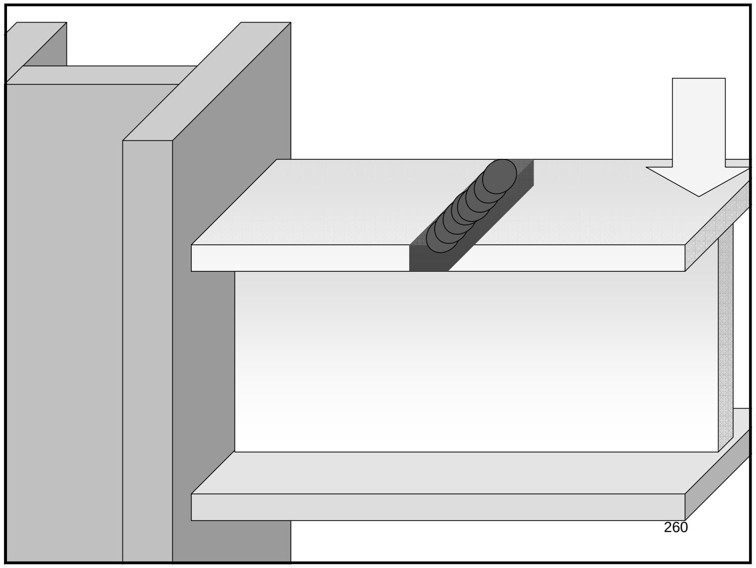
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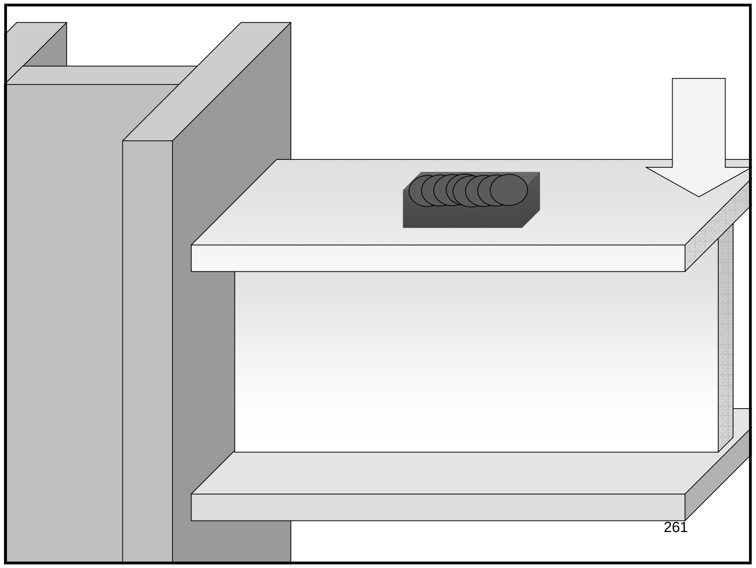
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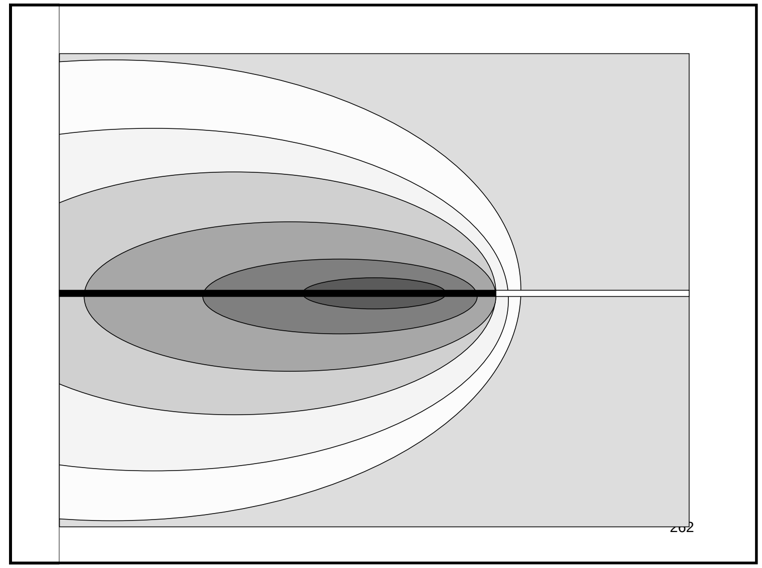
