AMT 110
Aircraft Metal Structural Repair
Statements

• The satisfactory performance of an aircraft requires continuous maintenance

• Repairs must be strong enough to carry all of the loads with the required factor of safety
  ✷ Repair must not have too much strength
    • Extra strength can cause damage
Statements

• The problem of repairing a damaged section is usually solved by duplicating the original part in strength, kind of material, and dimensions.
  - “Follow the manufacturer’s recommended procedures”
  - You don’t know what the engineering was thinking
  - AC43.13-1B is the FAA’s guidance
    • AC43.13-1B take precedence over textbook

• A scratch or gouge in the surface of a highly stressed piece of metal causes a stress concentration at the point of damage (“stress riser”) and could lead to failure of the part.
Stresses

• Six types of stress:
  - Tension
  - Compression
  - Shear
  - Bearing
  - Torsion
  - Bending
Tension

The stress that resists a force that tends to pull apart
Compression

B. Compression

The stress that resists a crushing force, tend to shorten or squeeze parts
Shear

The stress that resists the force tending to cause one layer of material to slide over an adjacent layer.

Think of shears cutting
Bearing

The surface pressure acting on a joint face directly as a result of the force applied by a fastener.

Top sheet is bearing against the bottom sheet. Fasteners are pressing top sheet against bottom bearing.

The force that tries to pull the two sheets apart.

Rivets
C. Torsion

The stress that resists twisting
Bending

E. Bending

Combination of compression and tension stress
Compression & Tension

Arrows are forces on hinges!

Compression
Tension
Compression
Tension
Compression
Tension

$\vec{mg}$
Tools

- Always have at least one machinist’s rule in 1/32” (or 1/64”)

- Pens
  - No pencils
  - Sharpies
    - Blue doesn’t bleed through paint as bad
  - Use instead of scribing

- Demo
  - Rivet spacer
  - Nibbler
Tools

- Demo
  - Deburring tools

- Drilling
  - Mark with a center punch
  - Metal twist drill bits have 118° head
    - Stainless steel use 140°
  - To prevent surface skating on aluminum, hand twist a couple of time before applying power
  - Cutting oil helps remove chips and is not used on sheet metal
  - For large holes, start with a small bit and then enlarge
Tools

• Drilling
  ❖ General rule for speed
    • Hard metal – slow and more pressure, soft metal – fast and low pressure
  ❖ Use a wood backer when drilling sheet metal
  ❖ Use a drill guide/holders if possible
  ❖ Use a drill stops in tight areas
  ❖ Use a drill press for critical repairs
  ❖ For complicated patterns:
    • Drill smaller holes first
    • Align pattern
    • Enlarge pattern
  ❖ Don’t be too proud or lazy to use support tools
Tools

- **Reamers**
  - Used to enlarge and smooth a hole
  - Used to create a precise hole diameter
  - Very brittle
  - Turn only one way
  - Follow the directions for drilling the initial hole

![Types Of Reamers](attachment://types_of_reamers.png)
Aluminum

- Used on aircraft because it is light and easy to work
- Pure aluminum is very weak
- Methods to increase strength and hardness
  - Other chemicals are added to make an alloy
    - 2024 is the most common sheet metal alloy
    - 2117 is the most common rivet alloy
    - Alloys usually reduce corrosion resistance
  - Heat treatment and tempering
  - Work or strain hardening
  - Age hardening
    - Aluminum alloys get harder with age
Aluminum

• Wrought (worked/beaten) aluminum designation:
  ❖ (4 digit alloy) – (temper & hardness)
    • e.g. 2024-T3
    • First digit (e.g. 2XXX) indicates the primary alloying agent

• Alcad™ or clad – very, very thin layer of pure aluminum use to protect against corrosion
  ❖ Can’t be reheated
  ❖ Can’t be welded
    • This why aircraft are riveted not welded
  ❖ Easy to scratch or nick
    • Exposes base metal to corrosion
# Aluminum Alloy Identifiers

