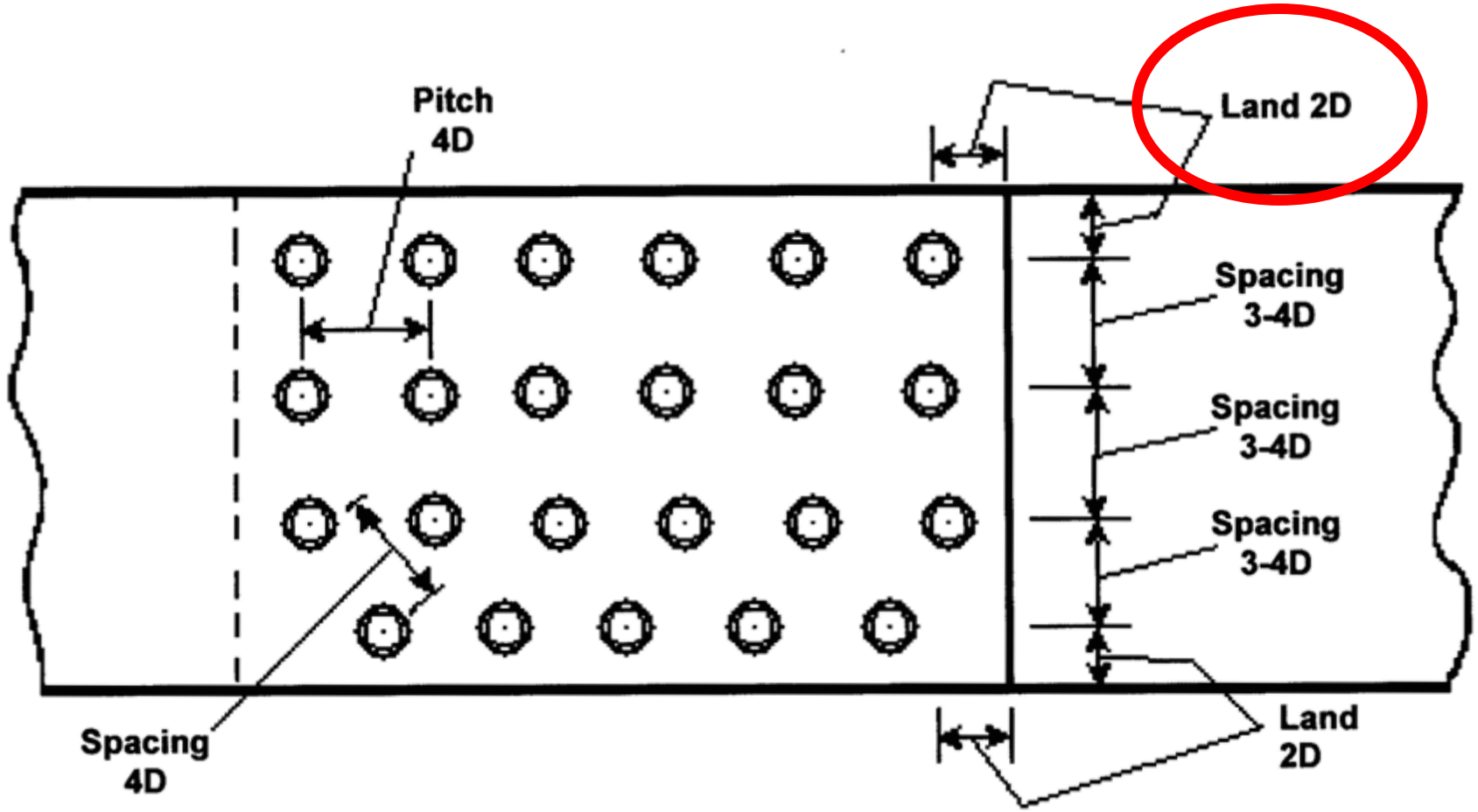
Aerospace Structures

M.Sc. Andrés Camilo Herrera Araujo

REPAIRS 2

Edge margin


Pitch
4D
Land 2D
Spacing
3-4D
Spacing
3-4D
Spacing
3-4D
Spacing
4D
Land
2D

Edge margin

Edge margin is the distance from the center of the first rivet to the edge of the sheet. To find the correct edge margin, you may need the data that follows:

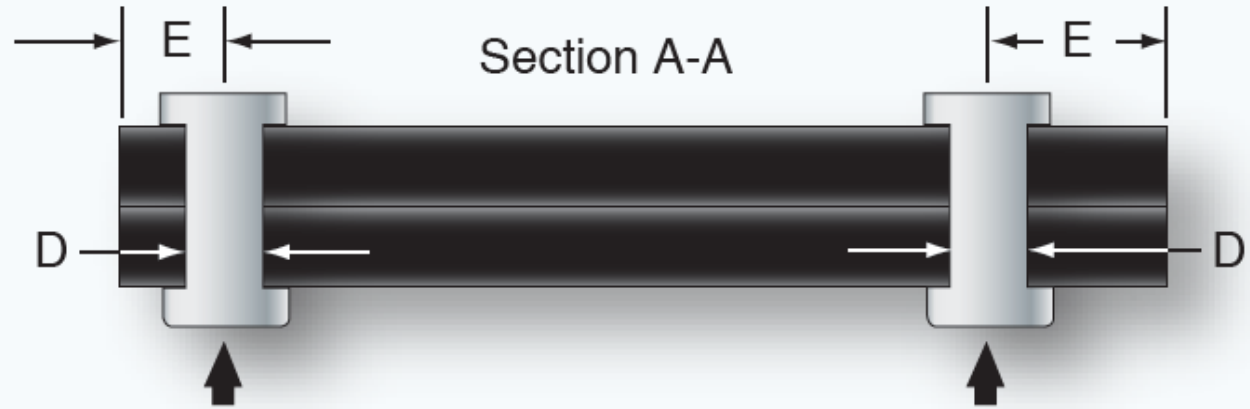
- The fastener diameter D
- The type of material
- The type of load in the fastened joint (single shear, double shear, tension…)
- The type of hole (countersunk, dimpled, straight shank)

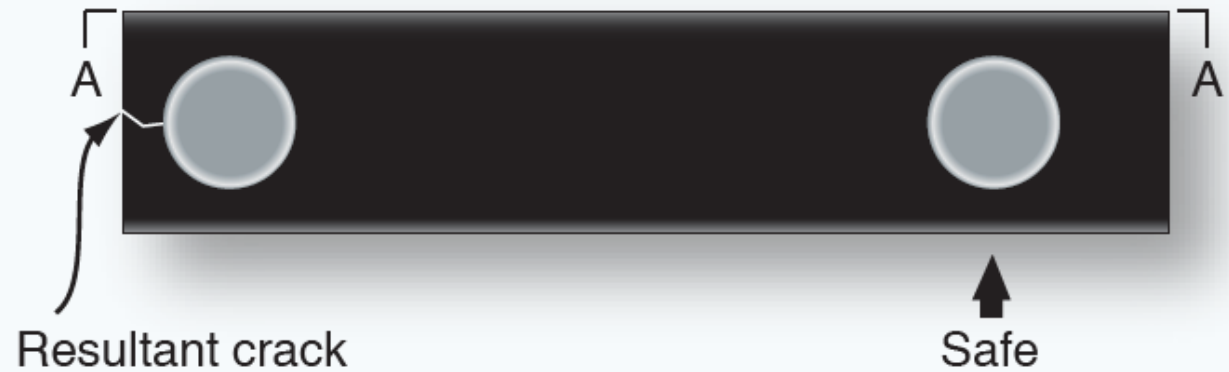
Edge margin

It should not **be less than 2 or more than 4 rivet diameters** and the recommended edge distance is about **2½ rivet diameters**.

- The minimum edge distance for **universal rivets** is **2 times** the diameter of the rivet
- the minimum edge distance for **countersunk rivets** is **2½ times** the diameter of the rivet

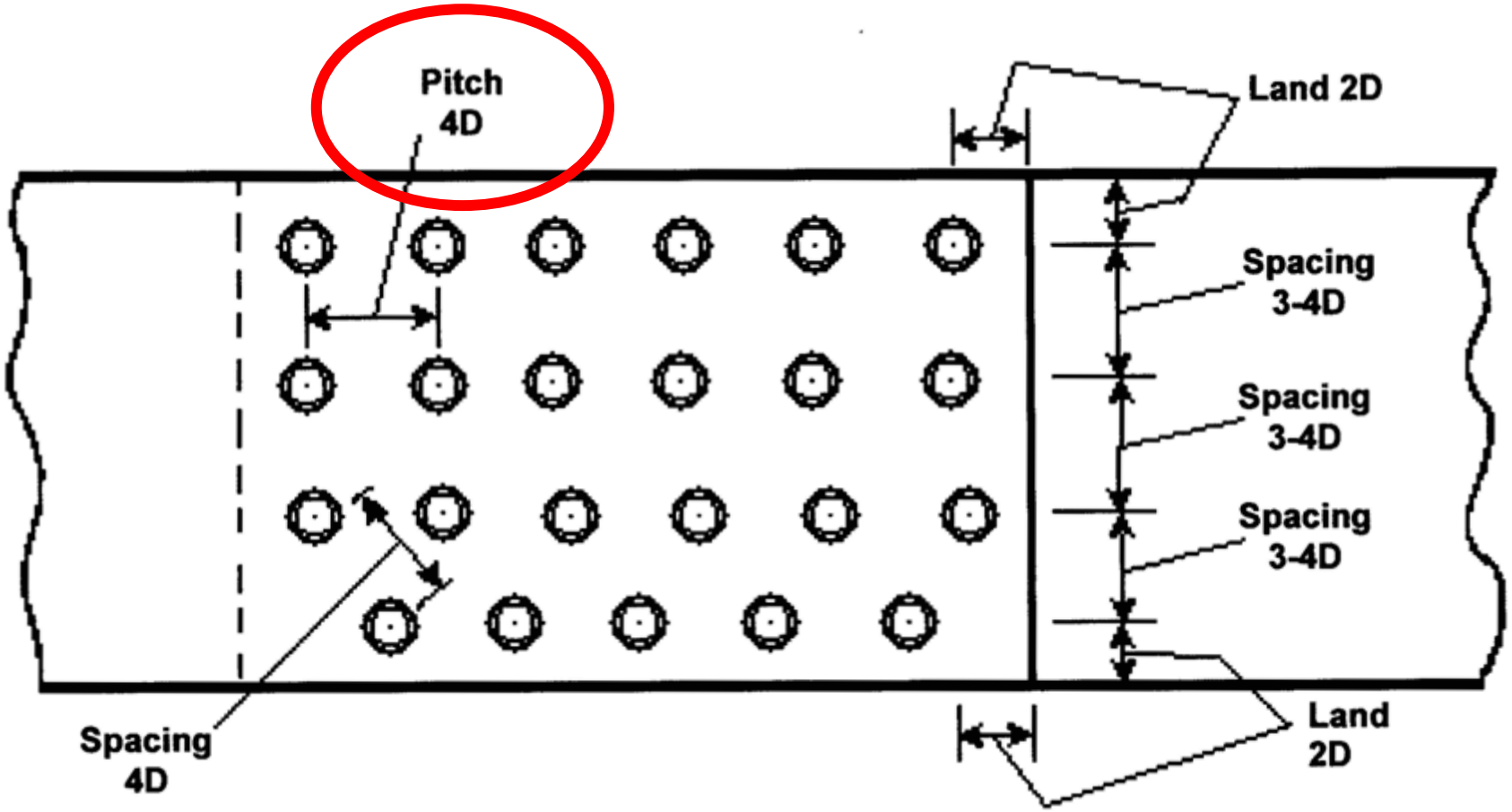
If rivets are placed too close to the edge of the sheet, the sheet may crack or pull away from the rivets





Edge Distance/Edge Margin	Minimum Edge Distance	Preferred Edge Distance
Protruding head rivets	2 D	2 D + 1/16″
Countersunk rivets	2½ D	2½ D + 1/16″

Rivet pitch


Pitch
4D
Land 2D
Spacing
3-4D
Spacing
3-4D
Spacing
3-4D
Spacing
4D
Land
2D

Rivet pitch

Rivet pitch is the **distance between the centers of neighboring rivets** in the same row.

The **smallest allowable rivet pitch is 3 rivet diameters**.

The **average rivet pitch usually ranges from 4 to 6 rivet diameters**, although in some instances rivet pitch could be as large as 10 rivet diameters.

Rivet pitch

Rivet spacing on parts that are subjected to bending moments is often closer to the minimum spacing to **prevent buckling of the skin between the rivets**.

The minimum pitch also **depends on the number of rows of rivets**:

- **One and three-row** layouts have a **minimum pitch of 3 rivet diameters**
- A **two-row** layout has a **minimum pitch of 4 rivet diameters**

For zero-timing:

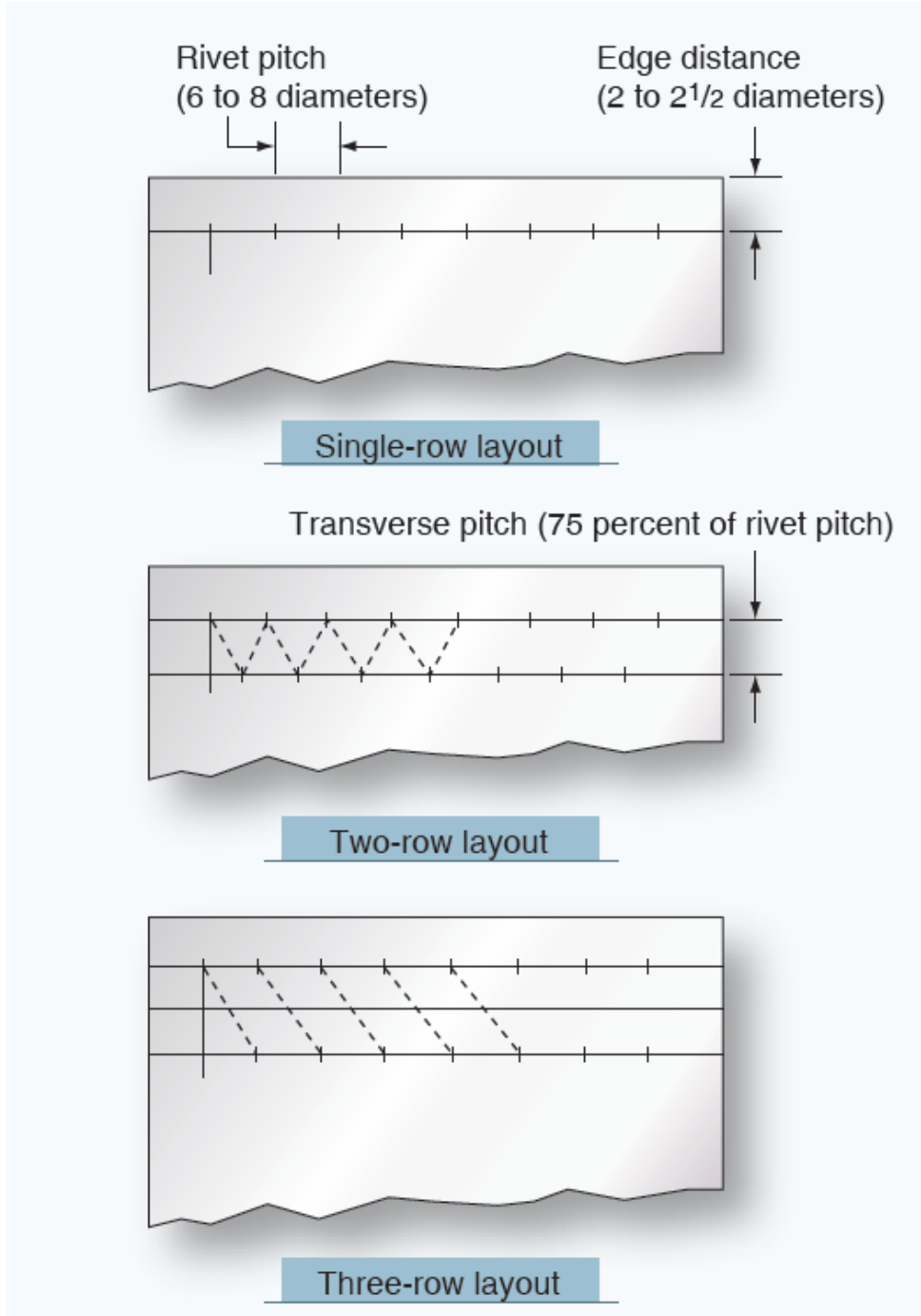
If the rivet spacing is made at least 1/16 in larger than the minimum, the rivet hole can be oversized without violating the minimum rivet spacing requirement.

Transverse pitch

Transverse pitch is the perpendicular distance between rivet rows.

- It is usually **75 % of the rivet pitch**
- The smallest allowable transverse pitch is **2½ in**

However, rivet pitch and transverse pitch often have the same dimension and are simply called rivet spacing.


Rivet pitch
(6 to 8 diameters)
Edge distance
(2 to 2½ diameters)
Single-row layout
Transverse pitch (75 percent of rivet pitch)
Two-row layout
Three-row layout

SKIN PLATES

1. General

These repairs are applicable for skin plates. For STA (FR) designation refer to Chapter 53-00-00 Pageblock 001 , the general repairs are listed in Table 201, the specific repairs are listed in Table 202. The appropriate repairs are described in more detail in the relevant Chapter.

NOTE: Repairs applicable in areas around static ports, pitot probes, total air temperature probes and angle of attack sensors, have to comply with aerodynamic smoothness requirements given in Chapter 53-00-11 Pageblock 101 .

NOTE: For Detailed definition of Repair Categories refer to Chapter 51-11-14 .

NOTE: For Damage/Repair Data Recording refer to Chapter 51-11-15 .

2. Safety Precautions

WARNING: OBEY THE MANUFACTURER'S INSTRUCTIONS WHEN YOU USE CLEANING AGENT, BONDING AND ADHESIVE COMPOUND, SEALANT, SPECIAL MATERIAL AND STRUCTURE PAINT. THESE MATERIALS ARE DANGEROUS.

CAUTION: THERE MUST BE A MINIMUM DISTANCE OF FOUR FASTENER SPACINGS BETWEEN THE OUTER ROWS OF ADJACENT REPAIR.

CAUTION: THERE MUST BE A MINIMUM DISTANCE OF THREE FASTENER SPACINGS BETWEEN THE OUTER ROW OF THE DOUBLER TO THE FIRST FASTENER ROW OF LONGITUDINAL OR CIRCUMFERENTIAL JOINT. IN CASE THIS DISTANCE CANNOT BE MAINTAINED, REFER TO THE INSTRUCTIONS FOR THE RELEVANT SRM JOINT REPAIR SCHEME.

CAUTION: USE ONLY SPECIFIED CLEANING AGENTS AND SOLUTIONS OR THEIR EQUIVALENTS. THE SURFACE PROTECTION COULD BE DAMAGED IF UNSPECIFIED MATERIALS ARE USED. IT IS IMPORTANT THAT THE MANUFACTURER'S MIXING, APPLICATION AND TREATMENT INSTRUCTIONS ARE FOLLOWED.

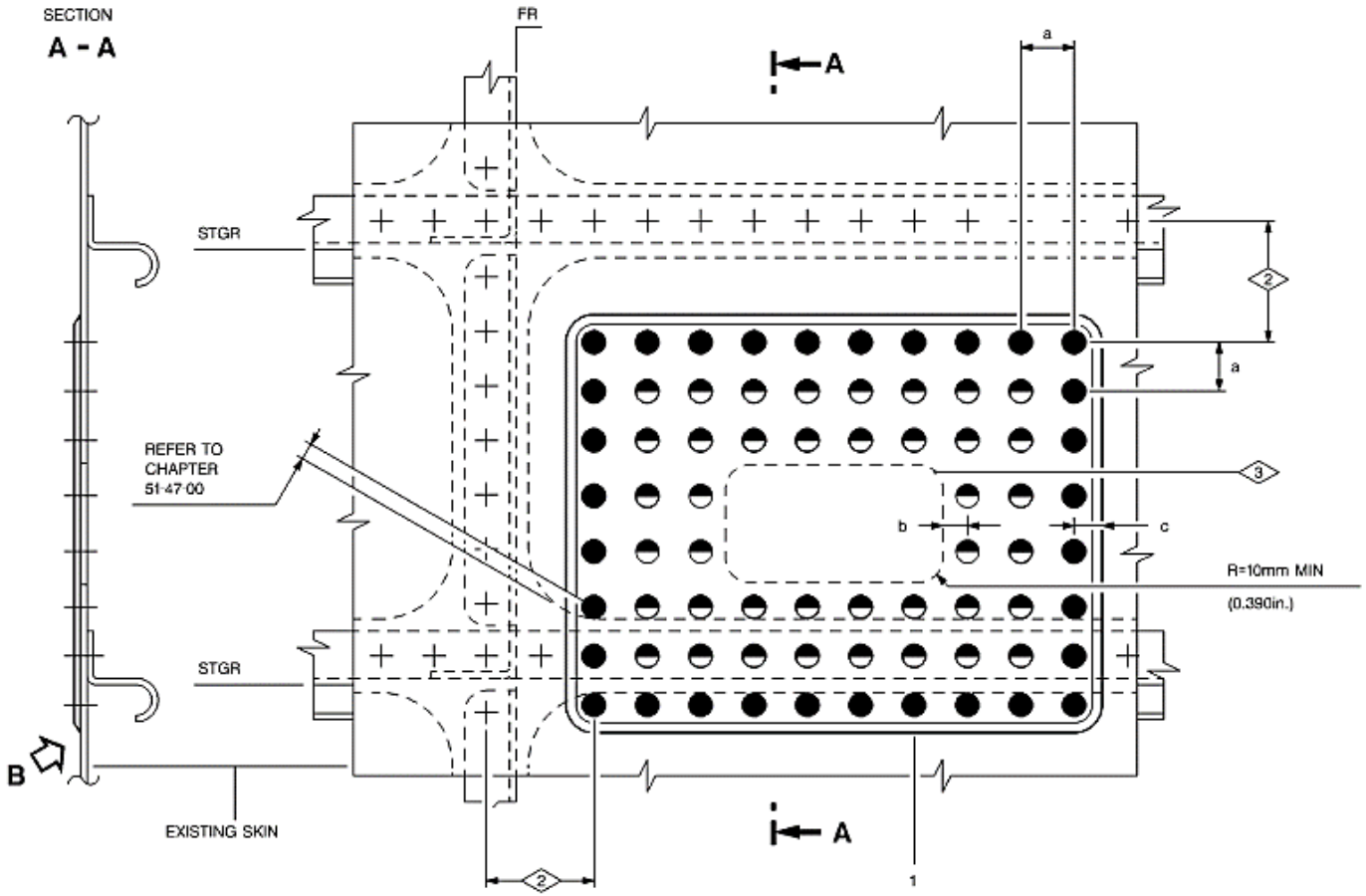
CAUTION: TO PREVENT DAMAGE TO THE SURFACE PROTECTION, MECHANICAL AND ELECT
COVER

CAUTION: OBEY

CAUTION: OBEY
GIVEN

CAUTION: FOR R
PARAG

CAUTION: HIDDE
STRUC



CAUTION: THERE MUST BE A MINIMUM DISTANCE OF FOUR FASTENER SPACINGS BETWEEN THE OUTER ROWS OF ADJACENT REPAIR.