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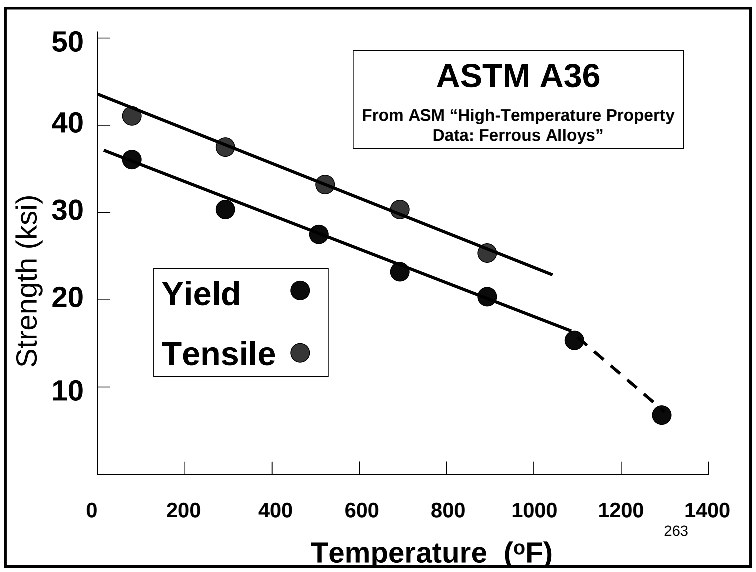
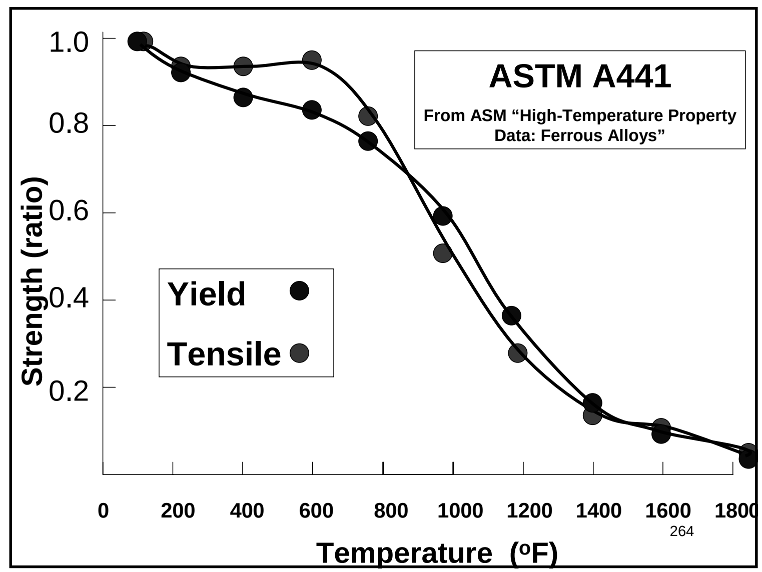
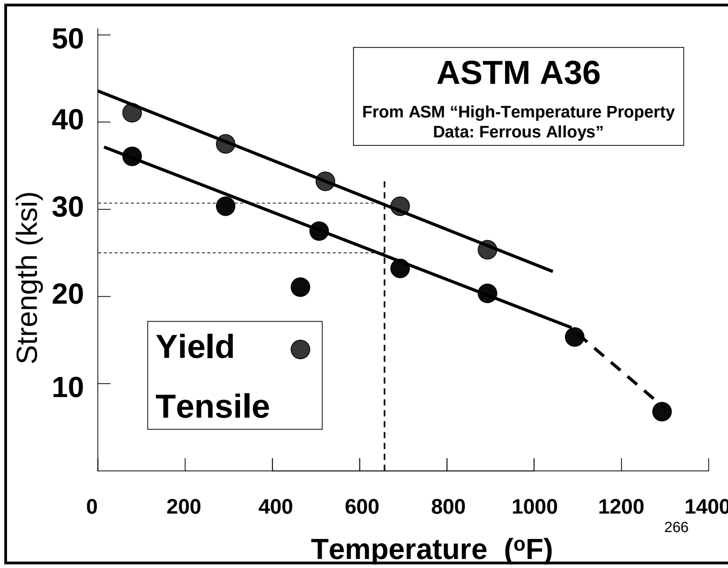