<table>
<thead>
<tr>
<th>Alloy Type</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum 99+% pure</td>
<td>1xxx</td>
</tr>
<tr>
<td>Copper</td>
<td>2xxx</td>
</tr>
<tr>
<td>Manganese</td>
<td>3xxx</td>
</tr>
<tr>
<td>Silicon</td>
<td>4xxx</td>
</tr>
<tr>
<td>Magnesium</td>
<td>5xxx</td>
</tr>
<tr>
<td>Magnesium and silicon</td>
<td>6xxx</td>
</tr>
<tr>
<td>Zinc</td>
<td>7xxx</td>
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# Aluminum

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Copper</th>
<th>Silicon</th>
<th>Manganese</th>
<th>Magnesium</th>
<th>Zinc</th>
<th>Nickel</th>
<th>Chromium</th>
<th>Lead</th>
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<tr>
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<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3003</td>
<td>—</td>
<td>—</td>
<td>1.2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
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<tr>
<td>2011</td>
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<td>—</td>
<td>—</td>
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<td>—</td>
<td>—</td>
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<tr>
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<td>0.5</td>
<td>0.5</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
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<td>—</td>
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<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
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<td>2.0</td>
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<td>4032</td>
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<td>0.25</td>
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<tr>
<td>7075</td>
<td>1.6</td>
<td>—</td>
<td>—</td>
<td>25</td>
<td>5.6</td>
<td>—</td>
<td>0.3</td>
<td>—</td>
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</tr>
</tbody>
</table>
Aluminum Hardness

- F — as fabricated
- O — annealed, recrystallized (wrought products only)
- H — strain hardened
- H1 (plus one or more digits) — strain hardened only
- H2 (plus one or more digits) — strain hardened and partially annealed
- H3 (plus one or more digits) — strain hardened and stabilized
Aluminum Heat Treatment

- **W**—Solution heat treated, unstable temper
- **T**—Treated to produce stable tempers other than F, O, or H
- **T2**—Annealed (cast products only)
- **T3**—Solution heat treated and then cold worked
- **T4**—Solution heat treated
- **T5**—Artificially aged only
- **T6**—Solution heat treated and then artificially aged
- **T7**—Solution heat treated and then stabilized
- **T8**—Solution heat treated, cold worked, and then artificially aged
Shear

Figure 4-24. *Foot-operated squaring shear.*
Figure 4-57. Cornice brake.
Box and Pan Brake (Finger Brake)

Figure 4-58. Box and pan brake.
Box and Pan Brake (Finger Brake)
Figure 4-60. Slip roll former.
Figure 4-61. Slip roll operation.
Rotary Machine

Figure 4-62. Rotary machine.
English Wheel

Figure 4-64. English wheel.

English Wheel Video
English Wheel Video 2
Simple and Cheap

• Block of wood
• Rubber or plastic hammer
• Small steel ball peen hammer
C-Clamp

- fixed jaw
- swivel head
- movable jaw
- throat
- adjusting screw
- frame
- handle
Machinist's Vise
Cleco
Cleco
Cleco
Solid Rivets

• Solid shank rivets are the most common type of rivet used on aircraft
  ✷ Most used of all fasters

• Riveting Video

• Rivet Head Types:
  ✷ Universal
    • 470 -> AN470 or MS20470
  ✷ Countersunk or Flush
    • 426 -> AN426 or MS20426
    • 100° head angle
Solid Rivets

MS20470 universal head rivet

MS20426 100°-countersunk head rivet

MS20430 round head rivet

MS20442 flat head rivet
Solid Rivets

Figure 4-75. Rivet head shapes and their identifying code numbers.
Solid Rivets

<table>
<thead>
<tr>
<th>Standard Rivet Alloy Code Markings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alloy code—A</strong>&lt;br&gt;Alloy—100 or 3003 aluminum&lt;br&gt;Head marking—None&lt;br&gt;Shear strength—10 KSI</td>
</tr>
<tr>
<td><strong>Alloy code—B</strong>&lt;br&gt;Alloy—2024 aluminum&lt;br&gt;Head marking—Raised dot&lt;br&gt;Shear strength—25 KSI</td>
</tr>
<tr>
<td><strong>Alloy code—C</strong>&lt;br&gt;Alloy—7075 aluminum&lt;br&gt;Head marking—Raised ring&lt;br&gt;Shear strength—41 KSI</td>
</tr>
<tr>
<td><strong>Alloy code—D</strong>&lt;br&gt;Alloy—2017 aluminum&lt;br&gt;Head marking—Two bars (raised)&lt;br&gt;Shear strength—40 KSI</td>
</tr>
<tr>
<td><strong>Alloy code—E</strong>&lt;br&gt;Alloy—9080 aluminum&lt;br&gt;Head marking—Mixed circle&lt;br&gt;Shear strength—54 KSI</td>
</tr>
</tbody>
</table>