CAUTION: THERE MUST BE A MINIMUM DISTANCE OF THREE FASTENER SPACINGS BETWEEN THE OUTER ROW OF THE DOUBLER TO THE FIRST FASTENER ROW OF LONGITUDINAL OR CIRCUMFERENTIAL JOINT. IN CASE THIS DISTANCE CANNOT BE MAINTAINED, REFER TO THE INSTRUCTIONS FOR THE RELEVANT SRM JOINT REPAIR SCHEME.

SKIN PLATES

1. General

This topic contains repair procedures for fuselage skin plates. For STA (FR) designation, refer to Chapter 53-00-00 Page Block 001. The appropriate repairs are listed under 3.A. and are described in more detail in the following text.

NOTE: Refer to each repair to determine the repair applicability.

NOTE: For Damage/Repair Data Recording refer to Chapter 51-11-15

2. Safety Precautions

WARNING: OBEY THE MANUFACTURER'S INSTRUCTIONS WHEN YOU USE CLEANING AGENTS, BONDING AND ADHESIVE COMPOUND, SEALANT, SPECIAL MATERIAL AND STRUCTURE PAINT. THESE MATERIALS ARE DANGEROUS.

CAUTION: HIDDEN DAMAGE CAN LEAD TO FAILURE OF THE REPAIR OR SURROUNDING STRUCTURE.

CAUTION: REPAIRS APPLICABLE IN AREAS AROUND STATIC PORTS, PITOT PROBES, TOTAL AIR TEMPERATURE PROBES AND ANGLE OF ATTACK SENSORS, HAVE TO COMPLY WITH AERODYNAMIC SMOOTHNESS REQUIREMENTS GIVEN IN Chapter 53-00-11 Page Block 101 PARAGRAPH 4.

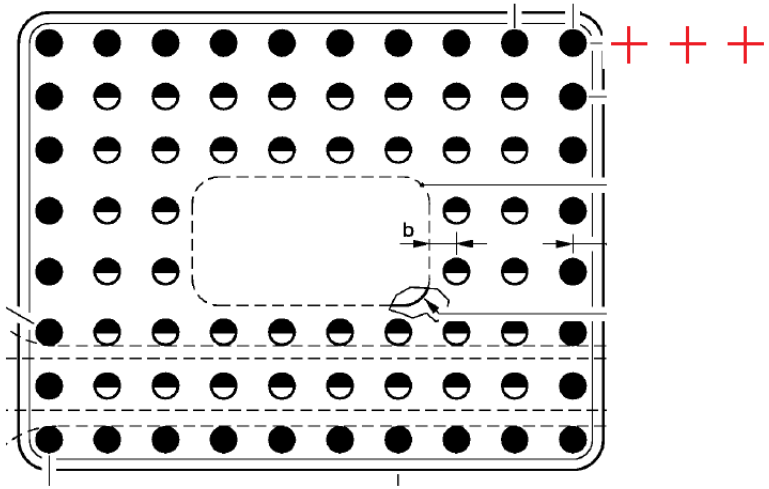
CAUTION: USE ONLY SPECIFIED CLEANING MATERIALS AND SOLUTIONS OR THEIR EQUIVALENTS. THE SURFACE PROTECTION COULD BE DAMAGED IF UNSPECIFIED MATERIALS ARE USED. IT IS IMPORTANT THAT THE MANUFACTURER'S MIXING, APPLICATION AND TREATMENT INSTRUCTIONS ARE FOLLOWED.

CAUTION: THERE MUST BE A MINIMUM DISTANCE OF FOUR FASTENER SPACINGS BETWEEN THE OUTER RIVET/FASTENER ROWS OF ADJACENT REPAIRS AND ANY EXISTING DOUBLERS.

CAUTION: THERE MUST BE A MINIMUM DISTANCE OF FOUR FASTENER SPACINGS BETWEEN THE OUTER RIVET/FASTENER ROW OF THE DOUBLER AND ANY EXISTING CUTOUT (E.G. DOOR/WINDOW).

CAUTION: THERE MUST BE A MINIMUM DISTANCE OF THREE FASTENER SPACINGS BETWEEN THE OUTER RIVET/FASTENER ROW OF THE DOUBLER TO THE FIRST RIVET/FASTENER ROW OF A LONGITUDINAL OR CIRCUMFERENTIAL JOINT. IN CASE THIS DISTANCE CANNOT BE MAINTAINED, REFER TO THE INSTRUCTIONS FOR THE RELEVANT SRM JOINT REPAIR SCHEME.

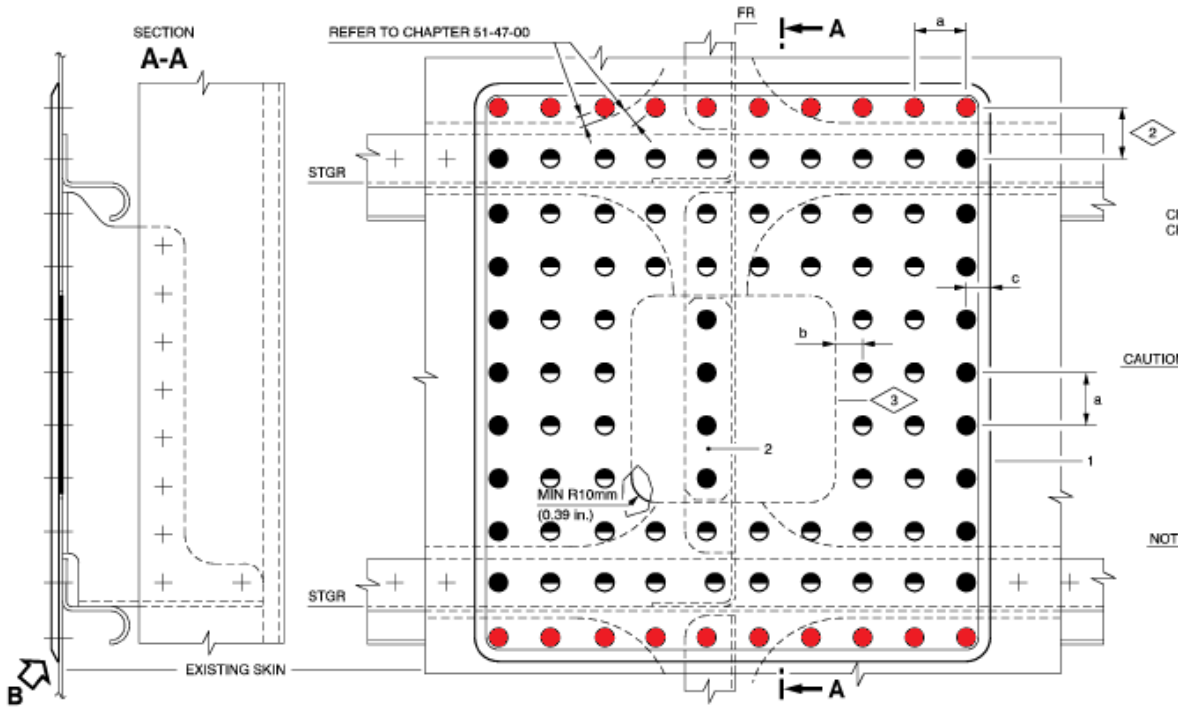
CAUTION: TO PREVENT DAMAGE TO THE SURFACE PROTECTION, MECHANICAL AND ELECTRICAL SYSTEMS, THE AREA SURROUNDING THE REPAIR MUST BE

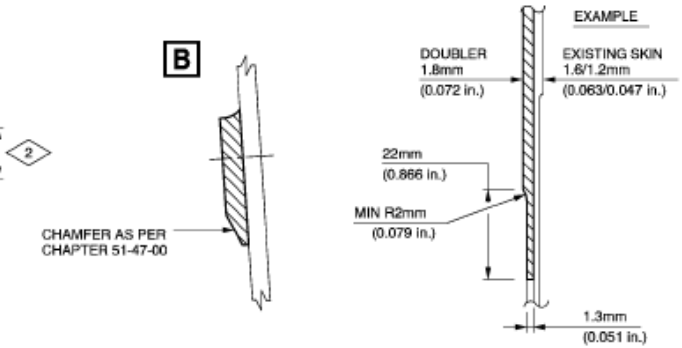


CAUTION: THERE MUST BE A MINIMUM DISTANCE OF FOUR FASTENER SPACINGS BETWEEN THE OUTER RIVET/FASTENER ROW OF THE DOUBLER AND ANY EXISTING CUTOUT (E.G. DOOR/WINDOW).

MINIMUM REPAIR DOUBLER/FRAME (OR STRINGER) OVERLAP

The repair doubler should not stop at a stringer of frame fastener line. If necessary, **extend the doubler by one additional fastener row**





REPAIR MATERIAL									
ITEM	NOMEN-CLATURE	MATERIAL	EXISTING SKIN ◇4						
			1.2mm (0.047 in.)	1.4mm — 1.45mm (0.055 in.) (0.057 in.)	> 1.45mm — 1.65mm (0.057 in.) (0.065 in.)	> 1.65mm — 2.0mm (0.065 in.) (0.080 in.)	> 2.0mm — 2.2mm (0.080 in.) (0.087 in.)		
1	DOUBLER ◇5	CLAD2024T3	1.4mm (0.056 in.)	1.6mm (0.063 in.)	1.8mm (0.071 in.)	2.0mm (0.080 in.)	2.2mm (0.090 in.)		
2	FILLER	CLAD2024T3	SAME THICKNESS AS EXISTING SKIN						
FASTENER SYMBOLS		+	REFERENCE ONLY						
		●	NAS1097DD5 ◇1						
		◒	NAS1097DD5 ◇1			NAS1097DD6 ◇1			
PITCH a			ACCORDING TO EXISTING PITCH OR REFER TO CHAPTER 51-47-00						
MARGIN b			10mm (0.390 in.)						
MARGIN c			REFER TO CHAPTER 51-47-00						

CAUTION: THIS REPAIR MAY REQUIRES AN INSPECTION AT 20000 FC IF CARRIED OUT ABOVE WINDOW LINE. FOLLOW THE INSTRUCTIONS GIVEN IN PARAGRAPH 4.A.

THERE MUST BE A MINIMUM DISTANCE OF FOUR FASTENER SPACINGS BETWEEN THE OUTER ROWS OF ADJACENT REPAIRS.

THERE MUST BE A MINIMUM DISTANCE OF THREE FASTENER SPACINGS BETWEEN THE ROW OF THE DOUBLER TO THE FIRST FASTENER ROW OF A LONGITUDINAL OR CIRCUMFERENTIAL JOINT. IN CASE THIS DISTANCE CANNOT BE MAINTAINED, REFER TO THE INSTRUCTIONS FOR THE RELEVANT SRM JOINT REPAIR SCHEME.

NOTE: THE REPAIR, APPLICABLE BETWEEN FR1 THRU FR35, HAS BEEN MOVED TO CHAPTER 53-11-11 AND 53-21-11.

THESE REPAIRS ARE APPLICABLE FOR DAMAGE TO THE SKIN WHERE THE SKIN THICKNESS IS BETWEEN 1.2mm (0.047 in.) AND 2.2mm (0.087 in.), AND ARE EFFECTIVE AS FOLLOWS:
- FROM FR35 THRU FR87

FOR SPECIFIC APPLICABILITY BETWEEN FR70 THRU FR87
REFER TO CHAPTER 53-51-11 PAGE BLOCK 201.
IF THE DOUBLER THICKNESS AT RUNOUT (LONGITUDINAL AND/OR CIRCUMFERENTIAL CIRCUMFERENTIAL DIRECTION) IS MORE THAN 0.4mm (0.016 in.) GREATER THAN EXISTING SKIN, THE DOUBLER HAS TO BE PROVIDED WITH A STEP OF 1.3mm (0.051 in.) DIMENSIONS REFER TO EXAMPLE.

FILL EXISTING COUNTERSINKS IN FUSELAGE SKIN (REFER TO CHAPTER 51-71-15).

◇1 IN THE AREA ENCLOSED BY BELLY FAIRING UNIVERSAL FASTENER MS20470DD MAY BE USED.

◇2 THE DOUBLER MUST NOT END ABOVE A STRINGER OR FRAME. EXTEND THE DOUBLER IF NECESSARY BY ONE FASTENER ROW AFTER THE FRAME OR STRINGER.

◇3 CUTOUT IN SKIN IS LIMITED TO A LENGTH OF HALF A FRAME BAY AND A WIDTH OF ONE STRINGER BAY.

◇4 REFERENCE FOR THE SKIN THICKNESS IS THE MAXIMUM THICKNESS OF THE CHEMICALLY MILLED POCKETS AROUND THE DAMAGE, (REFER TO FIGURE 201).

◇5 THE mm (in.) CONVERSION FOR THE DOUBLER THICKNESS CORRESPONDS TO THE US STANDARD ALUMINUM SHEET METAL GAGE AND IS NOT NECESSARILY THE EXACT CONVERSION.

Skin at Frame - External Repair
Figure 205

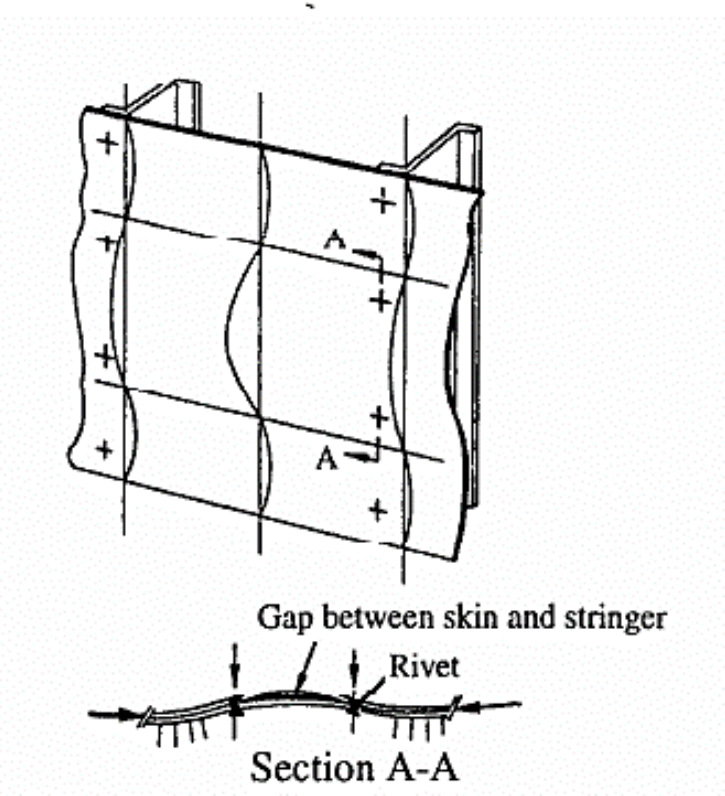
Printed in Germany

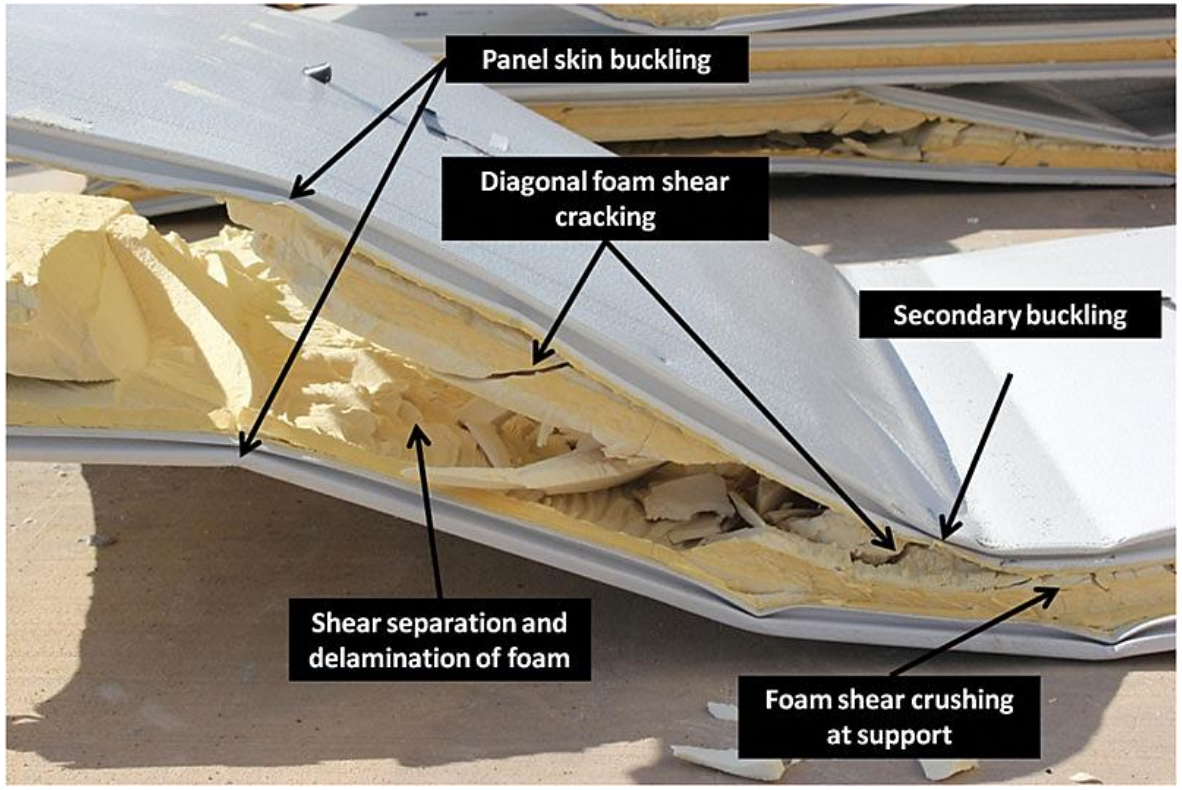
NS6 53 00 11 2 AEM0 05 0

◇2 THE DOUBLER MUST NOT END ABOVE A STRINGER OR FRAME. EXTEND THE DOUBLER IF NECESSARY BY ONE FASTENER ROW AFTER THE FRAME OR STRINGER.

Inner rivet buckling

Inner rivet buckling involves an area of material that has deflected significantly between the fasteners, regardless of the overall shape or size of the panel.