ASTM A36
From ASM "High-Temperature Property Data: Ferrous Alloys"
Strength (ksi)
50
40
30
20
10
Yield
Tensile
0
200
400
600
800
1000
1200
1400
Temperature (°F)
263


ASTM A441
From ASM "High-Temperature Property Data: Ferrous Alloys"
Strength (ratio)
1.0
0.8
0.6
0.4
0.2
Yield
Tensile
0
200
400
600
800
1000
1200
1400
1600
1800
Temperature (°F)
264

Welding on members under load

- The amount of material at temperatures >650 ^{o}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

265



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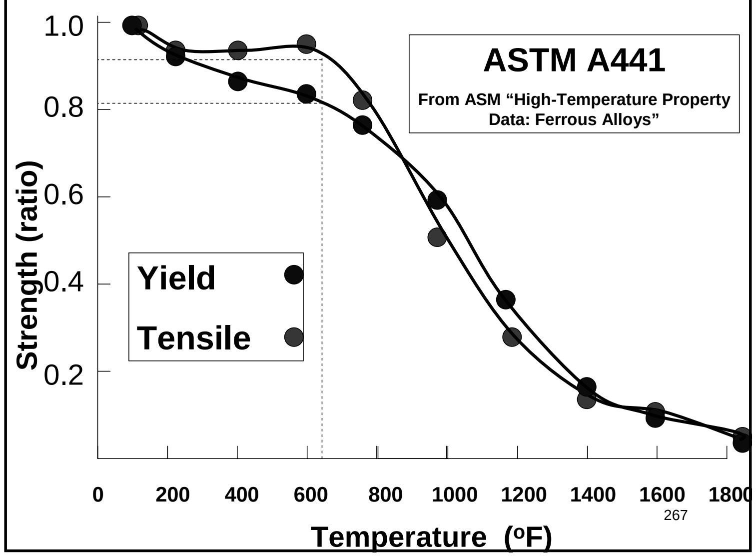


267

Special Welding Applications

Welding on Existing Structures

- Historic Steels
- Welding Under Load
- **Fire**
- Cold Worked/Strain Aging

268

Welding on Existing Structures

General precaution: Fire!

- **–From combustibles**
- **–From unintended work circuits**

269

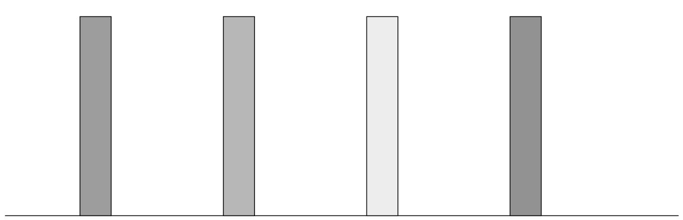
Special Welding Applications

Welding on Existing Structures

- Historic Steels
- Welding Under Load
- Fire
- **Cold Worked/Strain Aging**

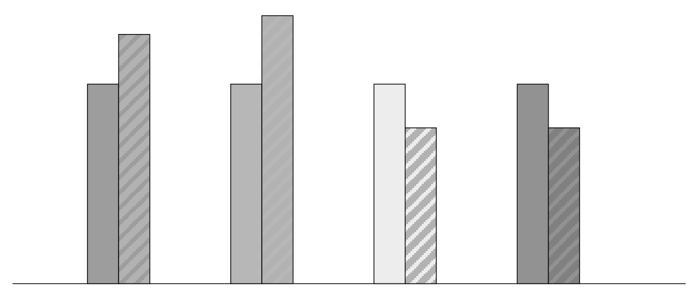
270

Effects of cold working



271

Effects of cold working



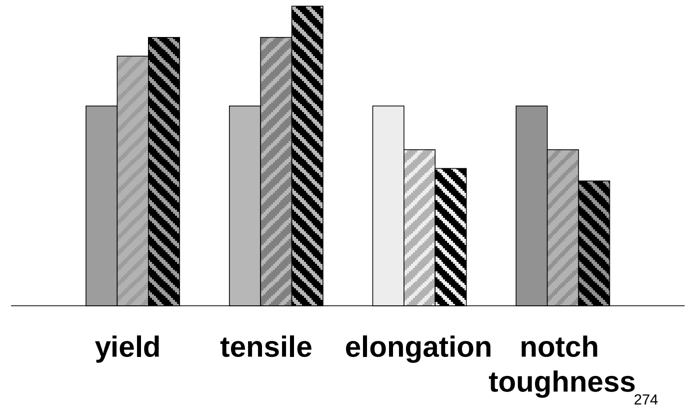
272

Strain Aging

- Occurs when steel is heated to 400-700^{o} F
- Yield, tensile increase
- Ductility, notch toughness decrease
- Aggravated by presence of “free” nitrogen