*Figure 6-77. Rivet allow strength.*
# Solid Rivets

<table>
<thead>
<tr>
<th>Head Mark</th>
<th>Alloy</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain</td>
<td>1100</td>
<td>A</td>
</tr>
<tr>
<td>Recessed dot</td>
<td>2117T</td>
<td>AD</td>
</tr>
<tr>
<td>Raised dot</td>
<td>2017T</td>
<td>D</td>
</tr>
<tr>
<td>Raised double dash</td>
<td>2024T</td>
<td>DD</td>
</tr>
<tr>
<td>Raised cross</td>
<td>5056H</td>
<td>B</td>
</tr>
<tr>
<td>Three raised dashes</td>
<td>7075 T73</td>
<td></td>
</tr>
<tr>
<td>Raised circle</td>
<td>7050 T73</td>
<td>E</td>
</tr>
<tr>
<td>Recessed large and small dots</td>
<td>Titanium</td>
<td></td>
</tr>
<tr>
<td>Recessed dash</td>
<td></td>
<td>F</td>
</tr>
<tr>
<td>Recessed triangle</td>
<td>Corrosion resistant steel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carbon steel</td>
<td></td>
</tr>
</tbody>
</table>
Solid Rivets

• A – 1100 – Pure aluminum
  ❖ Too soft for structural use
  ❖ For decorative trim only

• AD – 2117
  ❖ Most common rivet type
  ❖ Heat treated by the manufacturer and does’ t require heat treatment before being driven

• B – 5056
  ❖ Used for magnesium alloy structures

• M – Monel
  ❖ Used for nickel-steel
Solid Rivets

• D – 2017 & DD – 2024
  √ “Ice box” rivets
    • Annealed and stored in a freezer to retard hardening
    • Removed from freezer just before use
  √ Modern manufacturing now use E type rivets
  √ Must be reheat treated if left out too long
  √ Once installed, can take up to 4 days to fully age harden

• Mild Steel
  √ Used for steel
Solid Rivets

• Material substitution
  ❖ Follow the manufacturer’s recommended procedures
  ❖ D - 2017 – 3/16” (#6) or less
    • Replace with AD – 2117 of 1/32” diameter larger
      ❖ One size bigger
  ❖ DD - 2024 – 5/32 (#5) or less
    • Replace with AD – 2117 of 1/32” diameter larger
      ❖ One size bigger
Rivets Gun

Diagram of a rivets gun with labels:
- Sliding valve
- Piston
- Set sleeve
- Blank rivet set
- Exhaust deflector
- Cylinder
- Beehive spring set retainer
- Throttle
- Throttle lever
- Throttle valve
- Throttle tube
- Bushing
- Regulator adjustment screw
- Air path

Legend:
- Movement of air during forward stroke
- Movement of air during rearward stroke
Rivet Guns

- Long-stroke, slow-hitting, offset-handle rivet gun
- Long-stroke, slow-hitting, pistol grip rivet gun
- Fast-hitting, offset-handle rivet gun
- Fast-hitting, pistol grip rivet gun
- Fast-hitting, push button rivet gun
## Rivet Gun Sizes

<table>
<thead>
<tr>
<th>Rivet Gun Size</th>
<th>Maximum Rivet Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1x</td>
<td>3/32 inch</td>
</tr>
<tr>
<td>2x</td>
<td>1/8 inch</td>
</tr>
<tr>
<td>3x</td>
<td>3/16 inch</td>
</tr>
<tr>
<td>4x</td>
<td>1/4 inch</td>
</tr>
</tbody>
</table>
Rivet Sets

- Straight rivet set
- 10°-offset rivet set
- Double-offset rivet set
- Flush rivet set
The radius of the cup in a rivet set is slightly greater than the radius of the rivet head. This allows the blows from the rivet gun to be concentrated on the rivet head.
Bucking Bar
Compression Rivet Squeezer

C-yoke squeezer

Alligator-yoke squeezer
Cleco

Nomenclature of fastener

Cleco pliers for installing fasteners. Plunger is depressed and locks are pushed out beyond spreader so they fit into rivet hole.