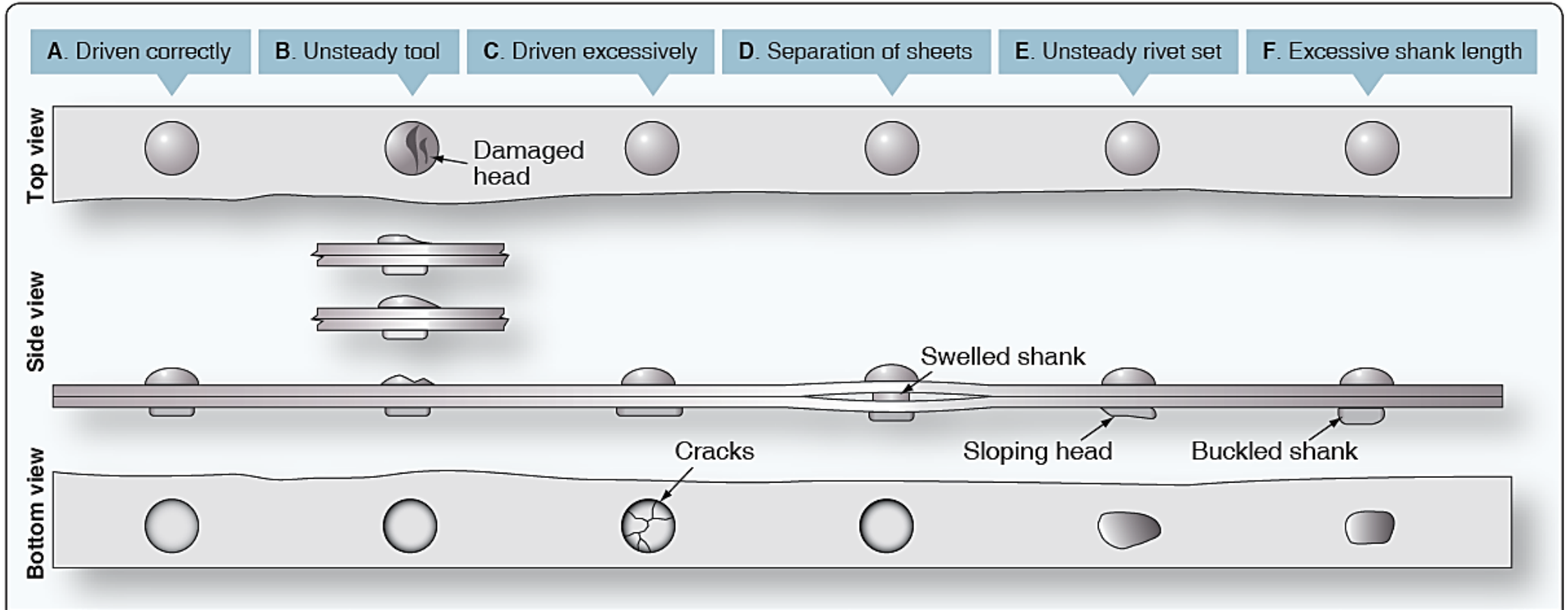


Evaluating the rivet

An **inspection must be made** of all rivets before the part is put in service

A **scale or rivet gauge** can be used to check the condition of the upset rivet head to see that it conforms to the proper requirements

Deformities in the manufactured head can be detected by the trained eye alone

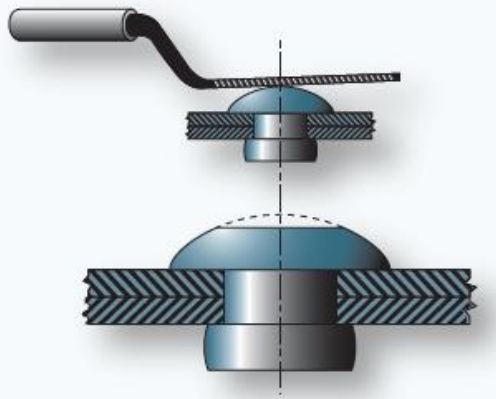


	Imperfection	Cause	Remedy	Action
A	None	None	None	None
B	Cut head	Improperly held tools	Hold riveting tools firmly against work	Replace rivet
C	Excessively flat head, resultant head cracks	Excessive driving, too much pressure on bucking bar	Improve riveting technique	Replace rivet
D	Sheet separation	Work not held firmly together and rivet shank swelled	Fasten work firmly together to prevent slipping	Replace rivet
E	Sloping head	a. Bucking bar not held firmly b. Bucking bar permitted to slide and bounce over the rivet	Hold bucking bar firmly without too much pressure	Replace rivet
F	Buckled shank	Improper rivet length, and E above	E above and rivet of proper length	Replace rivet

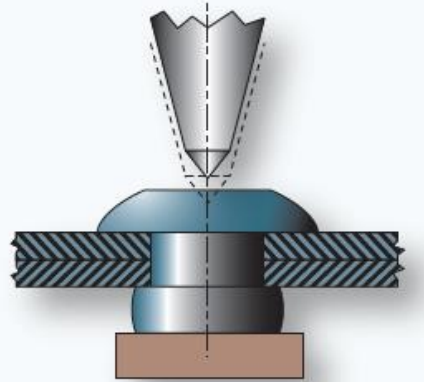
Rivet Removal

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 1/32 (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 tilt 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.

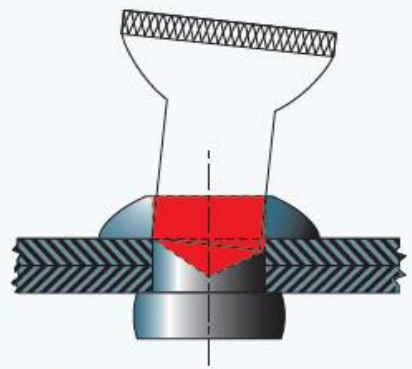


1. File a flat area on manufactured head

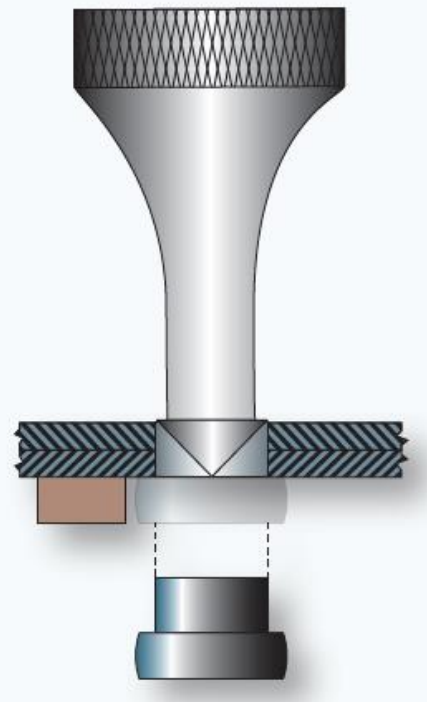


2. Center punch flat

3. Drill through head using drill one size smaller than rivet shank



4. Remove weakened head with machine punch



5. Punch out rivet with machine punch

Shear and bearing strength balance

Structural joint design involves an **attempt to find the optimum strength relationship** between being critical in shear and critical in bearing.

- The joint is critical in shear if **less than the optimum number of fasteners** of a given size are installed. The rivets will fail.
- The joint is critical in bearing **if more than the optimum number of fasteners of a given size are installed**. The material will crack and tear.

Repair design guidelines

Check 51-70-10-001

Structural repair manual

Airbus A321

REPAIR DESIGN GUIDELINE

1. General

CAUTION: THE STRUCTURAL ITEMS, FOR WHICH A REPAIR CAN BE DESIGNED USING THESE GUIDELINES ARE IDENTIFIED IN THE SPECIFIC SRM IDENTIFICATION AND/OR REPAIR PAGE BLOCKS.

A. Purpose of the Repair Design Guideline

Each repair on an aircraft structure has to be capable of sustaining the original justified design loads for static, fatigue and damage tolerance requirements. In most cases only the static requirements need to be met for the repair principles on secondary structure and only those will be addressed in this part.

A static or stress analysis is performed to make sure that the structure can withstand the applied ultimate loads without failure and without permanent deformation at limit load.

There are two main approaches in demonstrating the static strength capability of the repair design. The approach taken depends on how much is known concerning the existing loading in the repaired part.

(1) All details of the applied loading are known:

In this case, a detailed stress analysis of the part to be repaired results in an optimized repair design. This is generally the approach taken by the manufacturer.

(2) No details of the applied loading are known:

In this case the REVERSE ENGINEERING METHOD may be employed to evaluate the repair static strength capability.

B. Scope and Limitations

This topic presents some guidelines which may be used when designing repairs for extruded/formed sections. These guidelines are based on the reverse engineering method.

As explained in Paragraph 1.D. (Principle), these guidelines are based on the restoration of the static strength of the repaired part.

The resulting repair will therefore comply with the static strength requirements. These guidelines, when used together with the other standard SRM principles and guidelines (fastener hole and drill data, spacing and margin data, sealing, etc.) may be used repairs to secondary structure without referring back to AIRBUS.

These guidelines may also be used when designing repairs, which are to be submitted to AIRBUS for approval, however it should be noted that the assumption taken when designing a repair based on the reverse engineering method are often conservative and may result in over-designed repairs.

Acceptable methods, techniques and practices aircraft inspection and repair

AC 43.13-1B contains methods, techniques, and practices acceptable to the Administrator for the inspection and repair of non pressurized areas of civil aircraft, only when there are no manufacturer repair or maintenance instructions.

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentid/99861

Thickness "t" in inches	No. of 2117-T4 (AD) protruding head rivets required per inch of width "W"					No. of Bolts
	Rivet size					
	3/32	1/8	5/32	3/16	1/4	AN-3
.016	6.5	4.9	- -	- -	- -	- -
.020	6.5	4.9	3.9	- -	- -	- -
.025	6.9	4.9	3.9	- -	- -	- -
.032	8.9	4.9	3.9	3.3	- -	- -
.036	10.0	5.6	3.9	3.3	2.4	- -
.040	11.1	6.2	4.0	3.3	2.4	- -
.051	- -	7.9	5.1	3.6	2.4	3.3
.064	- -	9.9	6.5	4.5	2.5	3.3
.081	- -	12.5	8.1	5.7	3.1	3.3
.091	- -	- -	9.1	6.3	3.5	3.3
.102	- -	- -	10.3	7.1	3.9	3.3
.128	- -	- -	12.9	8.9	4.9	3.3

NOTES:

a. For stringers in the upper surface of a wing, or in a fuselage, 80 percent of the number of rivets shown in the table may be used.

b. For intermediate frames, 60 percent of the number shown may be used.

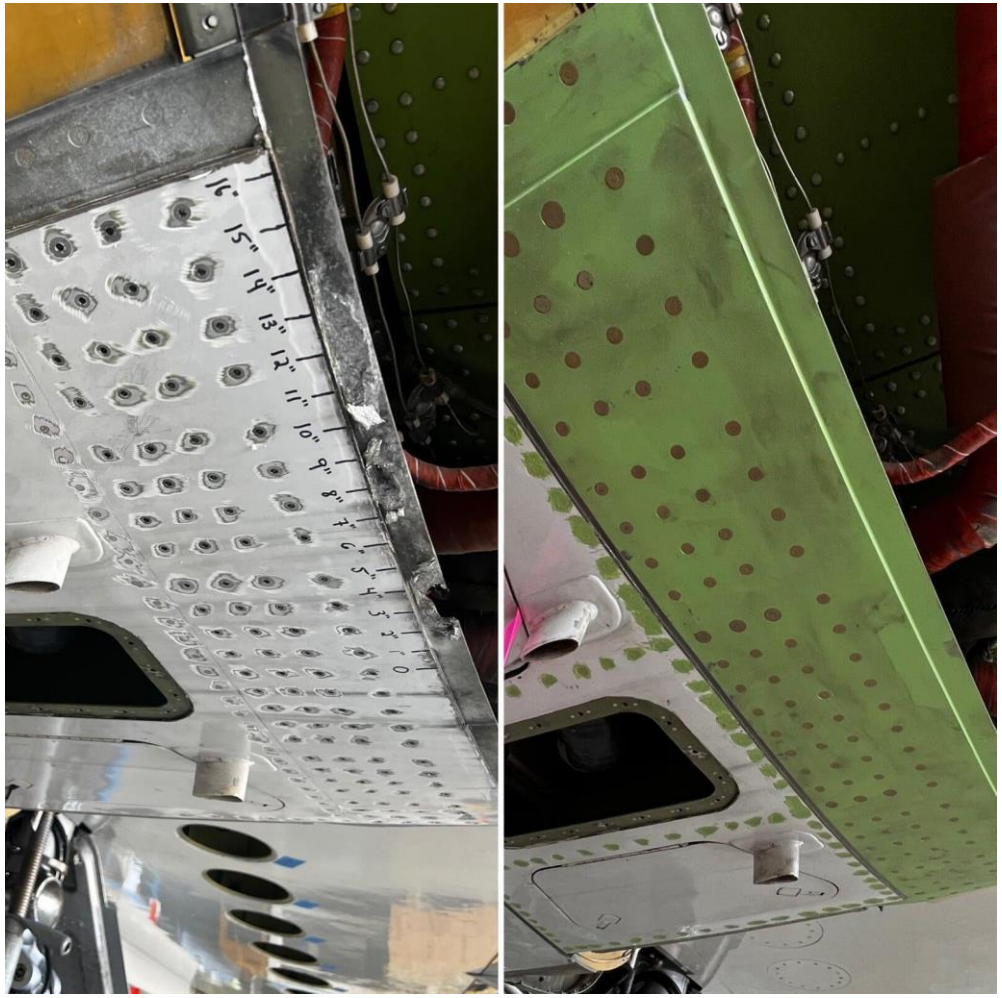
c. For single lap sheet joints, 75 percent of the number shown may be used.

General rules for repair

Ensure that the cross-sectional area of a splice or patch is at least **equal** to **or greater** than the damaged part

Avoid abrupt changes in cross sectional area

Eliminate dangerous **stress concentration** by tapering splices



General rules for repair

To reduce cracks starting from the corners of cutouts, try to make **cutouts** either **circular or oval in shape**

Where it is necessary to use a **rectangular cutout** make the radius of curvature at **each corner** no smaller than **1/2 in**

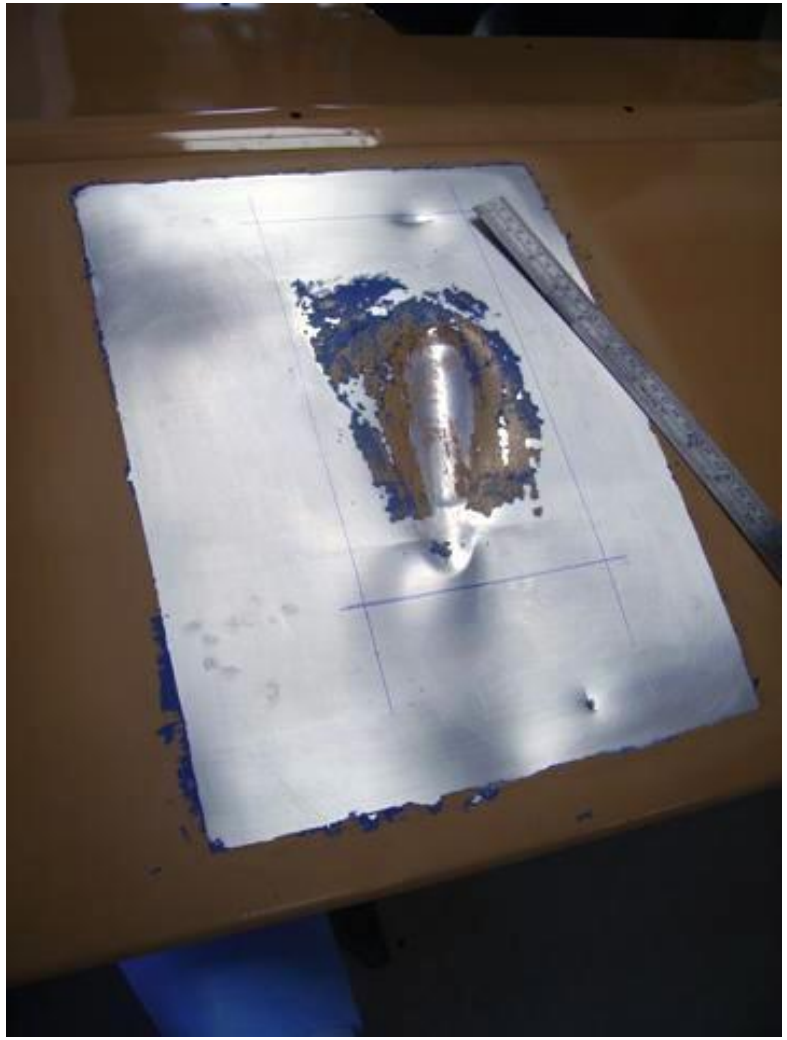
If the member is subjected to compression or bending loads, the **patch should be placed on the outside** of the member to obtain a higher resistance to such loads

General rules for repair

Replace buckled or bent members or reinforce them by **attaching a splice over the affected area**.

A buckled part of the structure **shall not be depended upon to carry its load again** no matter how well the part may be strengthened.

The **buckling and torsional strength** of many sheet metal and tubular parts depends primarily on the **thickness** of the material.



General rules for repair

Extensive **repairs that are made too strong can be as undesirable** as repairs weaker than the original structure.

All aircraft structure must flex slightly to withstand the forces imposed during takeoff, flight, and landing.

Repair of a stressed skin structure

Patches can be lap/scab patch or flush.

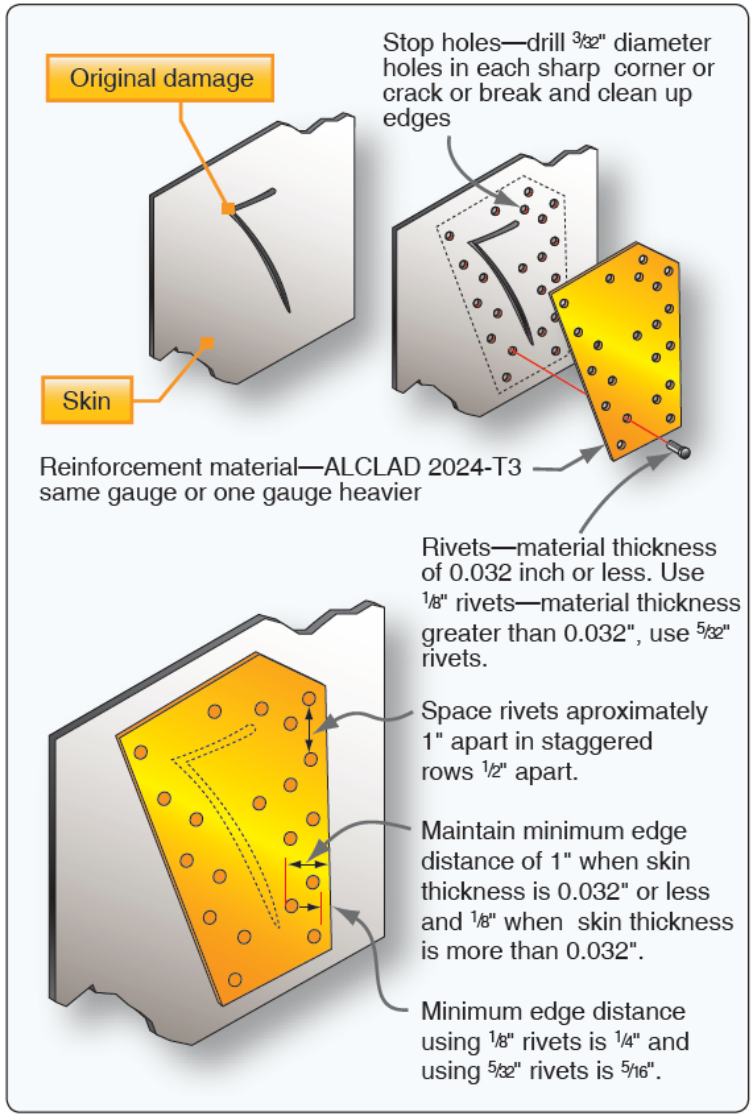
Minor damage to the outside skin of the aircraft can be **repaired by a patch to the inside of the damaged sheet**.

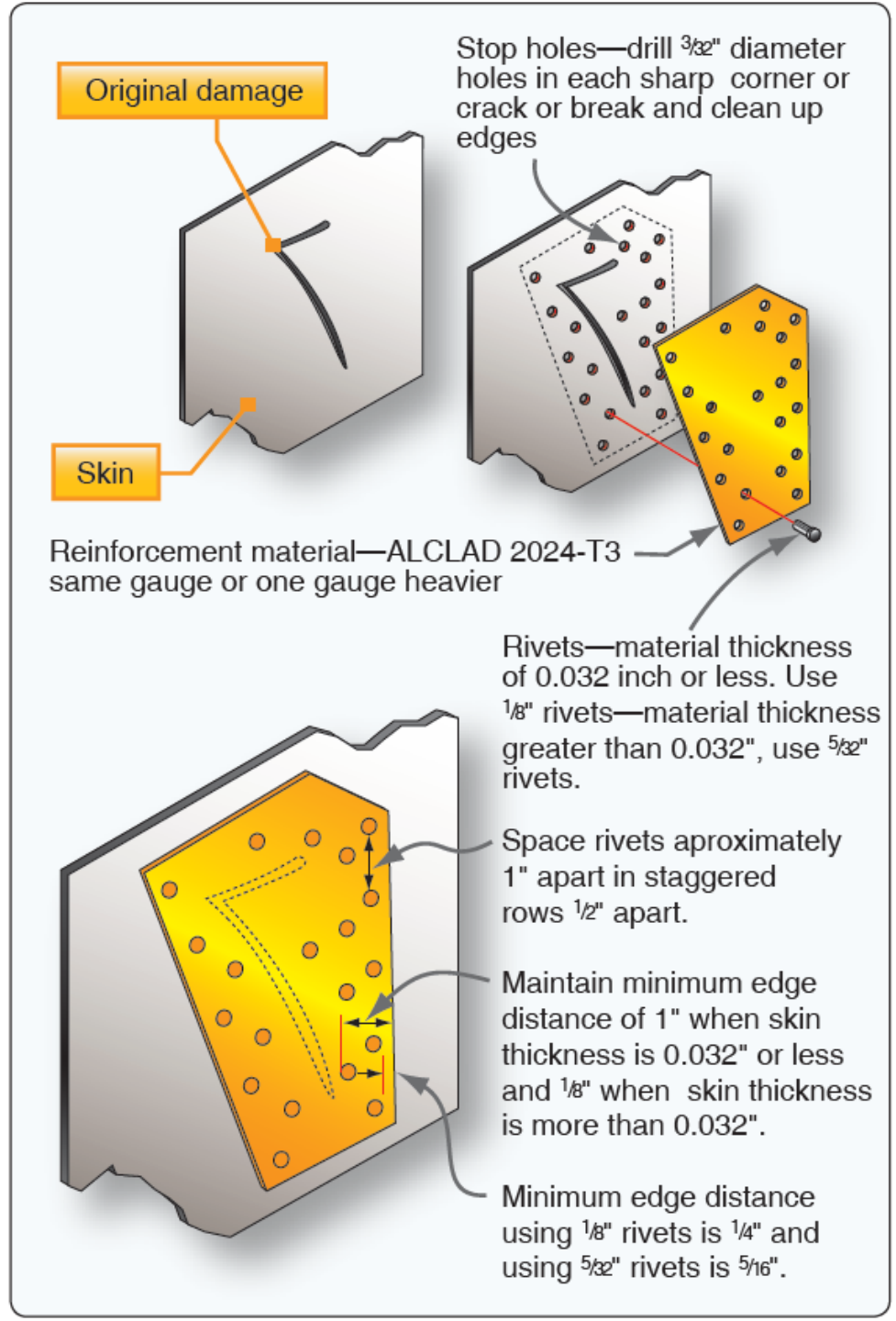
Lap or scab patch

The lap or scab type of patch is an **external patch** where the edges of the patch and the skin **overlap each other**.

The lap patch is riveted to the skin.

In repairing cracks, **a small hole must be drilled** in each end and sharp bend of the crack before applying the patch.