273

Effects of strain aging



274

Strain Aging

- Stress relief helps, but…
  - Typically impractical
  - Depending on alloy, may experience cracking (Cr, Mo, V, B)

275

Welding on plastically deformed members

- Reduced notch toughness make sure material is crack and notch free
- Reduced ductility minimize practices that increase ductility demand

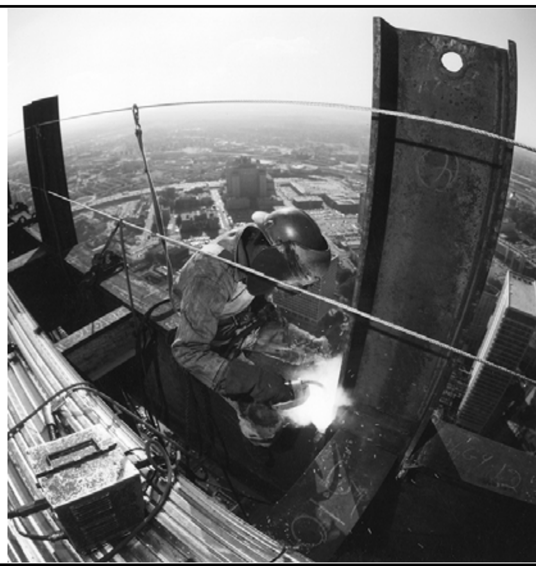
276

Special Welding Applications

- •Welding HSS
- •Welding AESS
- •Welding on Existing Structures
- •**Field Welding**
- •Heat Shrinking

277

278



279

Shop versus Field Welding

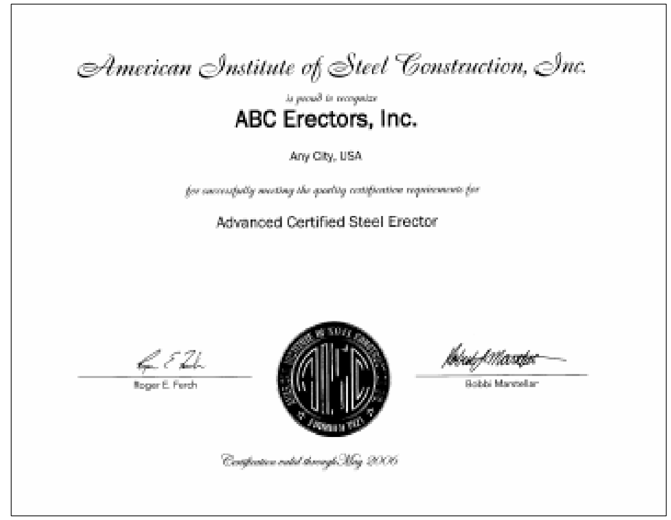
- Primarily an issue of cost
- Some environmental factors
- Position of welding
- Easier to control project in shop

280

MYTHS

- Can’t get quality weld out-of-position
- Can’t get quality in the field
- No codes apply
- Welders aren’t “certified”
- WPSs aren’t used
- No audit program for field contractors
- No contractor supplied inspectors

281



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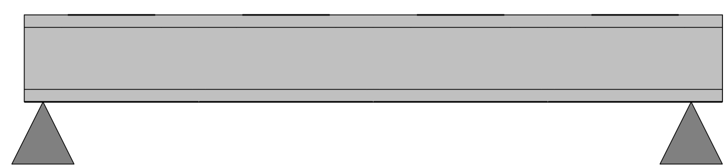
Special Welding Applications

- Welding HSS
- Welding AESS
- Welding on Existing Structures
- Field Welding
- **Heat Shrinking**