Fastener installed in metal
<table>
<thead>
<tr>
<th>Rivet Diameter (inch)</th>
<th>Cleco Fastener Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/32</td>
<td>Silver</td>
</tr>
<tr>
<td>1/8</td>
<td>Copper</td>
</tr>
<tr>
<td>5/32</td>
<td>Black</td>
</tr>
<tr>
<td>3/16</td>
<td>Brass</td>
</tr>
<tr>
<td>1/4</td>
<td>Copper</td>
</tr>
</tbody>
</table>
Solid Rivet Material

• A – 1100 – Pure aluminum
• B – 5056 – Used on magnesium
• AD – 2117 – Most common type; has dimple
• D – 2017 – “Ice box”
• DD – 2024 – “Ice box”
Rivet Dimensioning

• Diameter is in 1/32’s
  - #3 – 3/32, #4- 4/32 (1/8), #5- 5/32

• Length is in 1/16
  - AN470 – shaft length
  - AN426 – full rivet length
Rivet Designation

• (Head Type) (Material) (Diameter in 1/32s) – (Length in 1/16’s)

• Universal head, 2117, 3/32 diameter, 5/16 length
  ❖ AN470AD3-5 or MS20470AD3-5

• Countersunk head, 1100, 1/8 (4/32) diameter, 1/2 (8/16) length
  ❖ AN426A4-8 or MS20426A4-8
Drill Bits Sizes

- #3 – 3/32 - #40 drill bit
- #4 – 1/8 (4/32) - #30 drill bit
- #5 – 5/32 - #21 drill bit
Read AC43-13.1B
Par 4-57 Riveting
Rivet Layout

• Rivet Stresses
  ❖ Shear
    • Force required to cut a rivet
    • A repair or patch should be designed so it is under shear stress
  ❖ Tension
    • Resistance to tension is bearing
    • Tension stress pulling a patch apart
Dimpling

• Coin dimpling
  ❖ Rivet is the male die

• Radius Dimpling
  ❖ Hand squeezer
  ❖ Stationary dimpler

• Hot dimpling
  ❖ Uses heated dimpling dies to ensure the metal flows better during the dimpling process

• Dimpling, due to the nestling effect, gives a stronger joint than the non-flush type.
Countersinking

• Remove metal to install rivet
• Reduces strength of metal
• Edge distance is greater than when universal head fasteners
  ✷ 2 ½ D
• 100° countersink
• Sheet metal must be thicker than rivet head
• Use microstop countersink
Figure 4-91. *Countersinking* dimensions.
Countersinking

This top sheet is dimpled

Thick bottom material is countersunk

Figure 4-96. Predimple and countersink method.
Flush Shop Head

Figure 4-99. *NACA* riveting method.
Ugly!!!

Figure 4-97. Rivet defects.

<table>
<thead>
<tr>
<th>Imperfection</th>
<th>Cause</th>
<th>Remedy</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>B. Cut head</td>
<td>Improperly held tools</td>
<td>Hold riveting tools firmly against work</td>
<td>Replace rivet</td>
</tr>
<tr>
<td>C. Excessively flat head, resultant</td>
<td>Excessive driving, too much pressure on</td>
<td>Improve riveting technique</td>
<td>Replace rivet</td>
</tr>
<tr>
<td>D. Sheet separation</td>
<td>Work not held firmly together and rivet</td>
<td>Fasten work firmly together to prevent</td>
<td>Replace rivet</td>
</tr>
<tr>
<td>E. Sloping head</td>
<td>a. Bucking bar not held firmly</td>
<td>Hold bucking bar firmly without too much</td>
<td>Replace rivet</td>
</tr>
<tr>
<td></td>
<td>b. Bucking bar permitted to slide and</td>
<td>pressure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bucking bar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. Buckled shank</td>
<td>Improper rivet length, and E above</td>
<td>E above and rivet of proper length</td>
<td>Replace rivet</td>
</tr>
</tbody>
</table>
Remove rivets by drilling off the head and punching out the shank as illustrated.
1. File a flat area on the manufactured head of non-flush rivets.
2. Place a block of wood or a bucking bar under both flush and nonflush rivets when center punching the manufactured head.
3. Use a drill that is 1/2 (0.0312) inch smaller than the rivet shank to drill through the head of the rivet. Ensure the drilling operation does not damage the skin or cut the sides of the rivet hole.
4. Insert a drift punch into the hole drilled in the rivet and lift the punch to break off the rivet head.
5. Using a drift punch and hammer, drive out the rivet shank. Support the opposite side of the structure to prevent structural damage.
Back Riveting