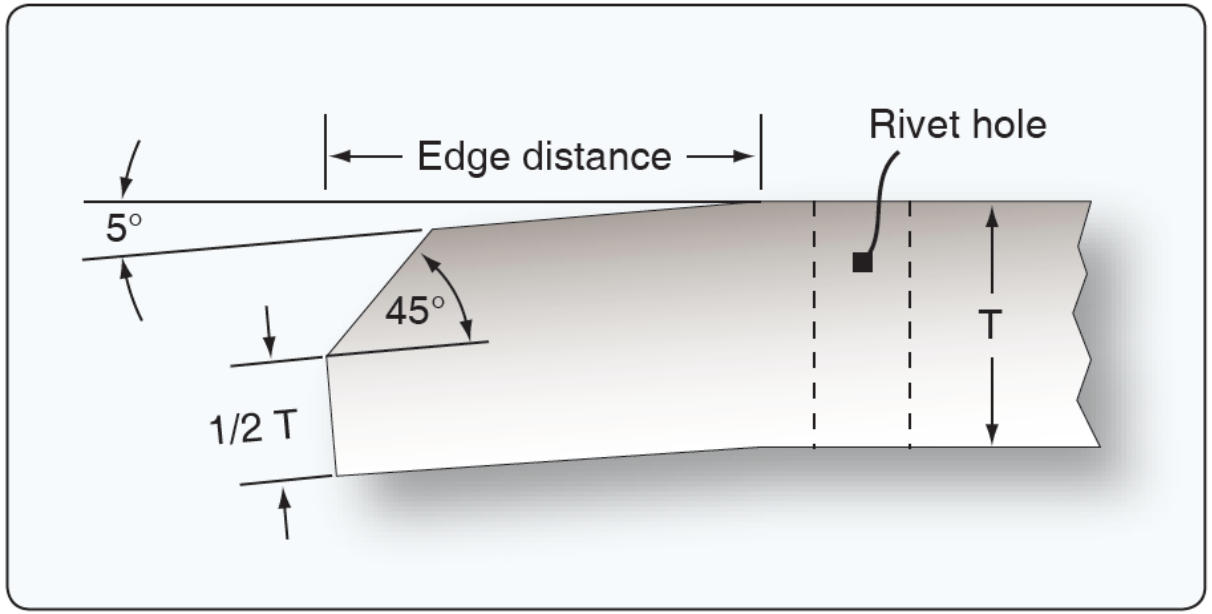

Original damage
Skin
Stop holes—drill 3/32" diameter holes in each sharp corner or crack or break and clean up edges
Reinforcement material—ALCLAD 2024-T3 same gauge or one gauge heavier
Rivets—material thickness of 0.032 inch or less. Use 1/8" rivets—material thickness greater than 0.032", use 5/32" rivets.
Space rivets aproximately 1" apart in staggered rows 1/2" apart.
Maintain minimum edge distance of 1" when skin thickness is 0.032" or less and 1/8" when skin thickness is more than 0.032".
Minimum edge distance using 1/8" rivets is 1/4" and using 5/32" rivets is 5/16".

Lap or scarf patch

The patch may be cut circular, square, or rectangular. If it is cut square or rectangular, the corners are rounded to a radius no smaller than 1/4 in

Edges must be chamfered to an angle of 45 for 1/2 the thickness of the material, and bent down 5 over the edge distance to seal the edges.

This reduces the chance that the repair is affected by the airflow over it



Flush patch

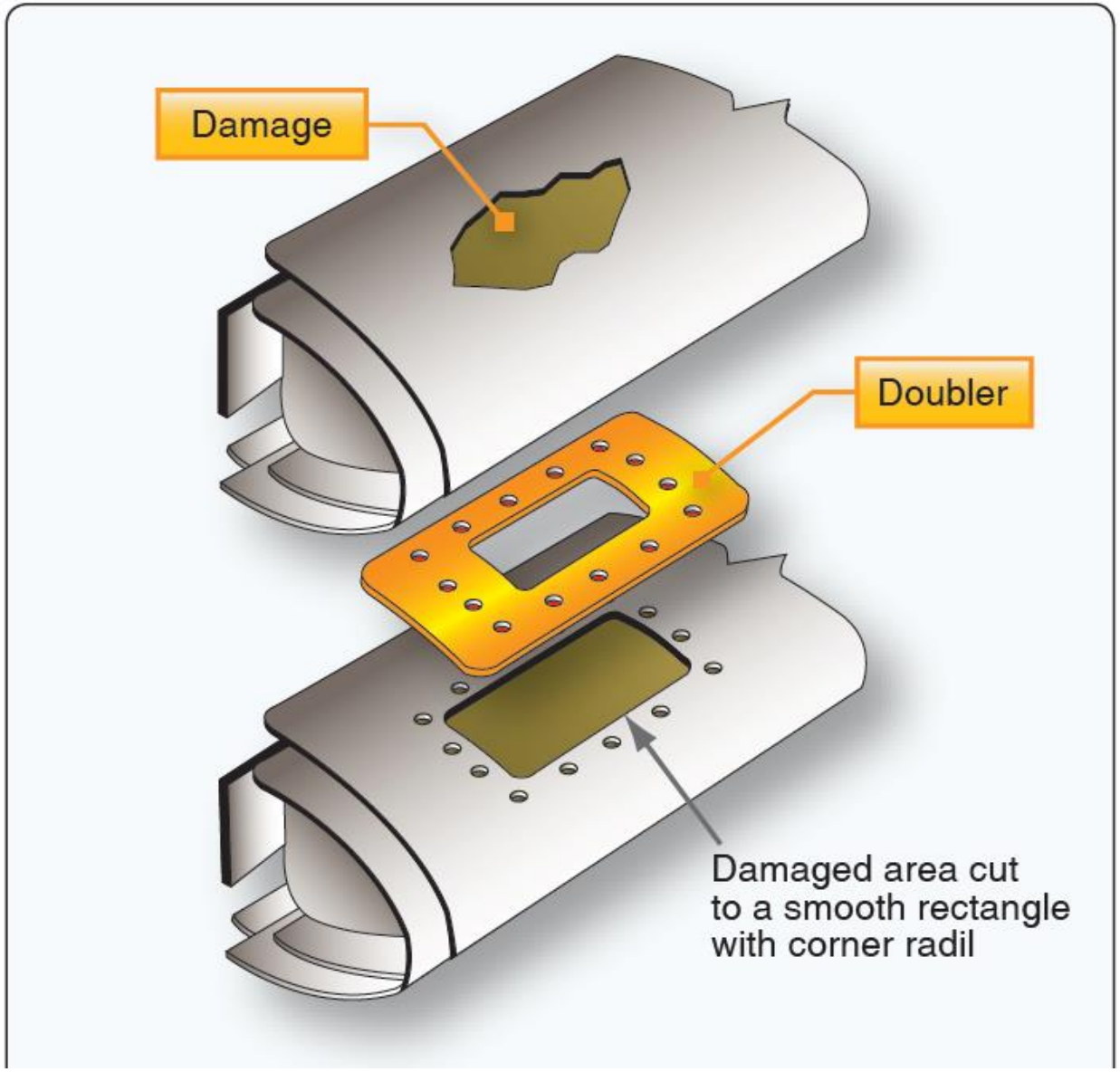
A flush patch is a **filler patch that is flush to the skin**.

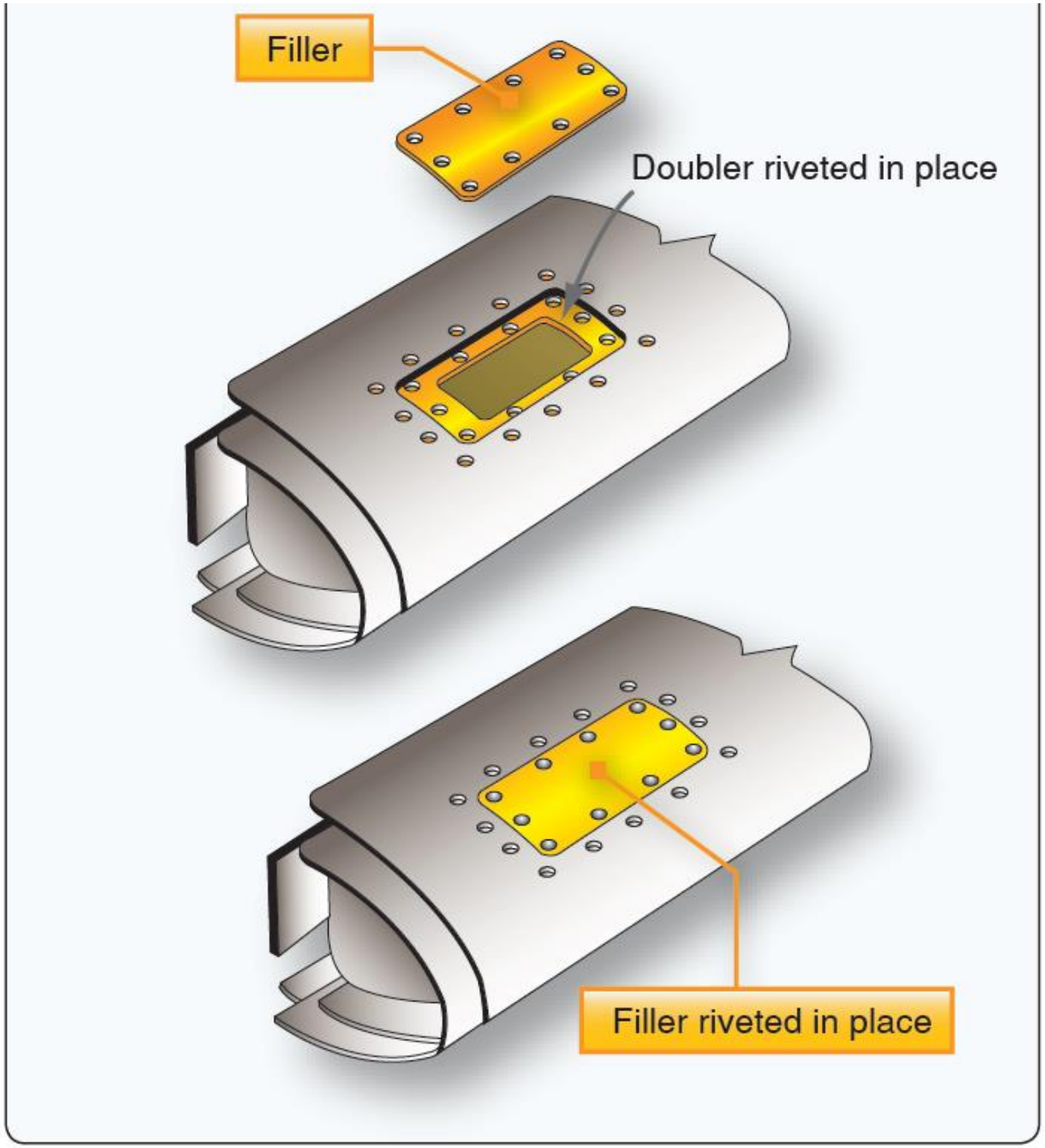
It is supported by and riveted to a reinforcement plate which is, in turn, **riveted to the inside of the skin**.

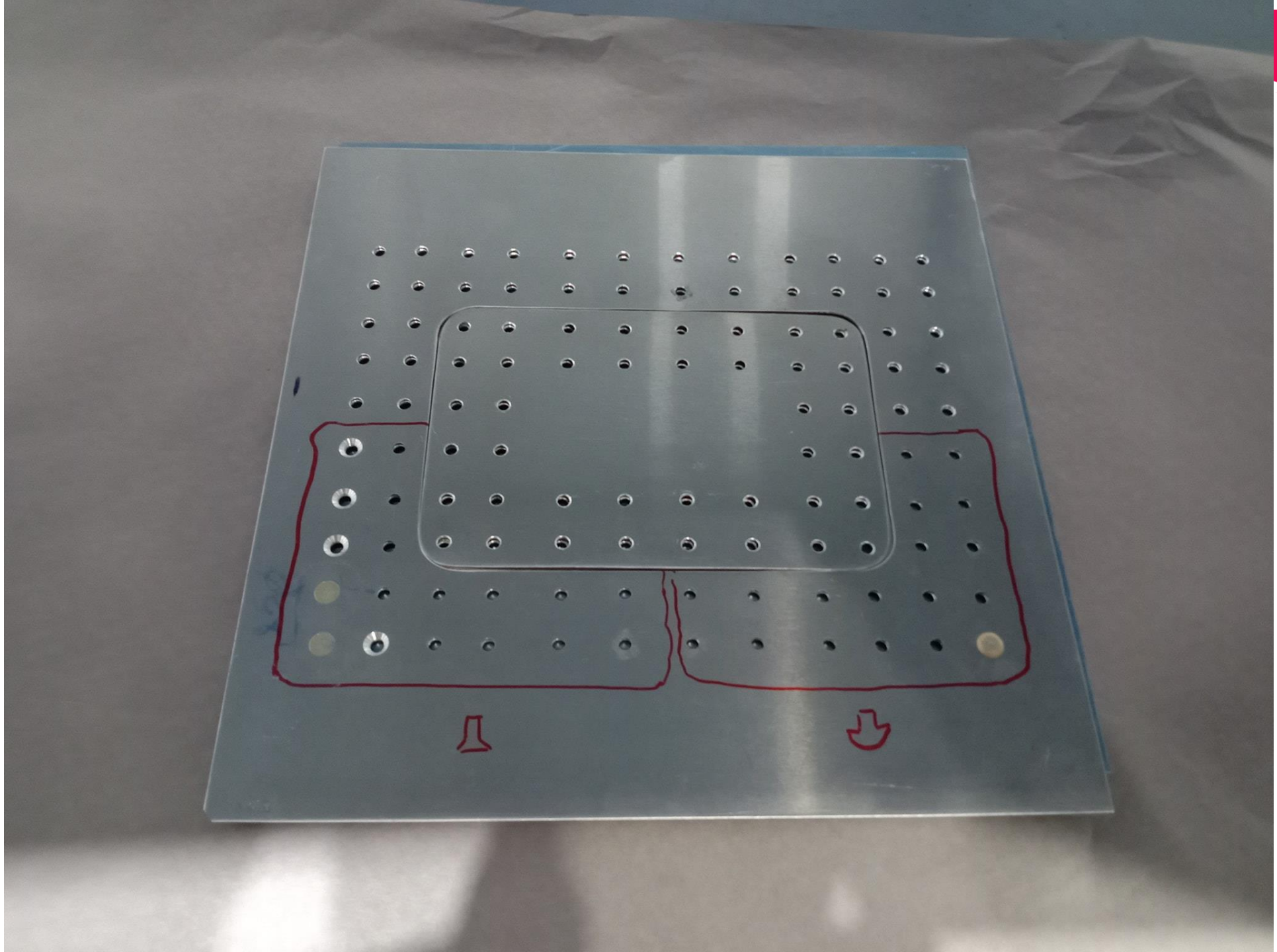
The doubler is inserted through the opening and rotated until it slides in place under the skin.

The filler must be of the **same gauge and material** as the original skin

The doubler should be of material **one gauge heavier** than the skin


Damage
Doubler
Damaged area cut
to a smooth rectangle
with corner radil


Filler
Doubler riveted in place
Filler riveted in place



Open and closed skin area repair

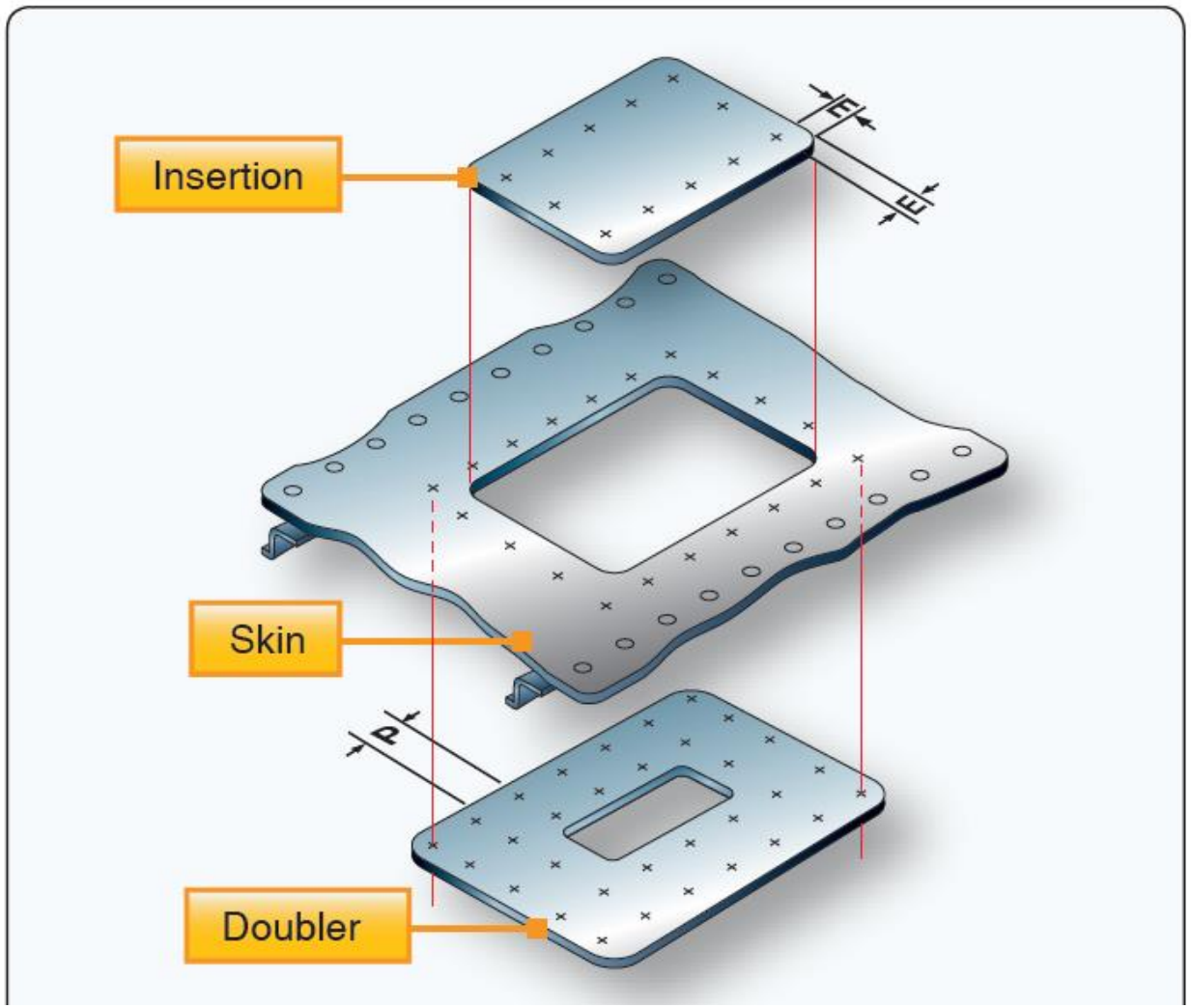
The factors that determine the methods to be used in skin repair are:

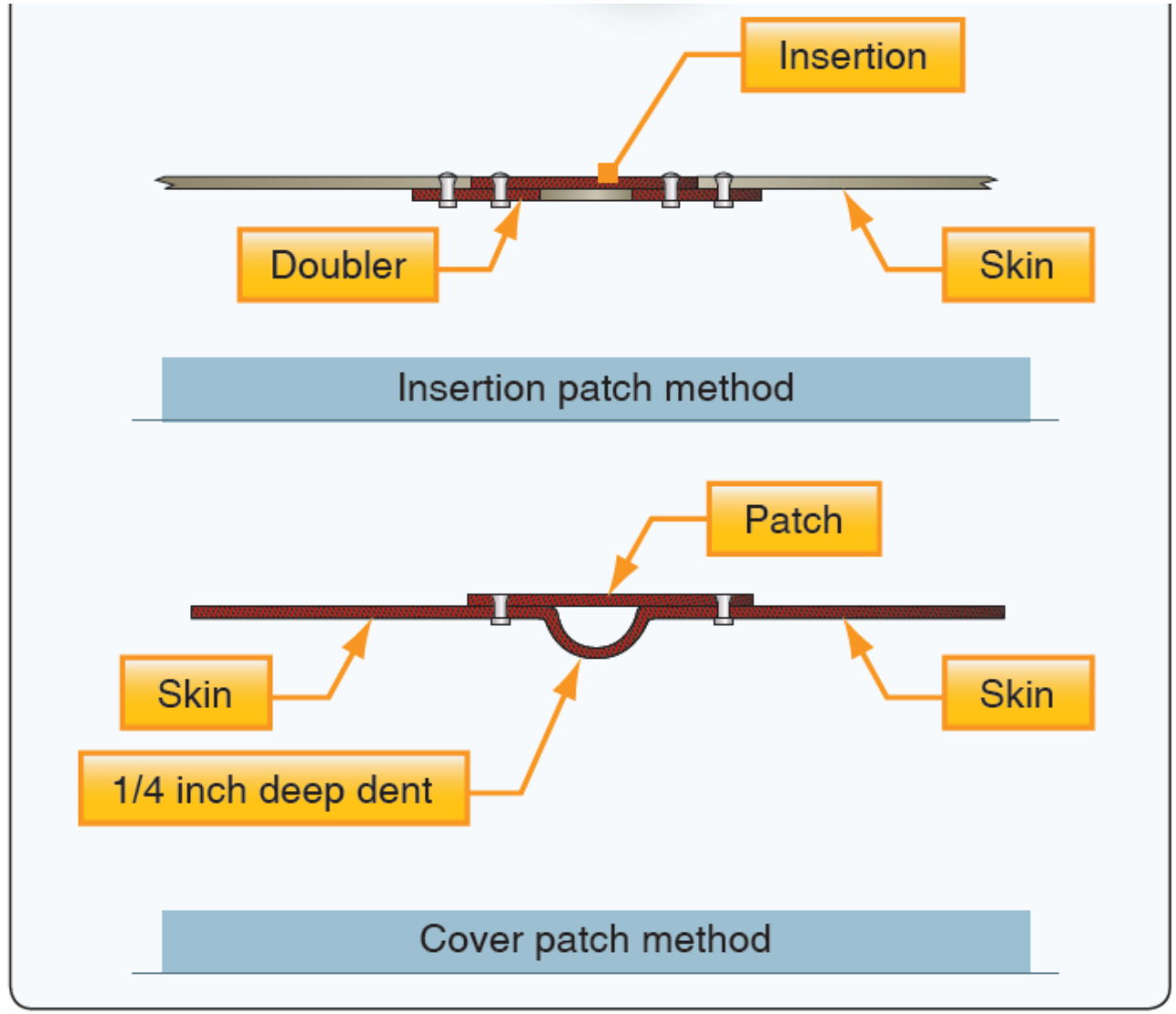
- Accessibility to the damaged area:
  - The skin on most areas of an aircraft is inaccessible for making the repair from the inside and is known as **closed skin** some type of special fastener must be used such as drive nut blind bolts.
  - Skin that is accessible from both sides is called **open skin** repairs to open skin can be made in the conventional manner using standard rivets