283



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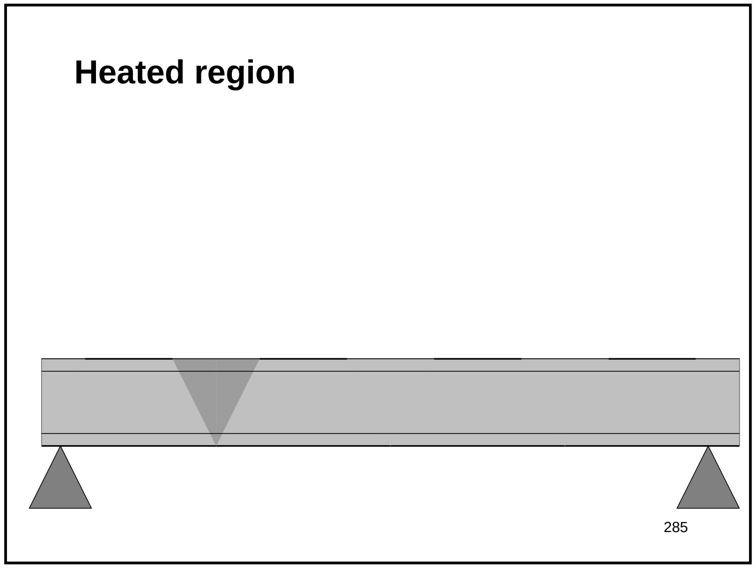
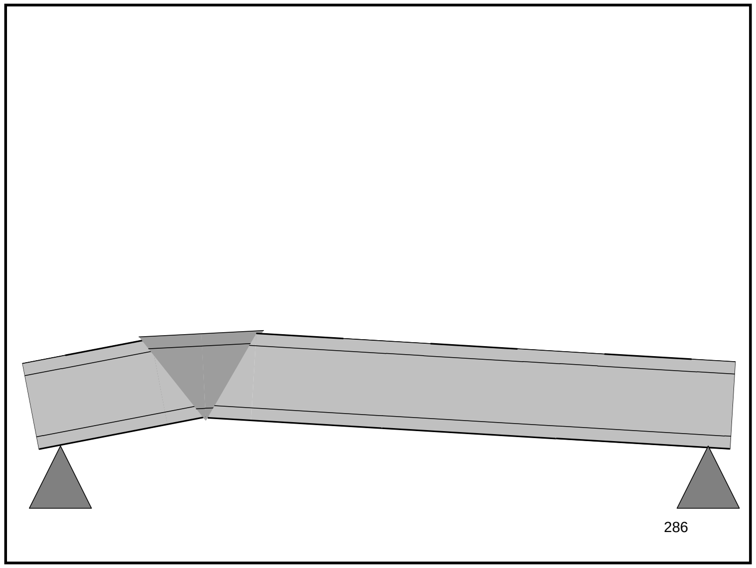