- Back Riveting Video
- Hot Riveting
Blind Rivets

• Can be install from one side
  ❖ Installed with “puller” tool

• Pop Rivet
  ❖ [Pop rivet installation]
  ❖ Used for no-structural work only
  ❖ Hollow after installation
Blind Rivets

• “Cherry Rivets”
  ❖ Not your hardware store rivets
  ❖ Wide variety – CherryLock, CherryMax, Huck-Clinch, Huck Max, Olympic-Loc
  ❖ CherryMax Animation
  ❖ CherryMax can replace a solid rivet of the same size diameter
    • Some mechanics are concerned about the rivets vibrating loose
  ❖ Install CherryMax Rivet
  ❖ Hard to remove
    • Read process on page 4-49
Cherry Rivet Removal

1. File end of stem flat.
2. Make center punch mark in center of stem.
3. Drill off tapered part of stem.
4. Pry out remainder of locking collar.
5. Drill almost through rivet head.
6. Pry off rivet head.
7. Drive rivet from hole.
Hi-Shear™

Hi-Shear rivet

Collar
Pin
Driven collar
Hi-Shear™

Correctly-driven pin rivet.

0.032-inch steel washer may be used to adjust grip length of pin.

Collar is underdriven. It may be driven more.

Collar is overdriven. If there is more than 1/32 inch between shearing edge of pin and top of collar, collar should be removed and a new one installed.

Pin is too long. Remove collar, install washer, or use shorter pin.

Pin is too short. Remove collar and use longer pin.
Hi-Lok™

- Installation Video
- Can be installed with standard tools
Huck Lockbolt™
Placed the pin in the hole from the back side of the work and slip the collar on. The hold-off head must be toward the gun. This allows the gun to preload the pin before swaging. Then apply the gun; the chuck jaws engage the pull grooves of the projecting pintail. Hold the gun loosely and pull the trigger.

The initial pull draws the work up tight and pulls that portion of the shank under the head into the hole.

Further pull swages the collar into the locking grooves to form a permanent lock.

Continued force breaks the pin and ejects the tail. Anvil returns and disengages from the swaged collar.
Huck Lockbolt™

More grooves for tension version
Rivnut™

Rivnut before installation

Rivnut after it has been upset

Good for thin sheet metal applications
Cherry Rivetless Nutplate

• Installation animation
Dzus™ Fastener
Dzus™ Fastener
Figure 5-12.—Dzus fastener.
Dzus™ Fastener

• Length specified in 1/100 (0.01) inch increments
• Diameter specified in 1/16 inch increments
• Head markings are body diameter, type of head, and length of the fastener
• Retention grommet/collar commonly come loose

F – Flush head
6⅜ – Body diameter in 16th’s of an inch
.50 – Length (50/100th’s of an inch)

Figure 6-18. Dzus identification.
Cam Lock Fastener
Airloc Fastener

Figure 5-61. Airloc fastener.
Anchor Nut & Tinnerman
Metal Bending
Metal Bending Layout Procedure

1. Obtain the dimensions of the shape
2. Determine size of the stock or “where to cut”
3. Locate brake reference lines or “where to bend”
4. Cut stock
5. Mark centers or “where to drill”
6. Drill holes
   - If joining multiple pieces, drill after bending
7. Bend metal
Why Bend Allowance?