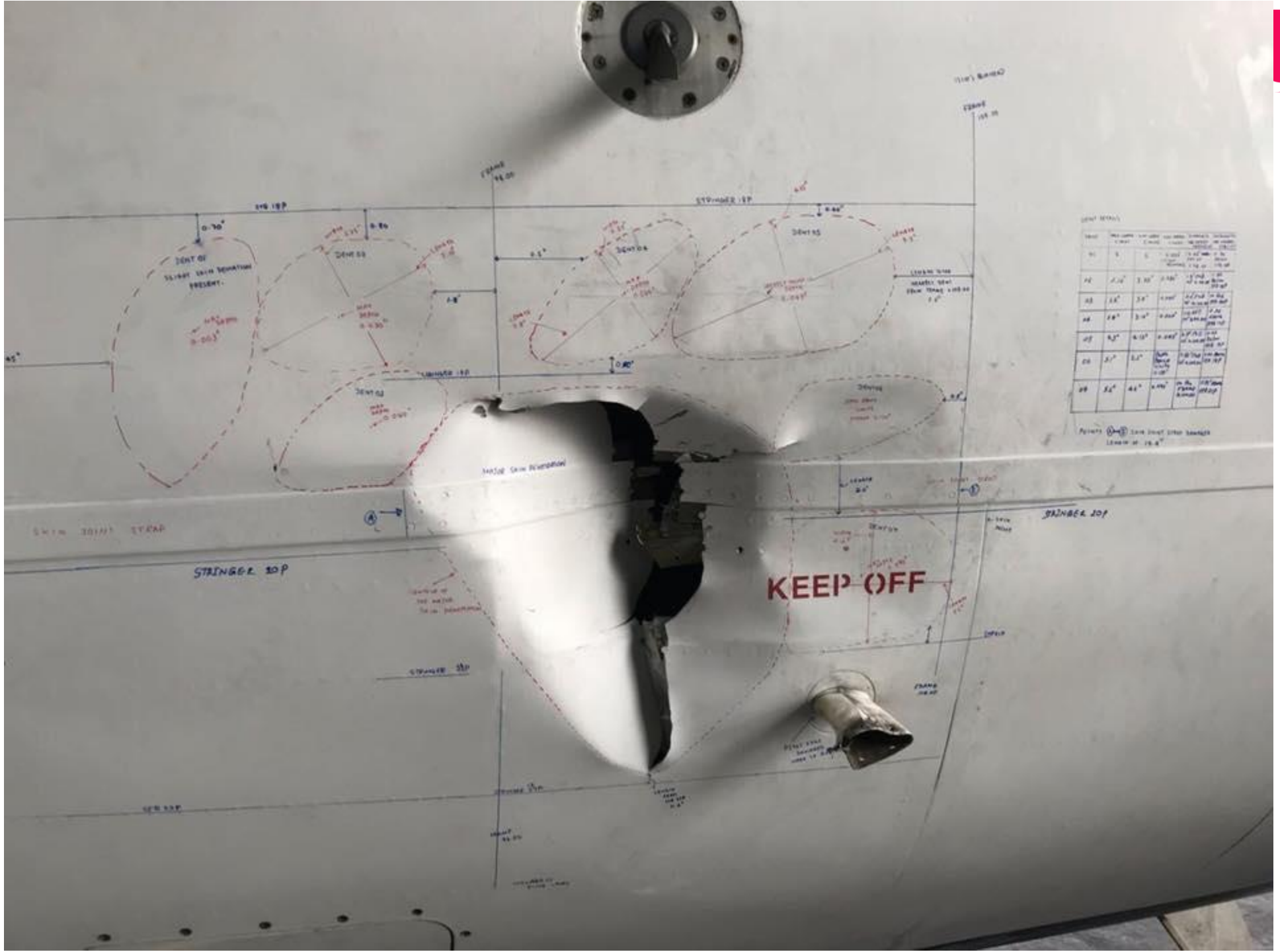
- The instructions found in the aircraft maintenance manual

Design of a patch for a non-pressurized area

- Cut the damage to a round, oval, or rectangular shape
- Round all corners of a rectangular patch to a min radius of 0.5 in
- Rivet spacing is typically between 4-6 D
- The size of the doubler depends on the edge distance and rivet spacing
- The doubler material is of the same material as the damaged skin, but of one thickness greater than the damaged skin
- The insert is made of the same material and thickness as the damaged skin
- The size and type of rivets should be the same as rivets used for similar joints on the aircraft

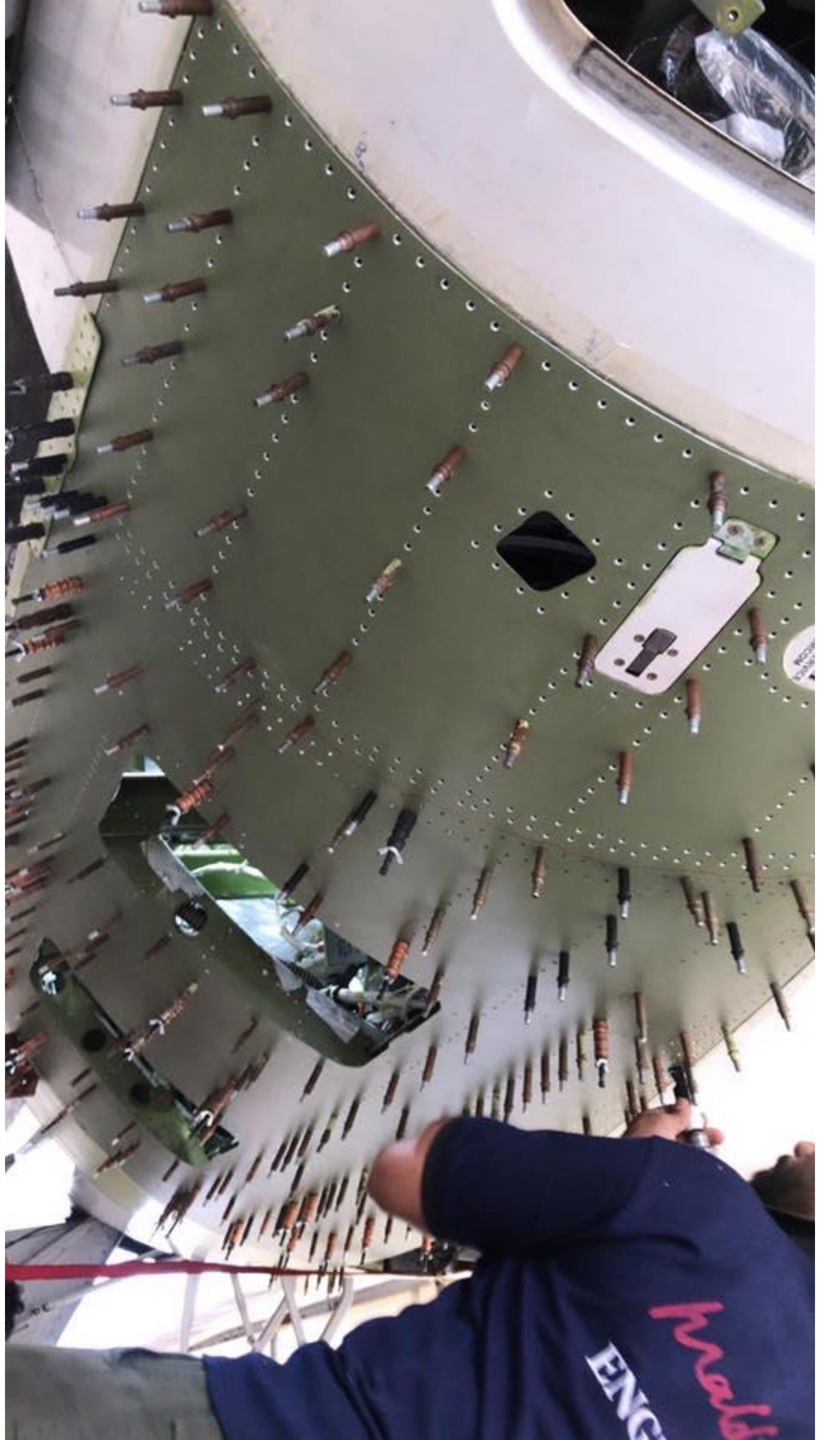

Insertion
Skin
Doubler
E
E
P


Insertion
Doubler
Skin
Insertion patch method
Patch
Skin
Skin
1/4 inch deep dent
Cover patch method


KEEP OFF
STRINGER 20P
STRINGER 20P


ETIHAD CRYSTAL CARGO
AIR


KOREAN AIR CARGO
AM



Repair of lightning holes

Lightning holes are cut in rib sections, fuselage frames, and other structural parts to reduce the weight of the part. The holes are flanged to make the web stiffer.

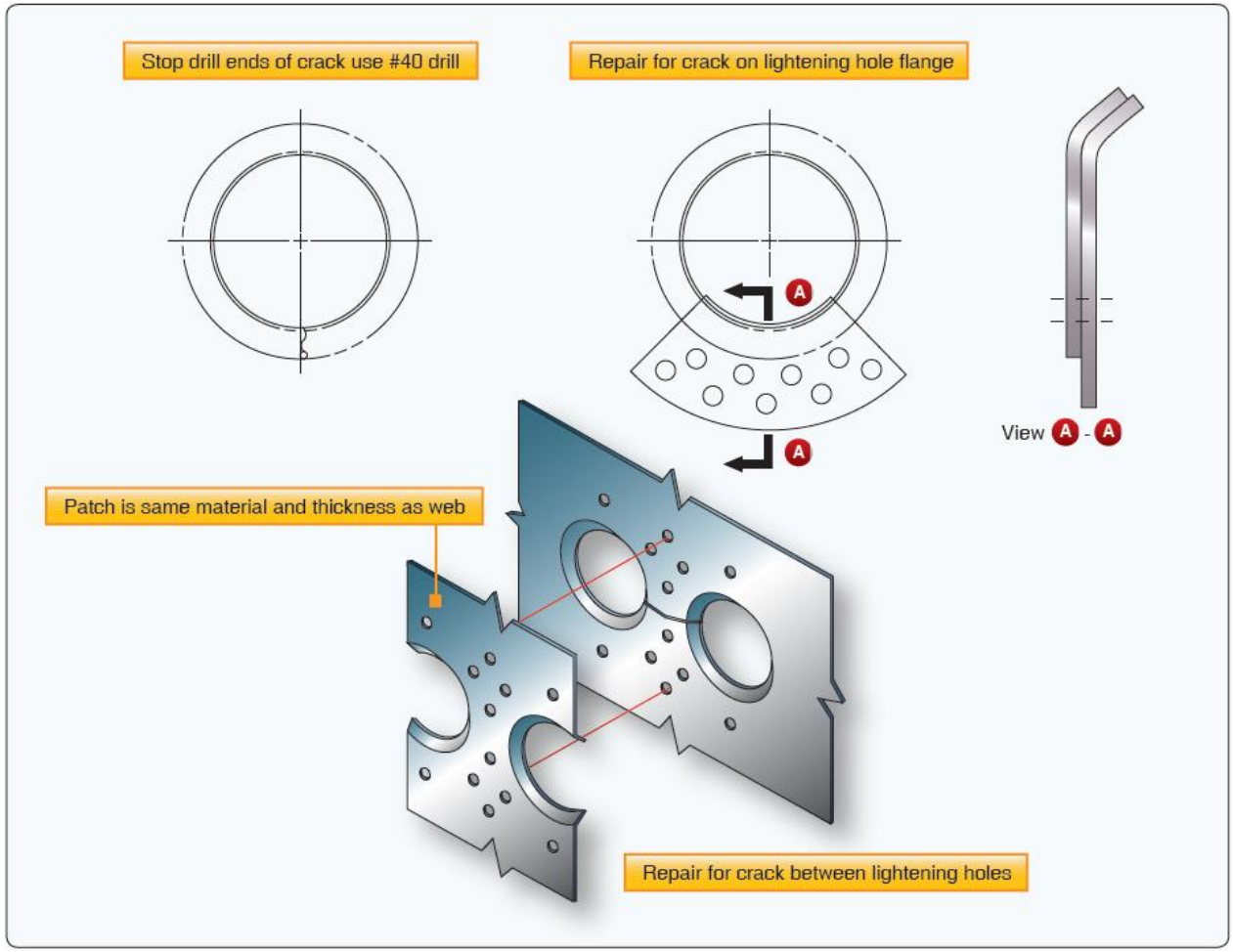
Cracks can develop around flanged lightning holes and these cracks need to be repaired with a repair plate.

Repair of lightning holes

The damaged area (crack) needs to be stop drilled or the damage must be removed.

The repair plate is made of the same material and thickness as the damaged part.

Rivets are the same as in surrounding structure and the minimum edge distance is 2 times the diameter and spacing is between 4 to 6 D



General comments for pressurized areas

The pressurization cycles apply loads to the skin, and the repairs to this type of structure requires more rivets than a repair to a non pressurized skin:

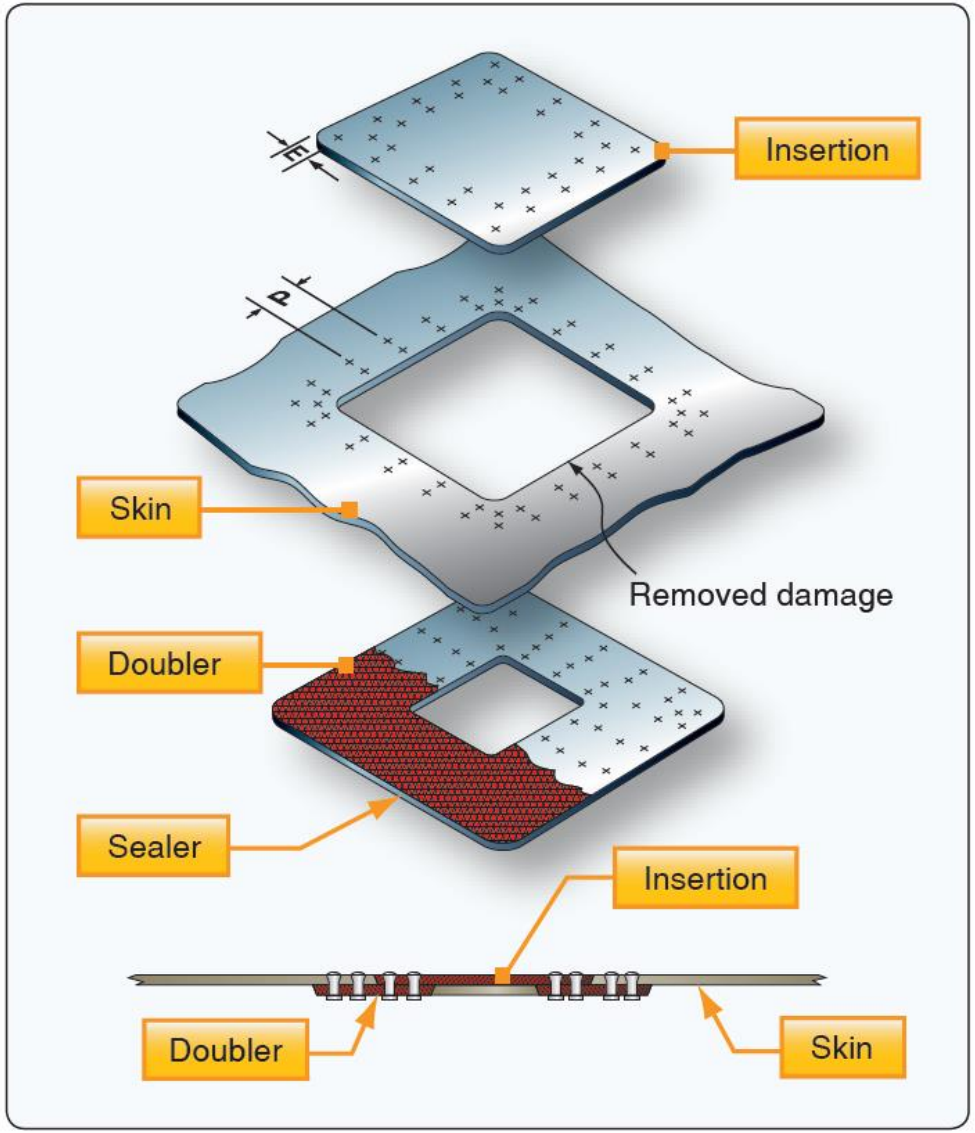
- Remove all damaged skin section
- Use doublers
- All corners must have at least 1/2 in
- The doubler will have the same type of material of the skin, but usually one size greater
- The size of the doubler depends on the number of rows, edge distance, and rivets spacing

General comments for pressurized areas

The insert must be of the same material and thickness as the skin. The clearance is usually between 0.015 in to 0.035 in.

Spread a thin layer of sealant on the doubler secure the doubler to the skin with Clecos.

Use the same type of fastener as in the surrounding area. Dip all fasteners in the sealant before installation



Stringer and longeron repair

The repair may require the use of **preformed or extruded repair material** formed by the airframe technician or both.

When repairing a stringer, first determine the **extent of the damage** and:

- Remove the rivets from the surrounding area
- Remove the damaged area by using a hacksaw, keyhole saw, drill
- **In most cases, a stringer repair requires the use of insert and splice angle**

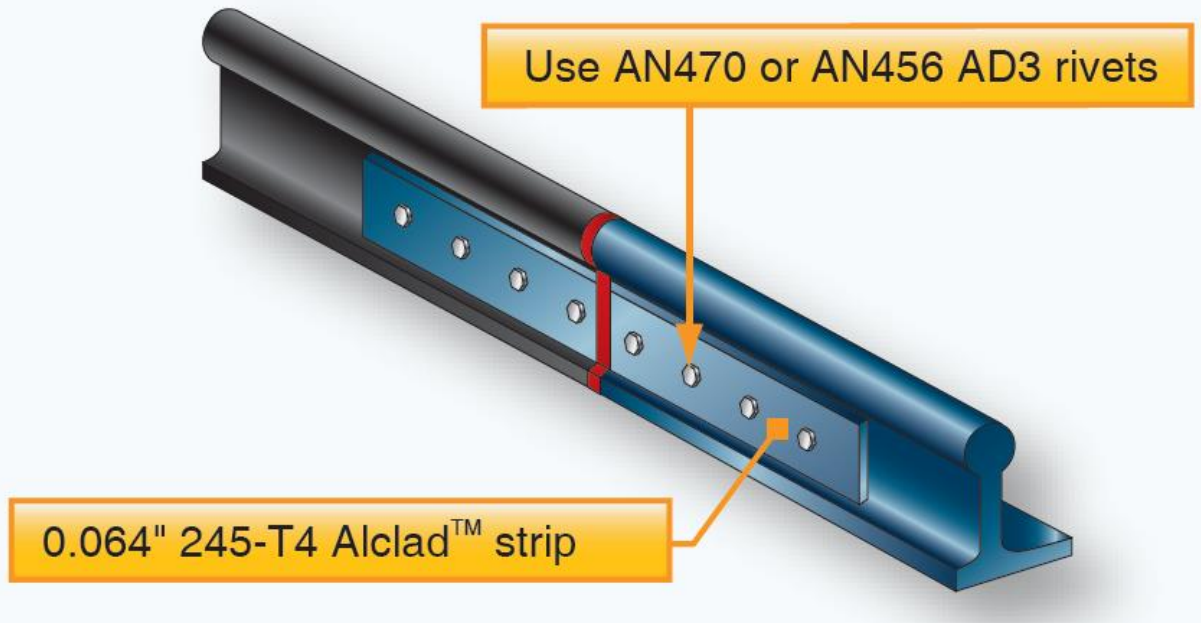
Stringer and longeron repair

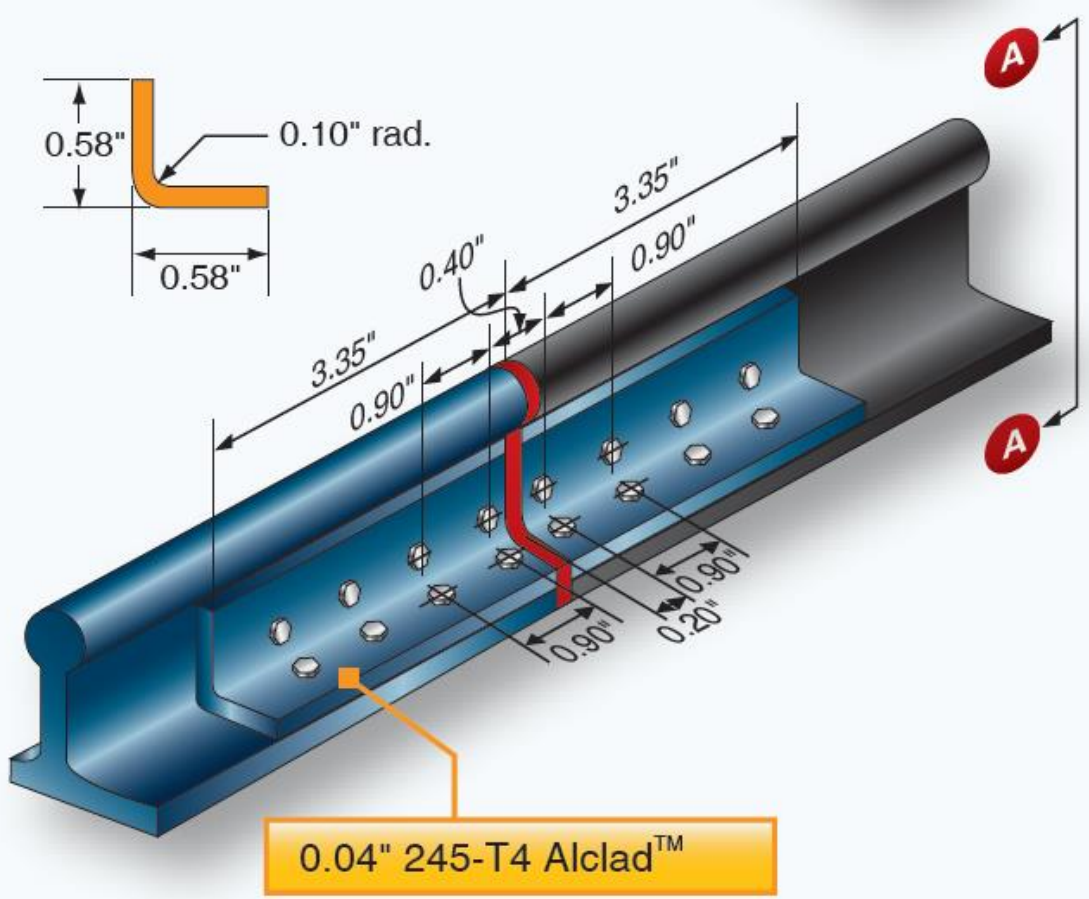
Because the longeron is a heavy member and more strength is needed than with a stringer, **heavy rivets are used in the repair**. **Sometimes bolts are used** to install a longeron repair, due to the need for greater accuracy, they are not as suitable as rivets.