Heated region
285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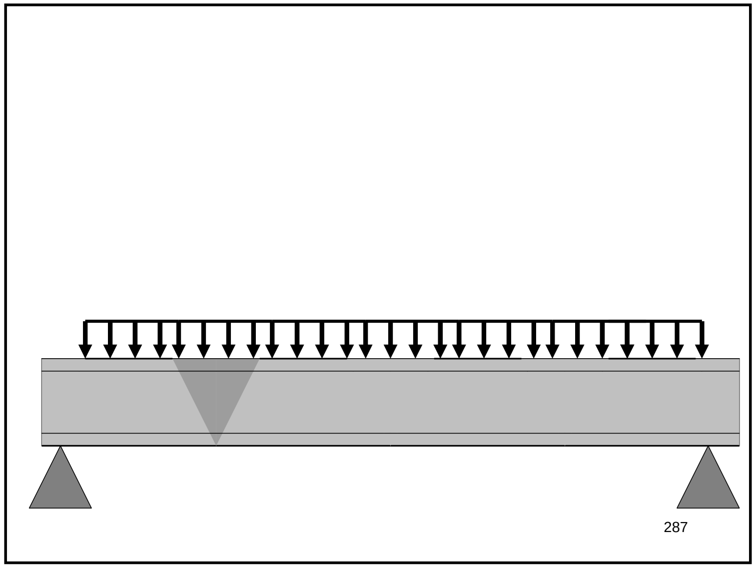
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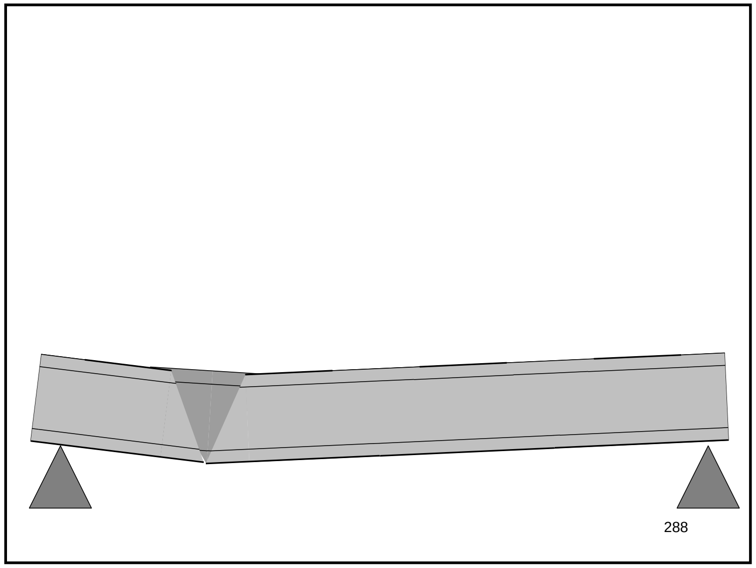
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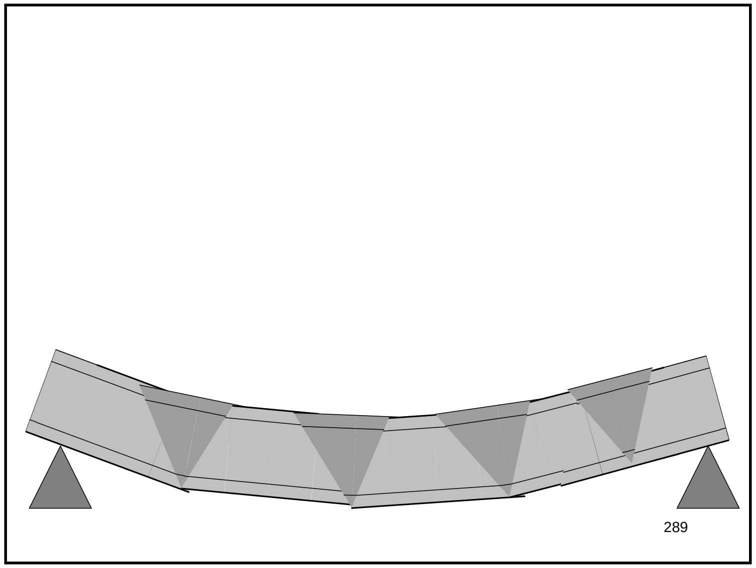
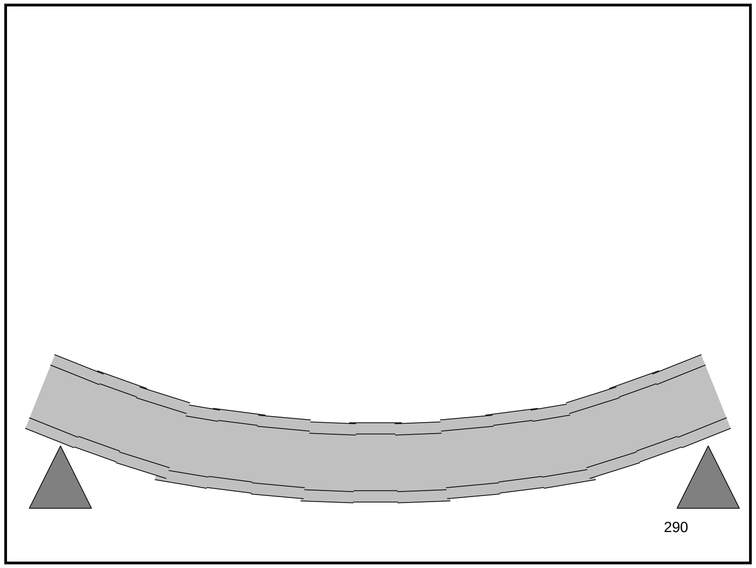