• Metal can not be bent at a perfect 90° angle
  ❖ It will break or crack

• A round bend is used to prevent breaking
  ❖ The bend is defined by its radius – bend radius
  ❖ The bend is portion of a circle

• A portion of a circle is shorter than a perfect 90°
Radius

The diagram illustrates a circle with center C and a point P on its circumference. The radius R connects the center C to the point P.
Why Shorter?

• The shortest distance between two points in a line

• A perfect 90° is the longest

• A curved bend is shorter than a perfect 90°
  - The bigger the radius, the shorter distance

• The heart of a bend radius calculation is to determine this shorter distance
Why Shorter?

Shortest

Longest

Shorter

Even Shorter
The Bending Tool

• The tool is called a Brake
  - Cornice Brake
  - Finger Brake

• Clamping bar holds the metal and determines radius
  - Clamp/Fingers can be changed to set radius

• Where to place the metal?
  - The front/nose of the clamp

• The goal of the calculations are to determine where the nose goes
Bending Brake
Bending Brake

- Upper Leaf
- Nose Bar
- Bed
- Bending Leaf
Bending Brake

- Sight line
- Bend tangent line
- Radius bar
- Brake bed
- Brake leaf
Bend Radius

FIGURE 2
Neutral Line

Neutral Line 35% to 45% of "T" from inner side of bend

The Neutral Line

Figure 3
Figure 4-121. *Bend allowance terminology.*
Bend tangent line dimension (BTLD)

MLD

SB

Mold point

T

R

MLD

SB

BTLD

MLD
Calculation Goals

• Determine the material dimensions/measurements
  - It is easier to cut the material before bending it

• Mark where bends should be located
  - Only reference on the brake is the nose of the clamp – sight line
  - Determine/mark where the nose will go
  - Nose location is called the “Brake Reference Line”
Terms/Vocabulary

• Mold Lines Dimension (MLD)—The method of defining a part on a drawing
  ❖ Example – 2” X 4” X 2” channel
  ❖ The length of a side if there was no bend
  ❖ Drawn as if the bend is a perfect 90° (0 radius bend)

• Bend Radius (R)—The size of the curve used to bend the metal
  ❖ Radius of the brake clamp nose
  ❖ Inside radius of bend
Terms/Vocabulary

Bend tangent line dimension (BTLD)

MLD

Mold point

SB

BTLD

MLD
Terms/Vocabulary

- Bend Tangent Line (BTL or BL) – The line where the bend starts or stops
Terms/Vocabulary

• Bend Tangent Line Dimensions (BTLD) – Length of the unbend sections
  
  ❖ Edge of metal to Bend Tangent Line (BTL)
  
  or

  ❖ BTL to BTL
Terms/Vocabulary

- **Bend Allowance (BA)** – The amount of material needed to make the bend or curve.
Terms/Vocabulary

• Developed Width (DW) – Material needed to make a piece/item
  ❖ You book calls it Total Developed Width (TDW)
  ❖ Total of all Bend Tangent Line Dimensions (BTLD) plus all Bend Allowances (BA)
    • All the straight parts plus the bent areas
Terms/Vocabulary

- Developed Width (DW) = BTLD(Section A) + BA + BTLD(Section C)
Terms/Vocabulary

• Developed Width (DW)

Figure 4-131. Flat pattern layout.
Terms/Vocabulary

• Setback (SB) – The difference between Mold Line Dimension and Bend Tangent Line Dimension
  
  ❖ The distance the jaws of a brake must be setback from the mold line to form a bend
  
  ❖ For 90°: SB = Metal Thickness + Bend Radius
    
    • SB = T + R
Terms/Vocabulary

• Brake Reference Line – Where the brake’s sight line will be placed – sometimes call Sight Line
Terms/Vocabulary

• Brake Reference Line is a Radius (R) away from Bend Tangent Line (BTL)
Open Angle

• Open Angle – Bent less than 90°
Closed Angle

- Closed Angle – Bent greater than 90°
Terms/Vocabulary

Bend tangent line dimension (BTLD)