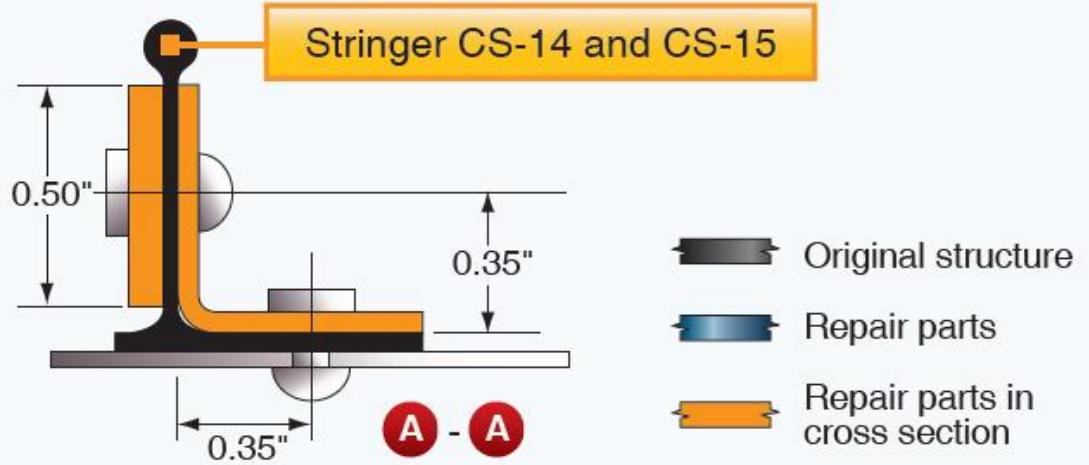
Bolts require more time for installation.

If the longeron consists of a formed section and an extruded angle section, consider each section separately.

If damage has been cut away from center section of stringer length, both ends of new portion must be attached as shown below.



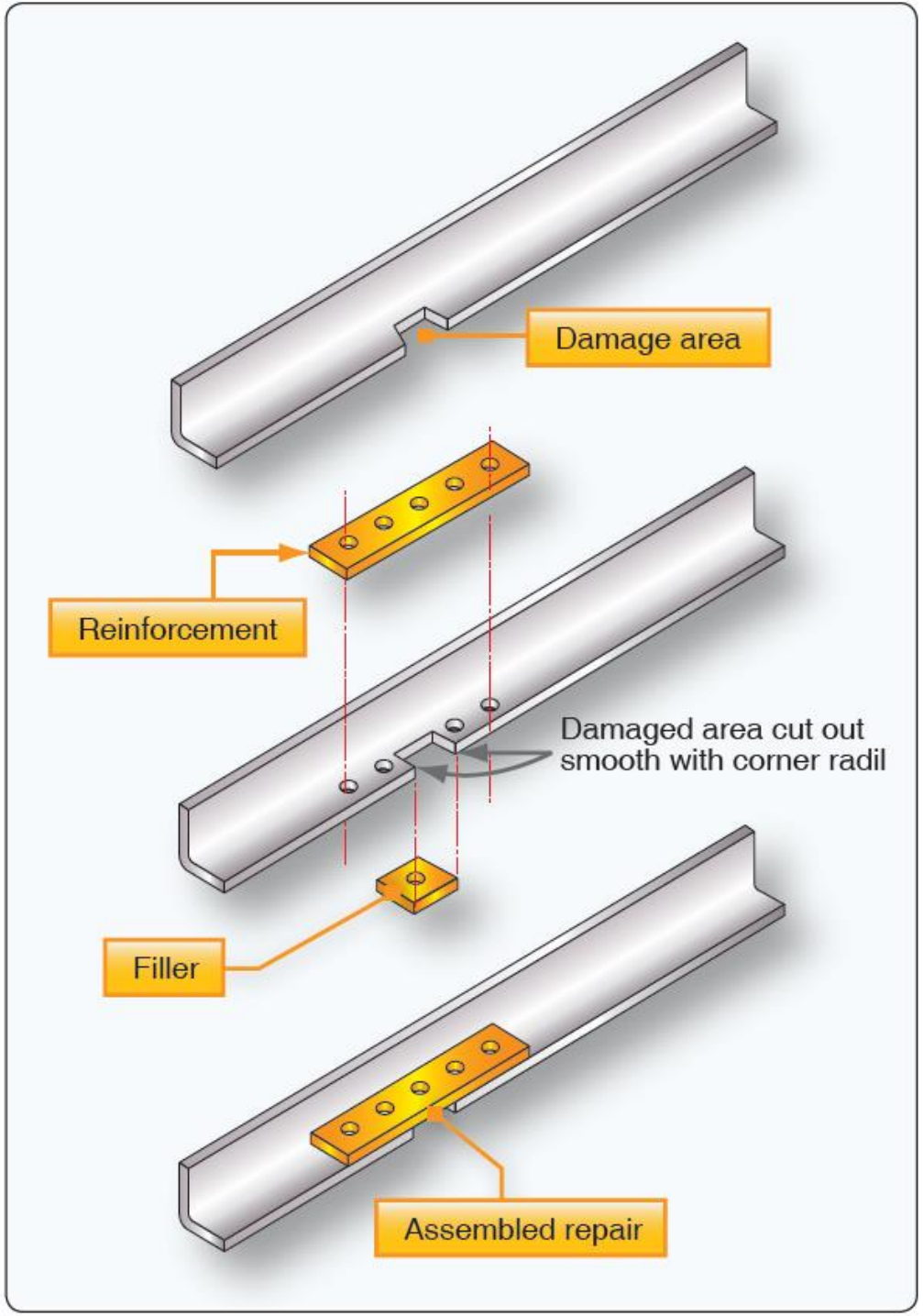




Stringer repair

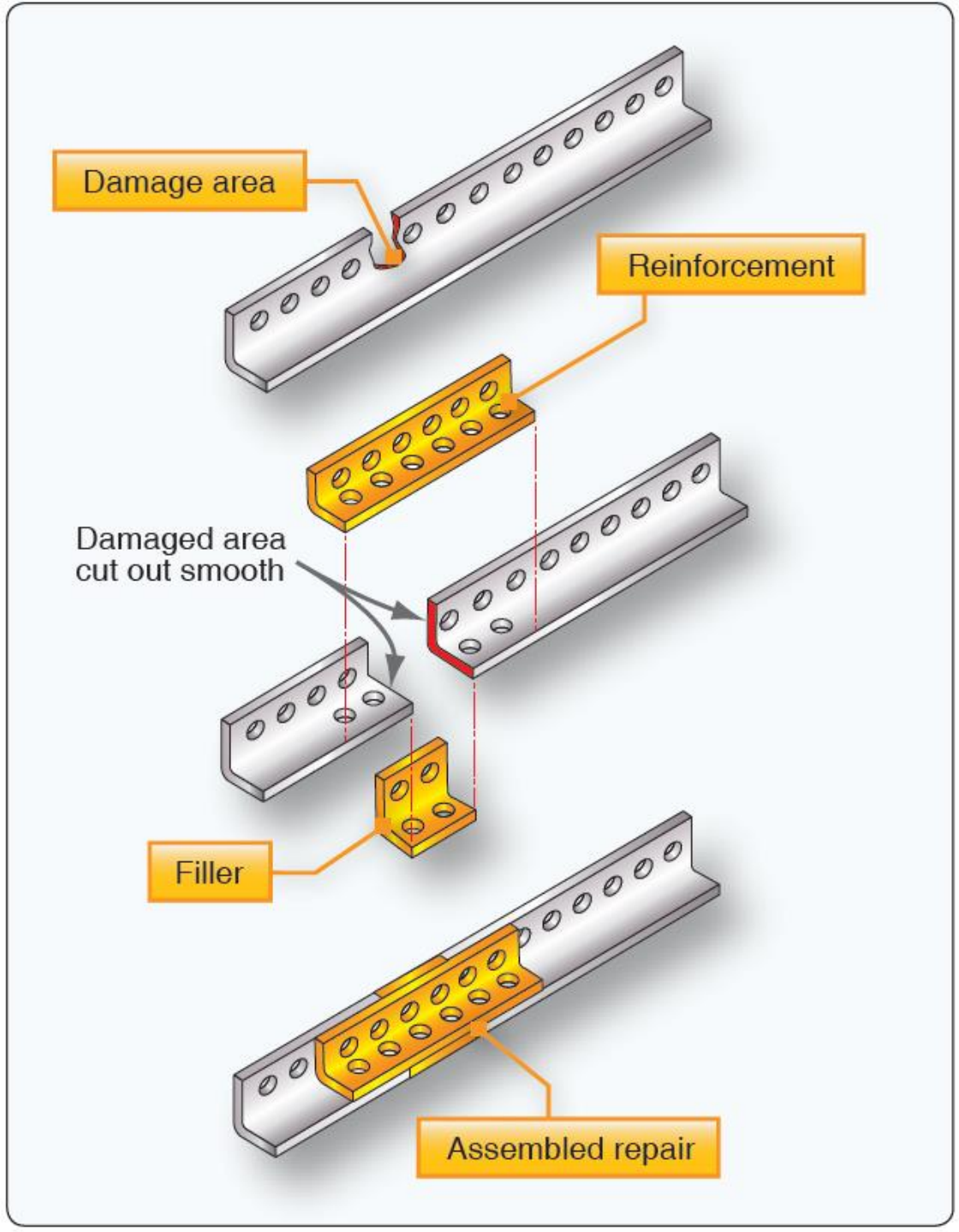
Stringer repair by patching. This repair is usually permissible when:

- The damage does **not exceed 2/3 of the width** of one leg
- It is **not more than 12 in long**



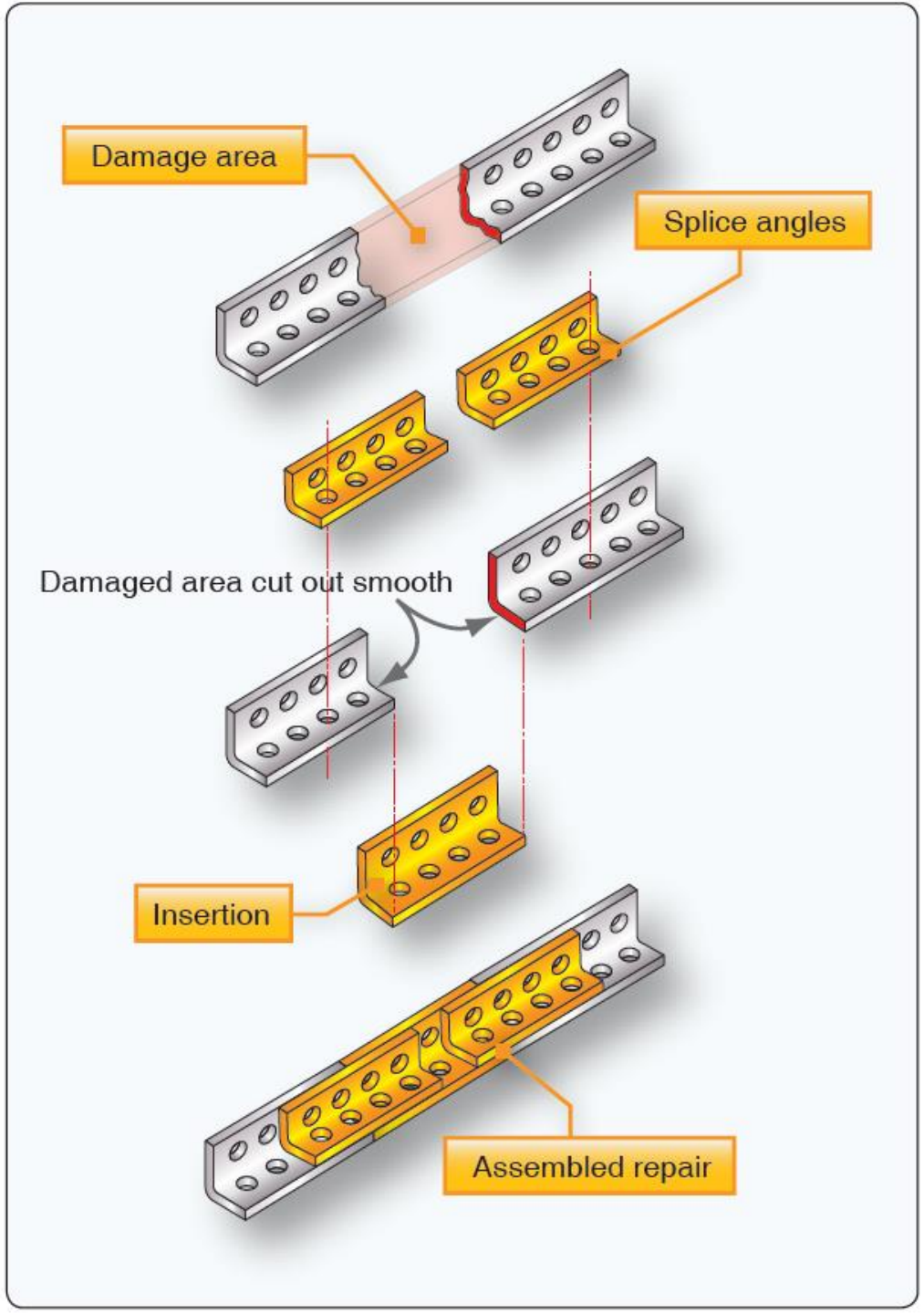
Stringer repair

Typical repair of a stringer **when damage exceed 2/3 of the width of one leg**, after a portion of the stringer is removed.



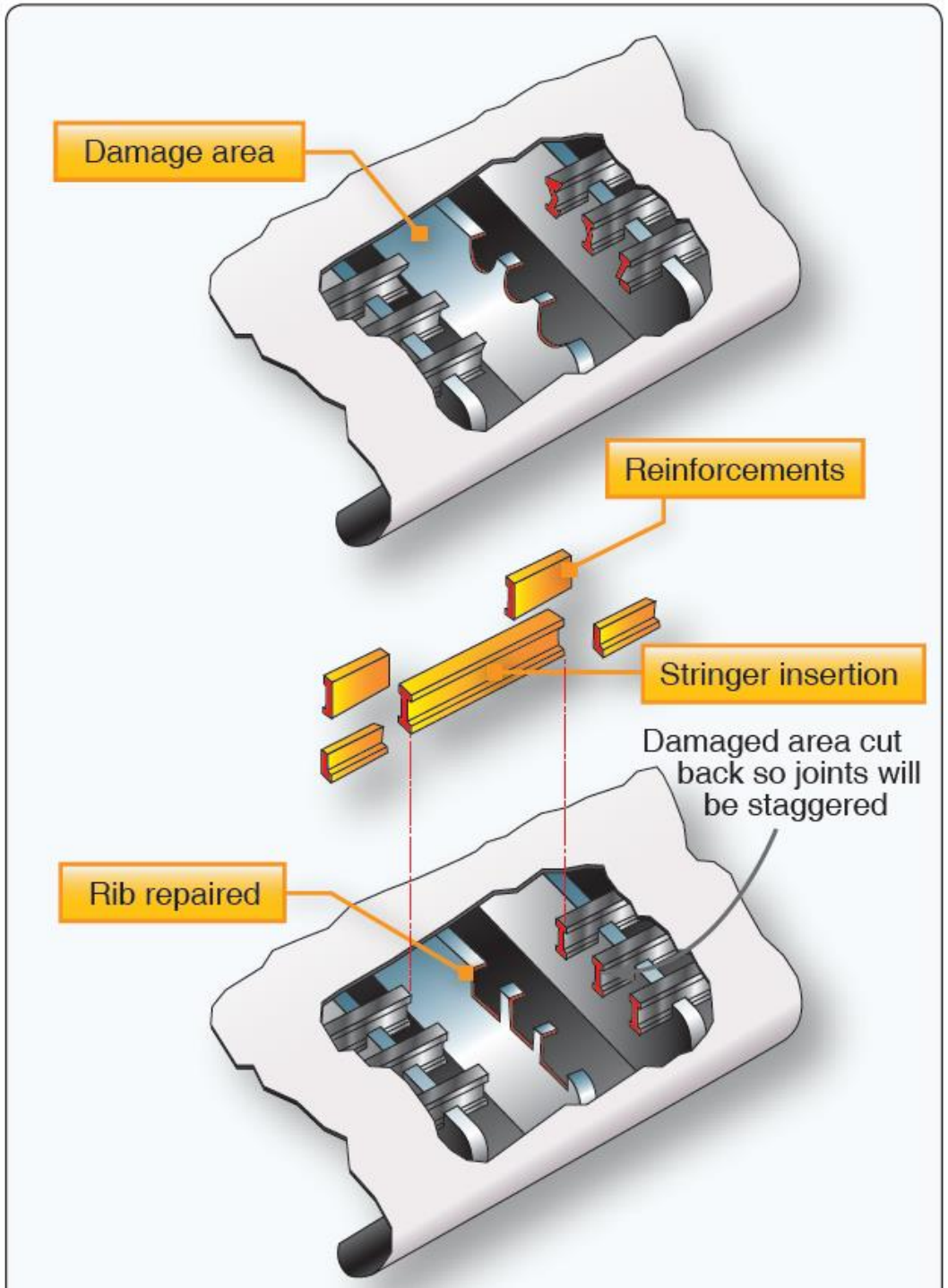
Stringer repair

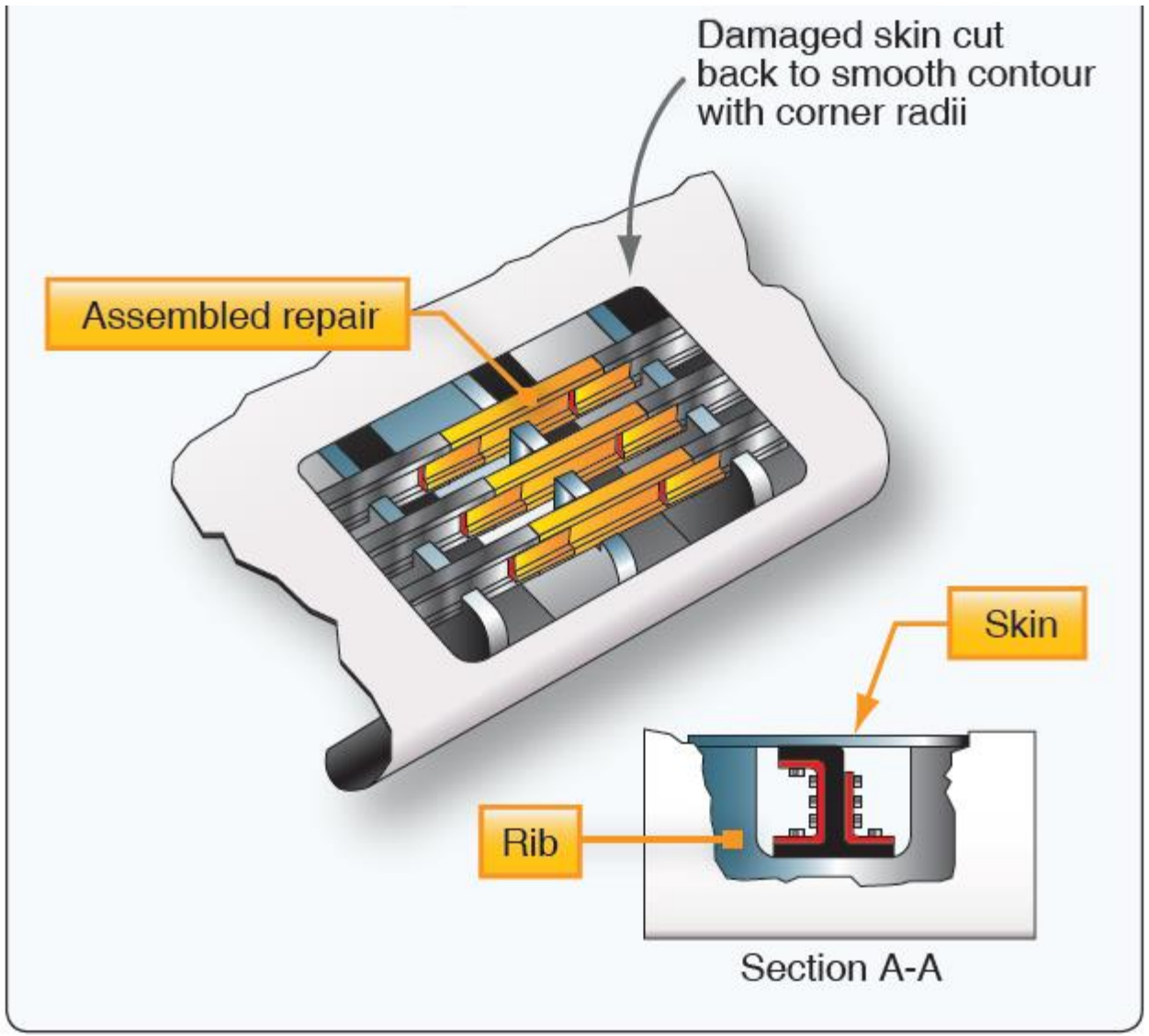
Repair by insertion when the damage exceeds 12 inches in length.