Heat Shrinking

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

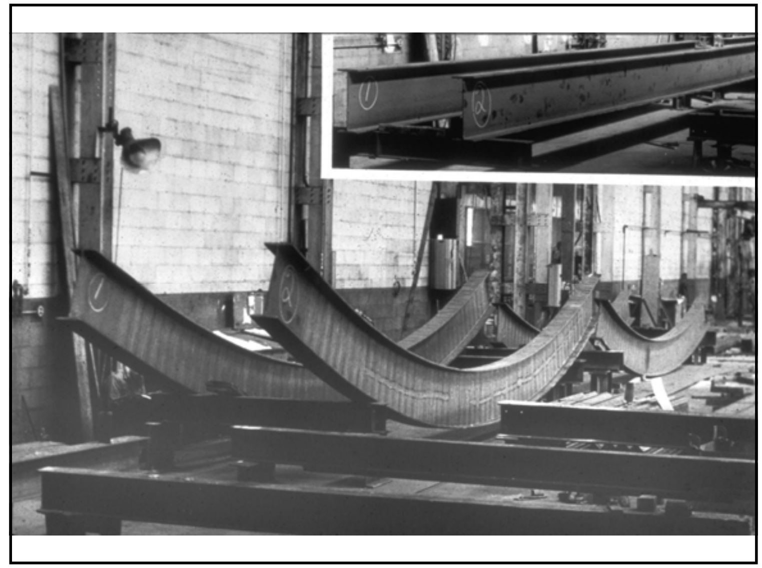
291

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%

292


293

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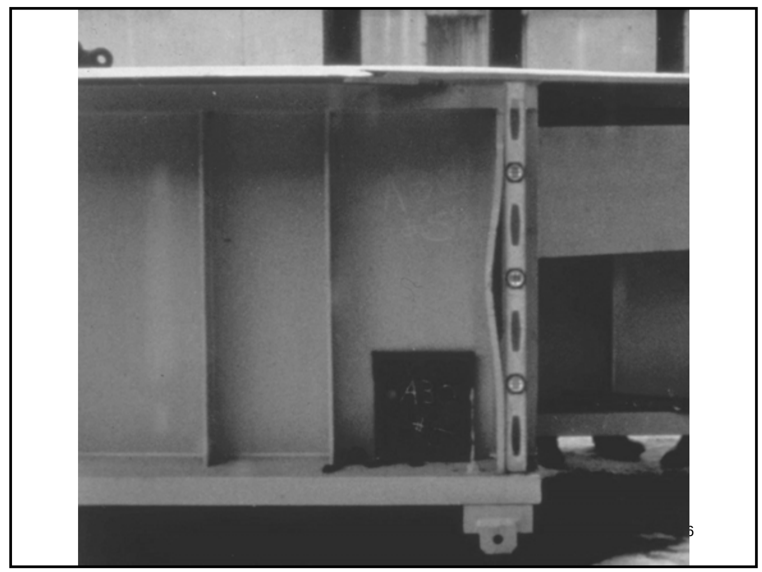

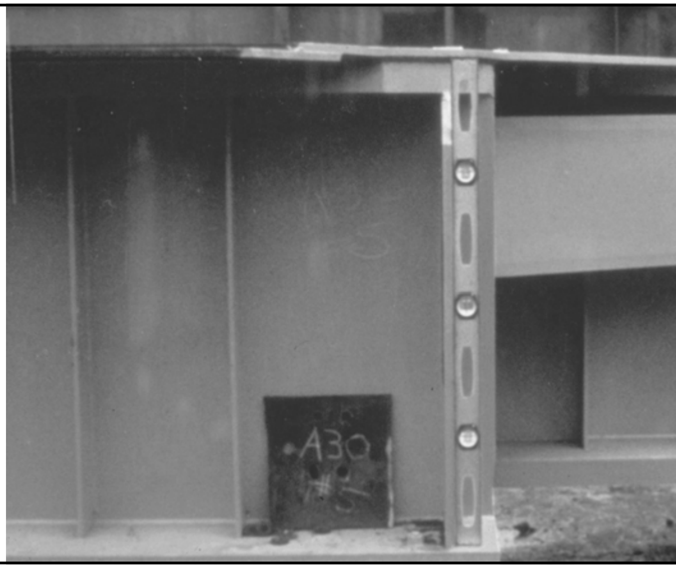

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Special Welding Applications

- Extending Anchor Rod
- Welding Anchor Rod to Base Plates
- Welding on Coated Steels
- Welding Heavy Sections
- Welding Under High Restraint

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Special Welding Applications

- Welding HSS
- Welding AESS
- Welding on Existing Structures
- Field Welding
- Heat Shrinking

303

Listen to the Steel!

Special Welding Applications

304

P-δ?

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- **Seismic Connections/ Manual –** Practical Applications of the 2005 Seismic Provisions
- **Practical Connection Design for Economical Steel Structures**
  De-mystify connection behavior and design
- **Listen to the Steel –** Duane Miller on Welding

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  December 10, 2009

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