MLD

Mold point

SB

BTLD

MLD
Calculation Order

1. MLD - Determine Mold Line Dimensions from problem

2. R- Radius
   - Get from problem
   - Or Minimum bend radius
     - AC 43.13-1B Table 4-6
     - FAA-H-8083-31A Vol. 1 Figure 4-124
Terms/Vocabulary

- **Bend Allowance (BA)** – The amount of material needed to make the bend or curve.
3. BA – Bend Allowance

- FAA-H-8083-31A Vol. 1 Figure 4-128
- \( BA = (0.01743 \times R + 0.0078 \times T) \times \) degree of bend
  - Book has typos
  - \( R = \) Radius & \( T \) is thickness of material
    - Sample \( R = 0.25" \) & \( T = 0.040" \) and \( 90° \) bend
      - \( BA = (0.01743 \times 0.25) + (0.0078 \times 0.04) \times 90 = 0.420255" \)
      - \( BA = 0.421" \) from FAA-H-8083-31
Terms/Vocabulary

• Setback (SB) – The difference between Mold Line Dimension and Bend Tangent Line Dimension
Calculation Order

4. SB – Setback

- For 90°, SB = T + R
  - T is thickness of material & R = Radius

- SB = K(T+R)
  - For 90°, K = 1
  - K charts
    - AC 43.13-1B Table 4-7
    - FAA-H-8083-31A Vol. 1 Figure 4-122
Terms/Vocabulary

- Bend Tangent Line Dimensions (BTLD) – Length of the unbend sections
Calculation Order

5. BTLD – Bend Tangent Line Dimension
   - Mold Line Dimension – Setback
   - BTLD = MLD – SB(s)
Terms/Vocabulary

- Developed Width (DW)

**Figure 4-131.** Flat pattern layout.
Calculation Order

6. DW - Developed Width

- Total of all the Bend Tangent Line Dimensions + all the Bend Allowances
- \( DW = \text{Total of all the BTLD(s)} + \text{all BA(s)} \)
Terms/Vocabulary

- Brake Reference Line is a Radius (R) away from Bend Tangent Line (BTL)
Calculation Order

7. Brake Reference Line (Sight Line)
   - Brake Reference Line = Bend Tangent Line Dimension + Radius
   - Brake Reference Line = BTLD + Radius
Example

Example: .032” 2024-T3
Dimension = 2” for both side, 90° bend

- Minimum Radius = R = 0.128 -> round to 0.125”
- BA = 0.218”
- SB = T + R
  - SB = 0.032” + 0.125” = 0.157”
- BTLD = MLD – SB
  - BTLD = 2” – 0.157” = 1.843”
- DW = BTLD + BA + BTLD
  - DW = 1.843” + 0.218” + 1.843” = 3.904”
- Brake Reference Line = BTLD + R
  - Brake Reference Line = 1.843” + 0.125” = 1.968”
Terms/Vocabulary

• Bend Tangent Line Dimensions (BTLD) – Length of the unbend sections
  ✤ Edge of metal to Bend Tangent Line (BTL)
  or
  ✤ BTL to BTL
Example

• Example: .080 7075-T6 – 5” X 6” X 5” channel
  ❖ Minimum Radius = R = 0.44” or (7/16) = 0.438”
  ❖ BA = 0.745”
  ❖ SB = T + R
    • SB = 0.080” + 0.438” = 0.518”
  ❖ BTLD = MLD – SB
    • BTLD (side) = 5” – 0.518” = 4.482”
    • BTLD (bottom) = 6” – 2 X 0.518” = 4.964”
  ❖ DW = BTLD + BA + BTLD + BA + BTLD
    • DW = 4.482” + 0.745” + 4.964” + 0.745” + 4.482” = 15.418”
  ❖ Brake Reference Line = 4.482” + 0.438” = 4.92” (from both sides)
Practice Problems

• .032” 2024-T5, Side 1 = 2 3/8”, Side 2 = 5.4”, 90° bend

• .040” 6061-T5 – 2.5” X 1” X 2.75” channel, all bends 90°

• .100” 2024-T5, Side 1 = 1 3/8”, Side 2 = 2 9/16”, 110° bend
Metal Working

- Follow manufacturer’s recommended procedures
- Follow AC43-13
- Heat treat untreated metals
  - Treated metals must be formed cold
- To prevent corrosion, use a protective layer between dissimilar metals
  - Paint or tape
- When using a form block, start at the edges and work to the center
- Use relief holes at bend intersections
Relief Holes