Stringer repair

Repair by an insertion (splice) when damage affects more than one stringer.

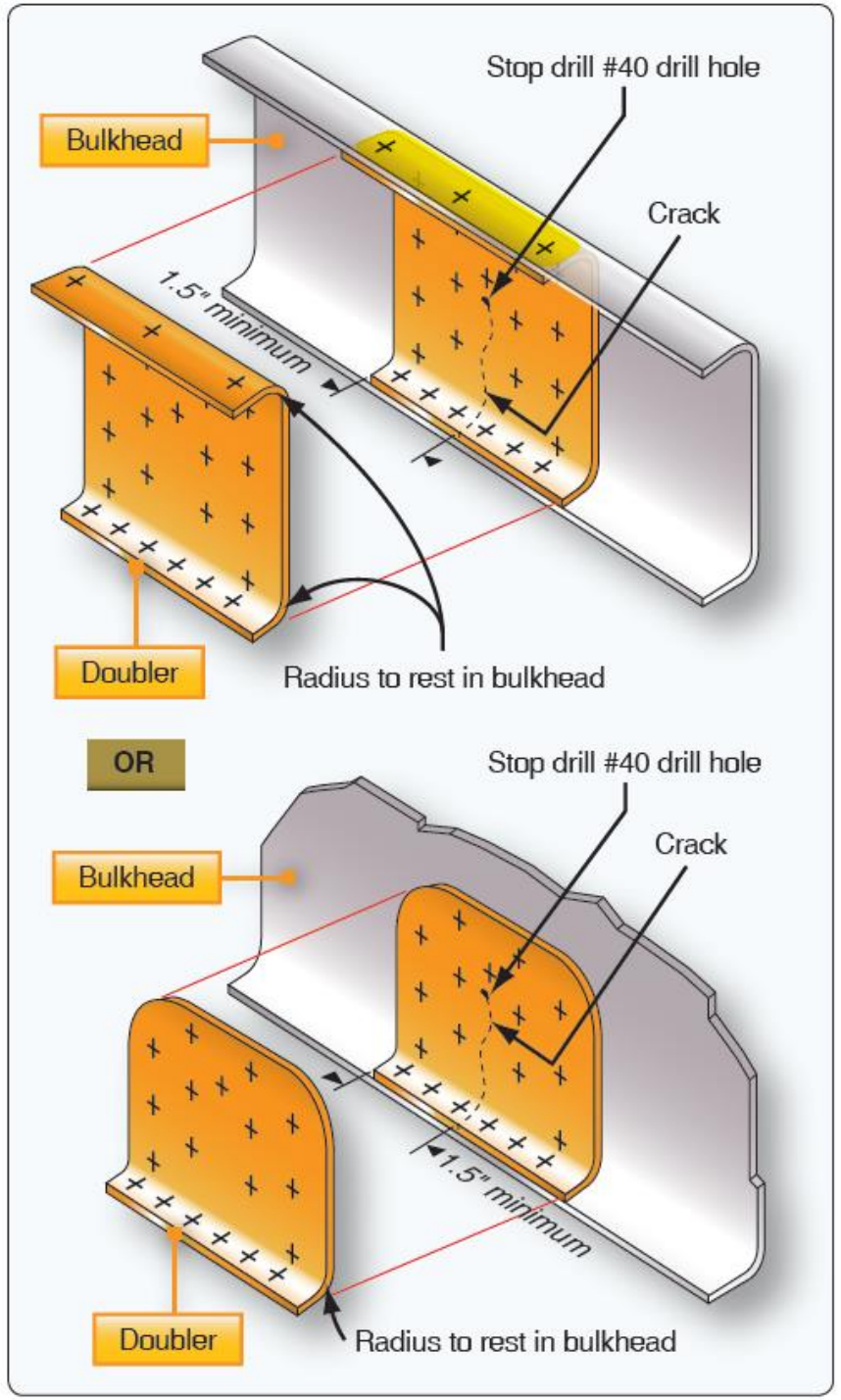

Damage area
Reinforcements
Stringer insertion
Damaged area cut back so joints will be staggered
Rib repaired


Damaged skin cut back to smooth contour with corner radii
Assembled repair
Skin
Rib
Section A-A

Former or Bulkhead Repair

Bulkhead are identified with station numbers that are very helpful in locating the repair information in the SRM. A typical repair may include:

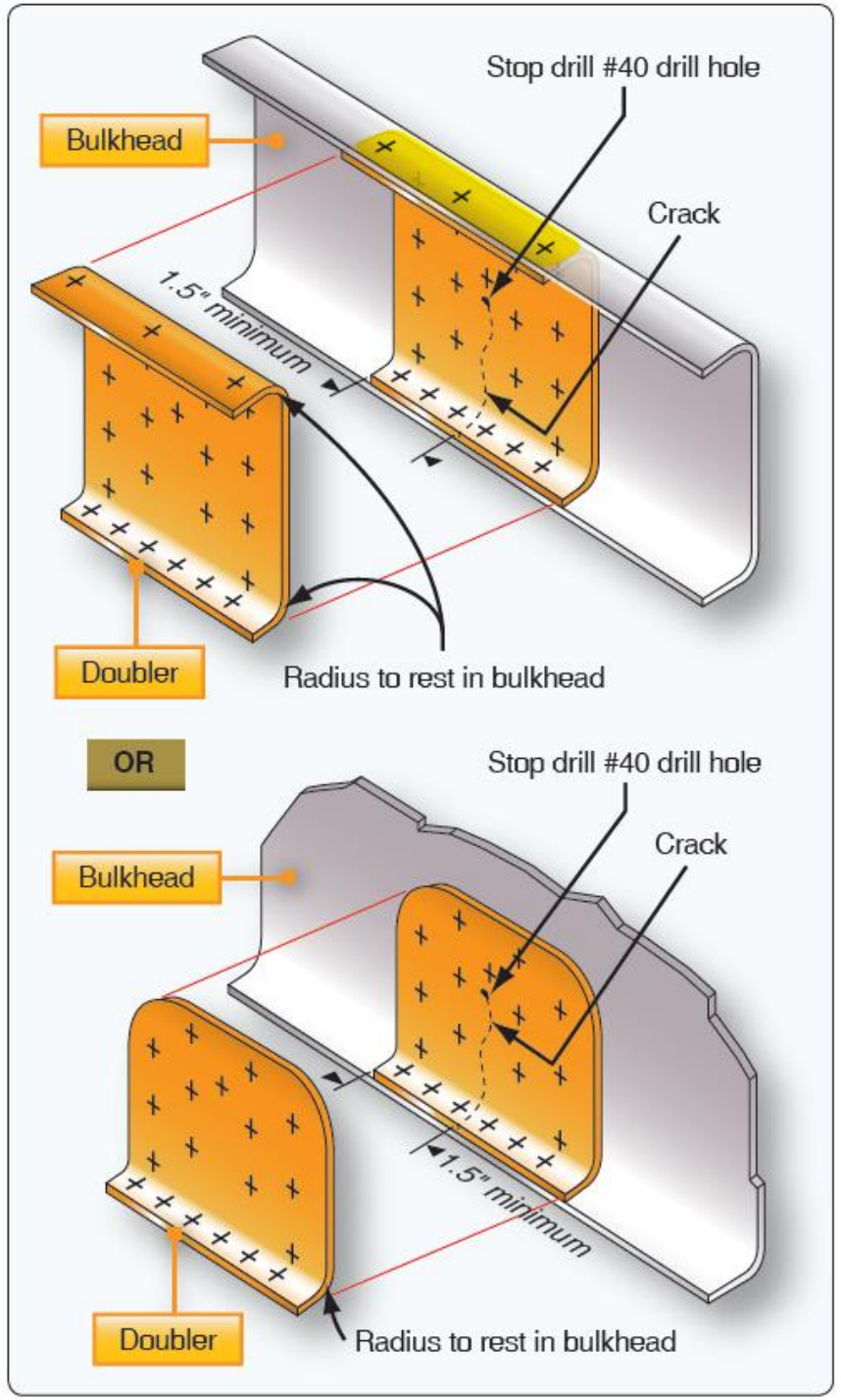
- Stop drill for cracks, #40 drill aprox (3/32 in or 2.4 mm)
- A doubler with the same material but one size thicker
- Attach the doubler to the part with clamps and drill holes
- Install rivets



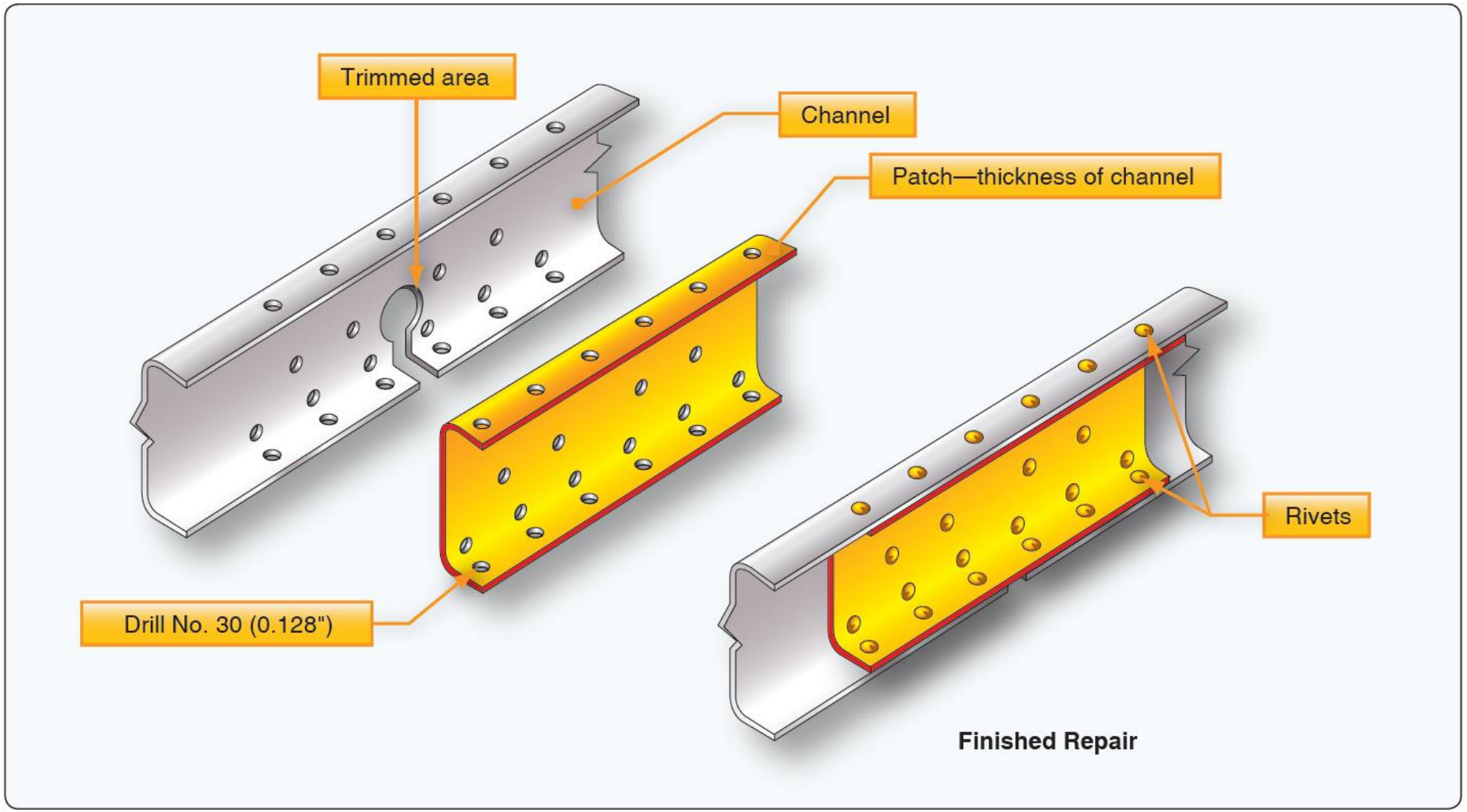
Former or Bulkhead Repair

The substitute material **must provide** cross sectional tensile, compressive, shear, and bearing **strength equal to the original material**.

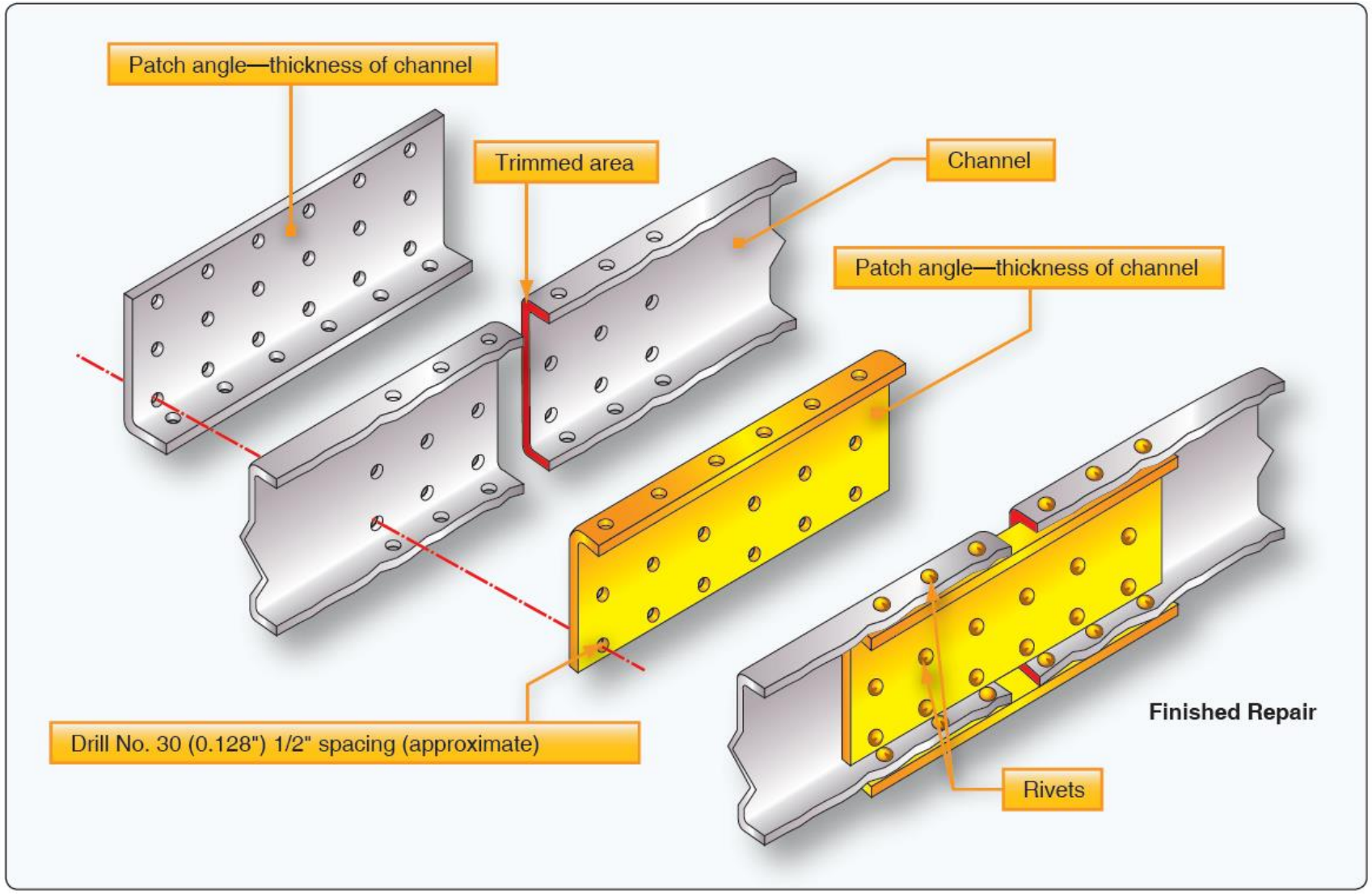
Never substitute material that is thinner or has a cross sectional area less than the original material.



Channel repair by patching



Channel repair by insertion



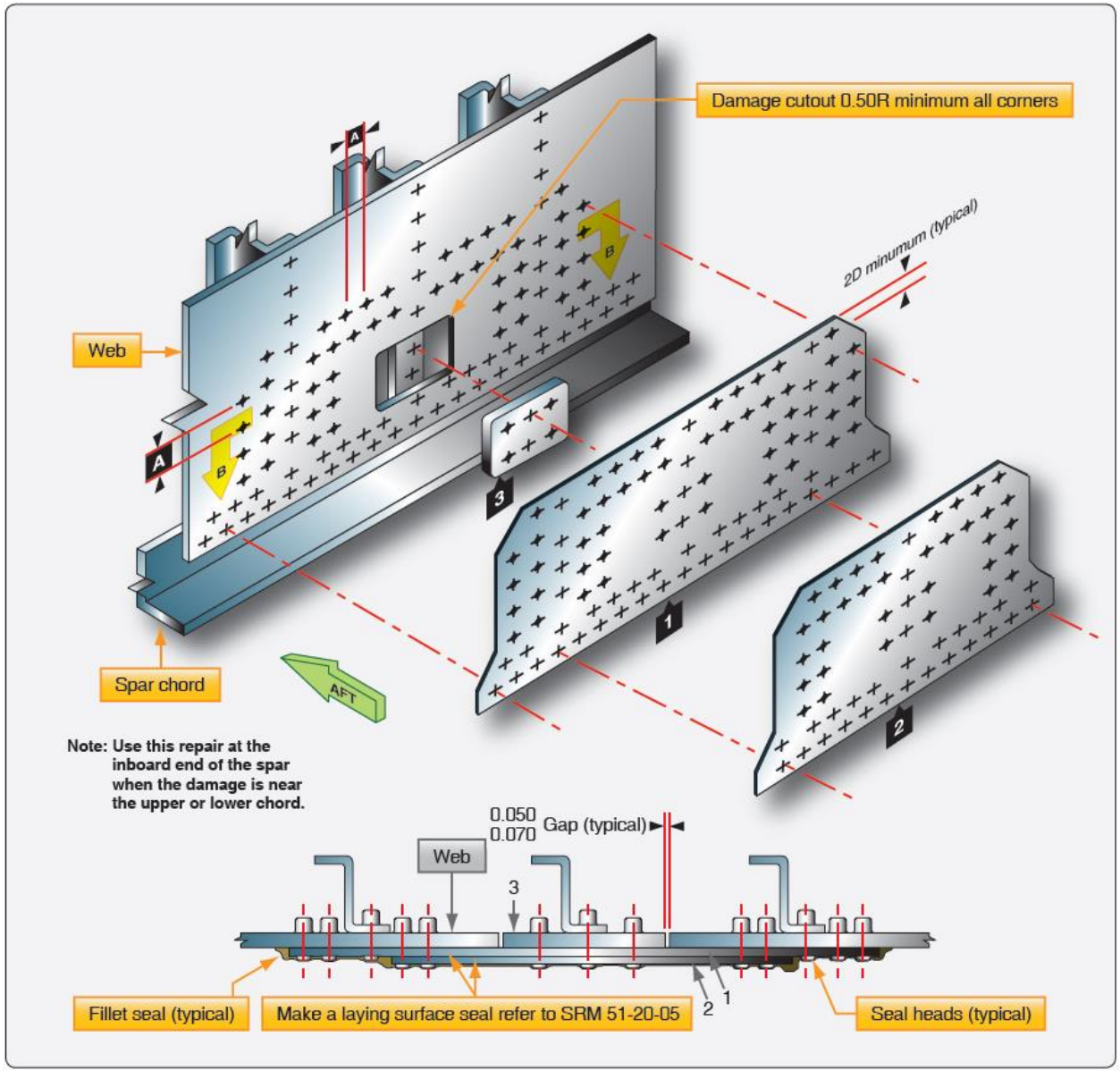
Spar repair

Because of the load the spar carries, it is very important that **particular care** be taken when repairing this member to **ensure the original strength** of the structure is not impaired.

Two general classes of repairs, web repairs and cap strip repairs are usually necessary.

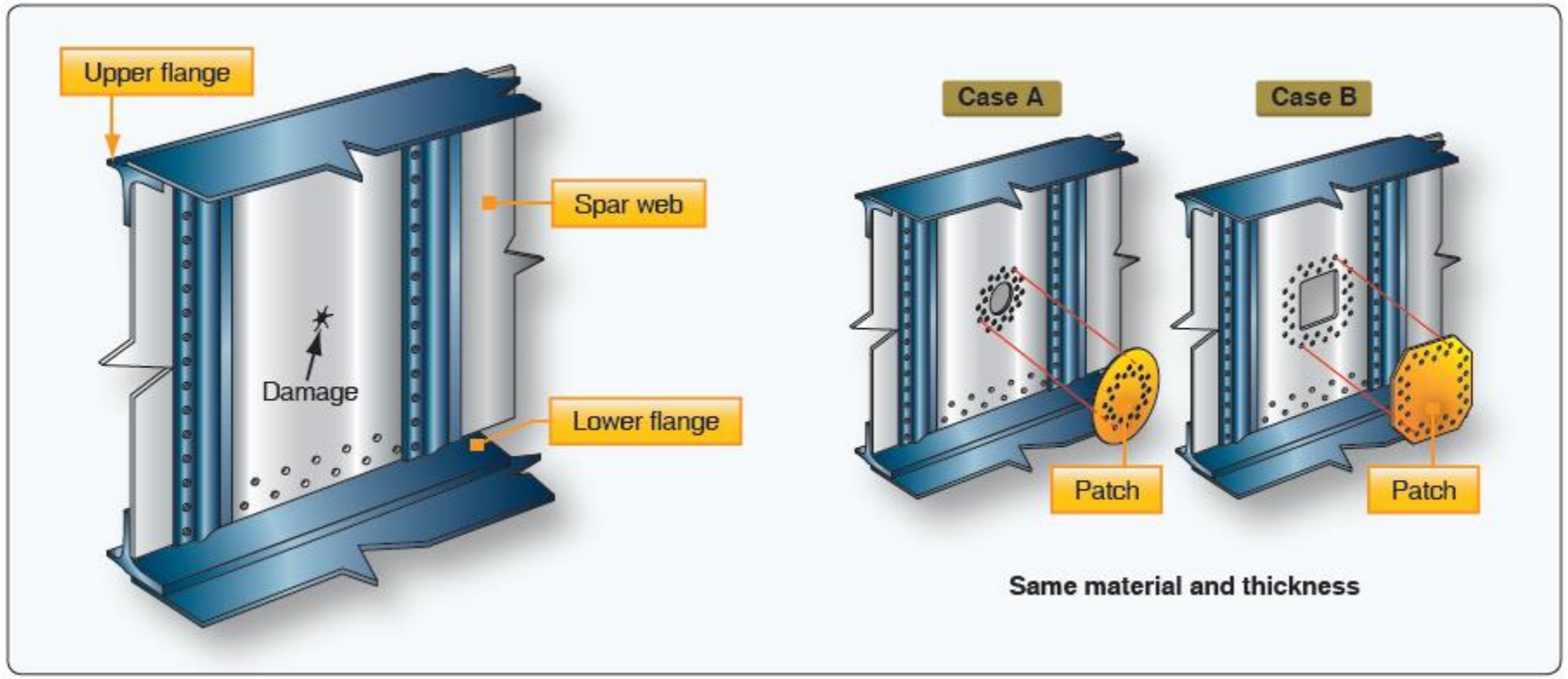
Spar repair

- Remove the damage and radius all corners to 1/2 in
- Fabricate doubler use same material and thickness. The doubler size depends on edge distance (2D min) and rivet spacing (4 to 6D)
- Drill through the doubler and the original skin and secure doubler with Clecos
- Install rivets



Spar repair

- The damage to the spar web can be repaired with a round or rectangular doubler
- **Damage smaller than 1 inch is typically repaired with a round doubler** and larger damage is repaired with a rectangular doubler



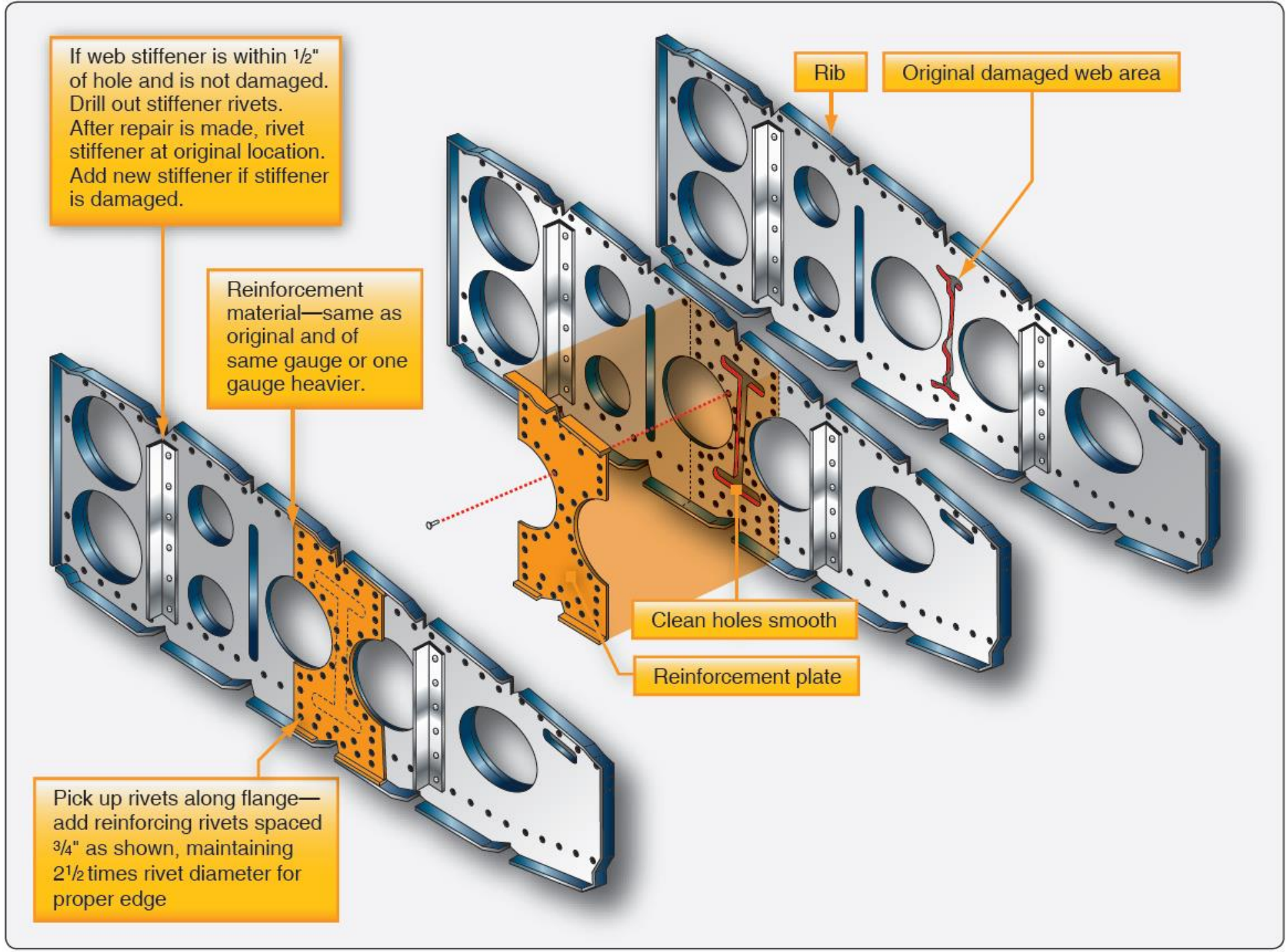
Rib and web repair

Rib web repair can be classified as:

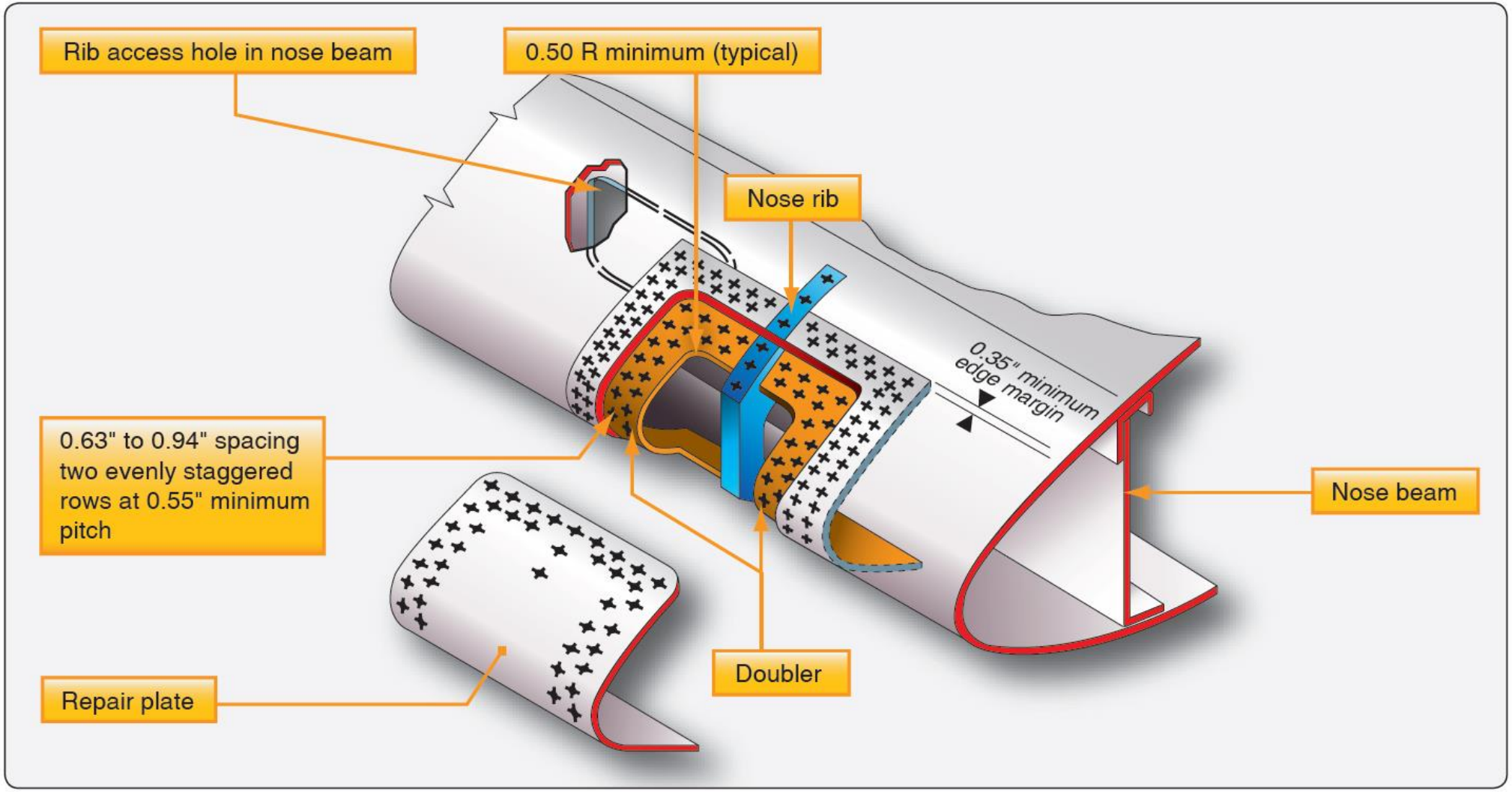
- **Critical**, wing ribs.
- **Less critical** , such as elevators, rudder, flaps.

Web sections must be repaired in such a way that the **original strength of the member is restored**.

Damage to ribs and webs, that require a repair larger than a simple plate, probably needs a patch plate, splice plates, or angles and an insertion.

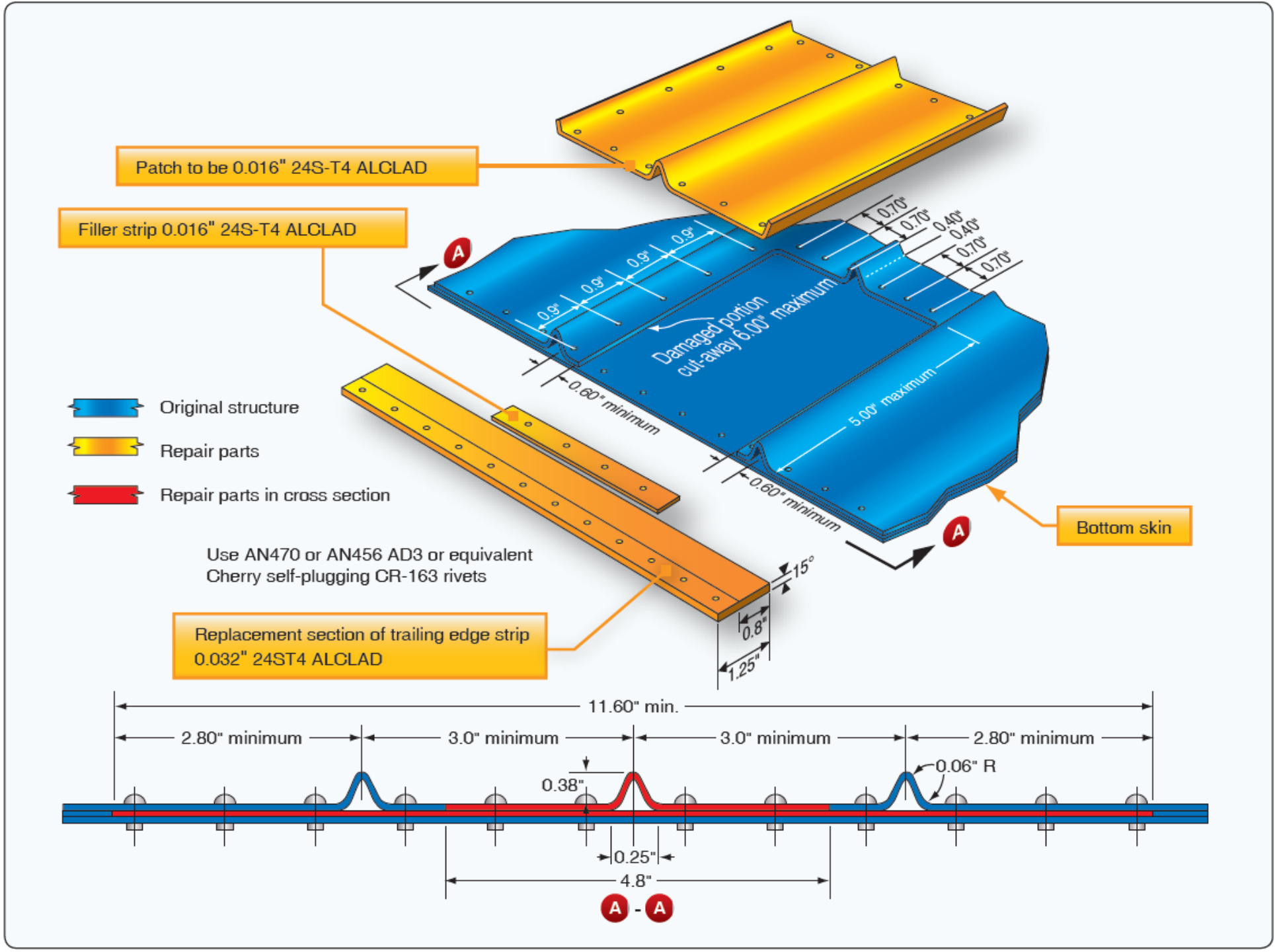

If web stiffener is within ½" of hole and is not damaged. Drill out stiffener rivets. After repair is made, rivet stiffener at original location. Add new stiffener if stiffener is damaged.
Reinforcement material—same as original and of same gauge or one gauge heavier.
Rib
Original damaged web area
Clean holes smooth
Reinforcement plate
Pick up rivets along flange—add reinforcing rivets spaced ¾" as shown, maintaining 2½ times rivet diameter for proper edge

Leading edge repair



*Use only flush rivets

Trailing edge repair

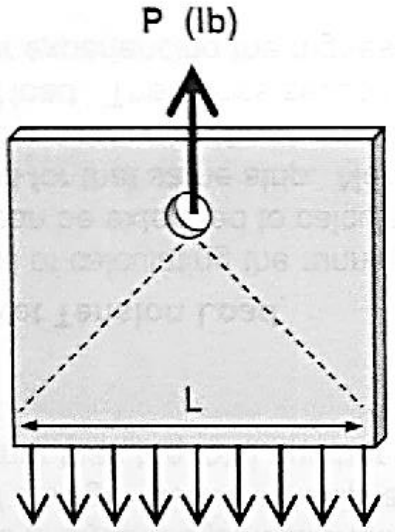


Running load

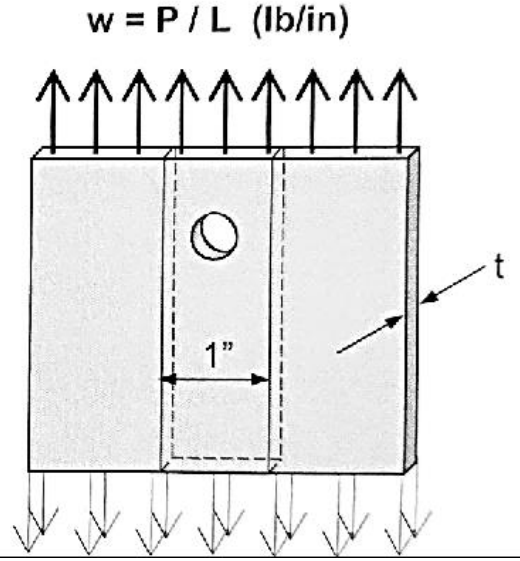
A useful method for analyzing joint load capability for a skin or web is to express the load in terms of force per unit length

Since loads can vary significantly over a given length of a web or skin, a load in terms of pounds (or kilogram) is oversimplified as well as more difficult to analyze.

Concentrated Load



Running Load



$$\sigma = \frac{w}{t}\left(\frac{lb}{in^2}\right)$$

$$\sigma = \frac{w}{L \times t}$$

P: applied load (lb)

w: running load (lb/in)

σ: stress (lb/in^2 or psi)

Running load

The method of calculating the running load of a strip unit with can be extended to calculation of the net tension load for that same strip.

Net tension will be calculated for a cross section perpendicular to the direction of load.

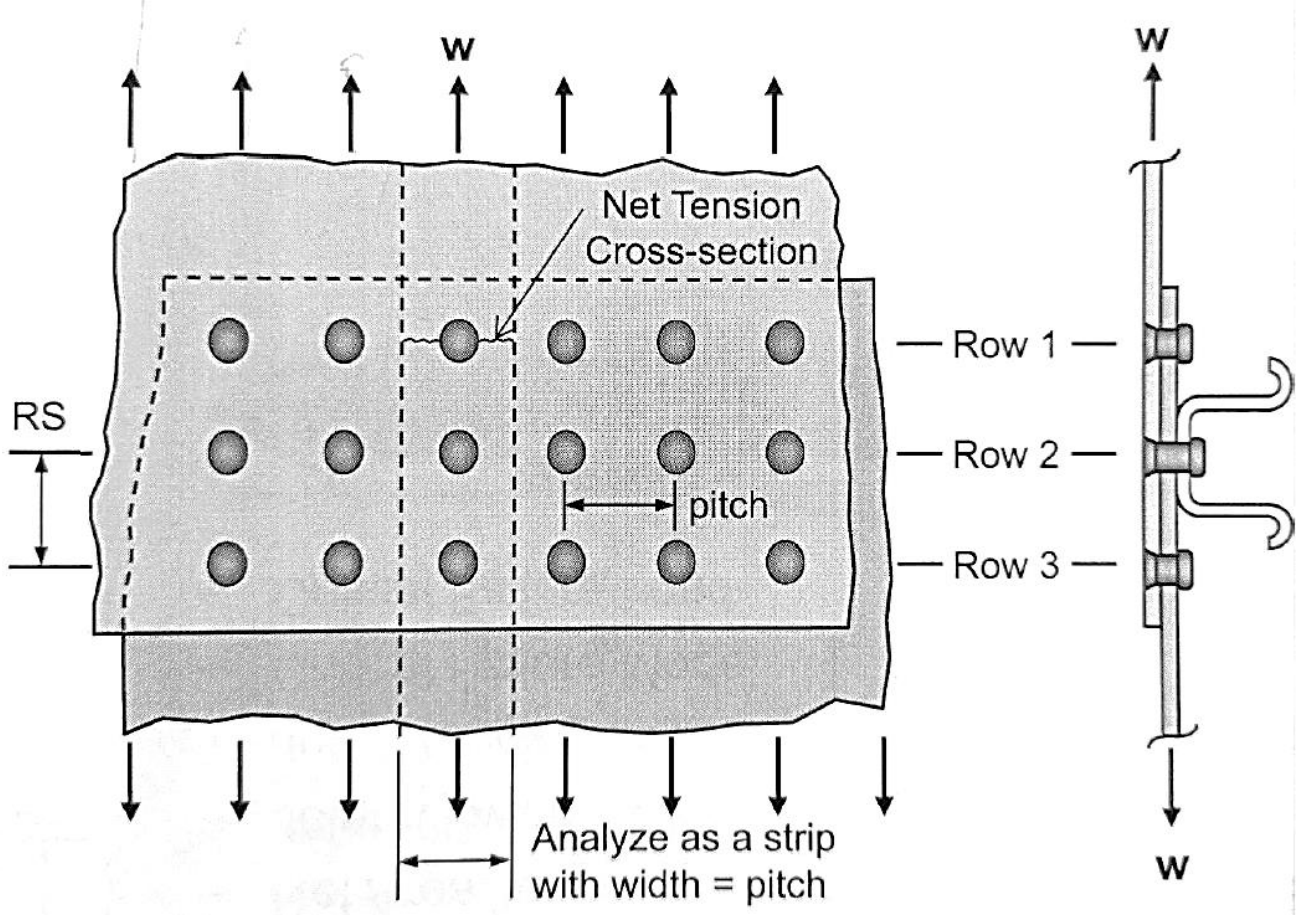
That cross section will typically be at the fastener experiencing the highest loads in each of the panels.

Fastener running load calculation

$$w_{joint} = \frac{n_{rows} \times P_{all/fast}}{pitch}$$

Material running load

$$w_{net} = \frac{\sigma_{du} \times (pitch - D) \times t}{pitch}$$



$P_{all/fast}$: Joint load per fastener (lb)

w_{joint}: running load based on joint capability (lb/in)

w_{net}: running load based on material net tension (lb/in)

RS: row spacing (in)