Figure 4-147. Relief hole layout.
Fluting Sheet Metal

- Video 1
- Video 2
Inspect for Damage

• Look for:
  - Corrosion
    • Treat or replace
  - Cracks
  - Elongated holes
  - Dents, scratches, nicks, pits & cuts
  - Wrinkles or bents
  - Loose rivets
    • “Smoking” rivets are indication of rubbing or fretting
    • Tipped rivets
      • If there is one, there is usually a whole row in the same direction
  - Look for force transmission
Smoking Rivets
Patching Sheet Metal Damage

• Consult Manufacturer’s repair manual and/or AC43-13 for best repair method
  - The goal is to return the structure to its original strength
  - Manufacturer may limit what you can repair
• Support damaged area
• Stop drill cracks or cut out damage.
  - Leave no stress risers – no sharp corners
• Calculate the number of rivets
  - Try to make your repair based on the rivet shear strength
Patching Sheet Metal Damage

• Make a paper design of a patch
  - Mark holes to insure no interference
  - Use transparency if possible

• Create a patch
  - Same material and same thickness or greater
  - Patch will go under skin if possible

• Make filler plug if needed – flush patch

• Drill holes

• Apply corrosion inhibitor/primer

• Apply sealant for pressurized repairs
Patching Sheet Metal Damage

• Rivet
• Prime and Paint
• Complete 337 and log repair
Stop Drill
Flush Patch

Figure 4-177. Typical flush patch repair.
Number of Rivets – AC43.13-1B

• Use Tables 4-9, 4-10 or 4-11 for rivets per inch.
  ❖ Page 4-37, 4-38 or 4-39
  ❖ Check notes

• # Rivets = Length of crack X Rivets per inch

• # Rivets is only for one side.

• The total rivets used is 2 X # Rivets
Rivet Spacing

• Rivet pitch - the distance between the centers of adjacent rivets in the same row.
  - Minimum – 3D; Maximum – 10D
  - Typical 6D to 8D
• Transverse pitch - the perpendicular distance between rivet rows
  - 75% of rivet pitch
  - Minimum – 2 1/2D
• Edge Distance – 2D to 4D
Rivet Spacing

Rivet pitch (6 to 8 dia.)

Edge distance (2 to 2.5 dia.)

Single-row layout

Transverse pitch (75% of rivet pitch)

Two-row layout

Three-row layout

Figure 5-42. Rivet spacing.
Elongated Octagonal Patch
Elongated Octagonal Patch

Locate rivets

Added rivet

2-1/2 D radius

Draw outline of patch
Round Patch

Approx 3/4" transverse pitch

2-1/2 D
Turn Down Edge

Approx 1/64"

45°

1-1/4 D

2-1/2 D
Panel Repair

- Repair seam same as strongest parallel adjacent seam.
- Use original holes & add as needed.
- Additional Rivets
- Trimmed Hole Radiused Corners

Rivet Symbols
Patch Ideas
Your Guides

- Follow manufacturer’s instructions
  - Maintenance/Repair manual
  - Copy rivet hole pattern
  - Use same material and rivets

- Use AC43.13-1B Par 4-58
Sample Questions

• Shallow scratches in sheet metal may be repaired by
  ❖ burnishing

• When a piece of aluminum alloy is to be bent using a minimum radius for the type and thickness of material
  ❖ the layout should be made so that the bend will be 90° to the grain of the sheet.
  ❖ AC 43-13-1B 4-55B says “preferably”
Sample Questions

• If it is necessary to compute a bend allowance problem and bend allowance tables are not available, the neutral axis of the bend can be found by adding approximately one-half of the stock thickness to the bend radius.

• You can distinguish between aluminum and aluminum alloy by testing with a 10 percent solution of caustic soda.
Sample Questions

• The most important factors needed to make a flat pattern layout are
  a. radius, thickness, and mold line.
  b. radius, thickness, and degree of bend.
  c. the lengths of the legs (flat sections).

• Answer: b