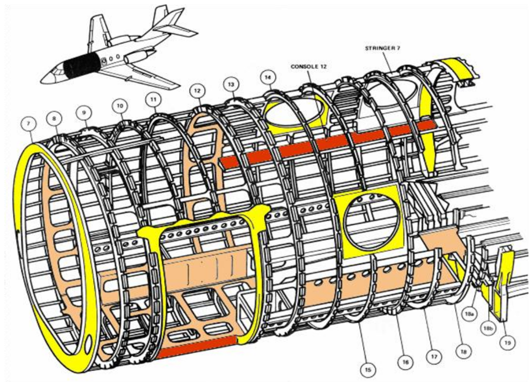
Slide 1

Blue Tuna

Slide 2

BASIC AIRCRAFT STRUCTURE REPAIR



Prior to performing maintenance on aircraft structures the mechanic or technician should have a basic understanding of the repair including structural loads and stresses of the aircraft. Understanding material types and stress loads are essential.

During this course the objectives technician should understand are the following:

- **Proper identification of the aircraft structural material**
- **Airworthiness**
- **Aluminum alloy structures**
- **All Metal Aircraft**
- **Aircraft principal structural elements**
- **Weight and balance effects of the repair**
- **Understanding the Repair**
- **Transfer of stresses within a structure**
- **Rivets and Holes**

Slide 3

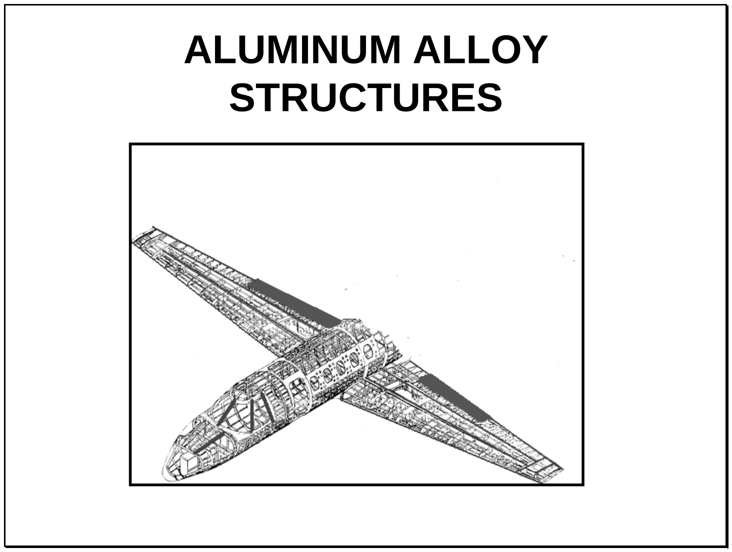
AIRWORTHINESS

A very basic complete understanding of AIRWORTHINESS— is a requirement.
Airworthiness is when an aircraft or one of its component parts meets its type design and is in a condition for safe operation. Flight Safety-Critical Aircraft Part (FSCAP)
The aircraft must conform to its type design. Conformity to the type design is considered attained when the aircraft configuration and the engine, propeller, and articles installed are consistent with the drawings, specifications, and other data that are part of the TC. This includes any supplemental type certificate (STC) and repairs and alterations incorporated into the aircraft.

b. The aircraft must be in a condition for safe operation. This refers to the condition of the aircraft relative to wear and deterioration, for example, skin corrosion, window delaminating/crazing, fluid leaks, and tire wear.

If one or both of these conditions are not met, the aircraft would not be considered airworthy. All aircraft being returned to service must be airworthy.

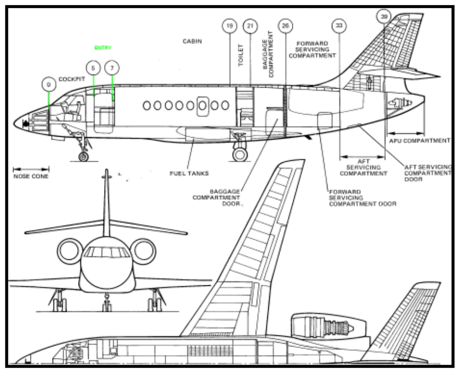
Slide 4



ALUMINUM ALLOY STRUCTURES.
Extensive repairs to damaged stressed skin on monocoque-types of aluminum alloy structures must be performed in accordance with FAA-approved manufacturer's instructions or other FAA-approved source.

Slide 5

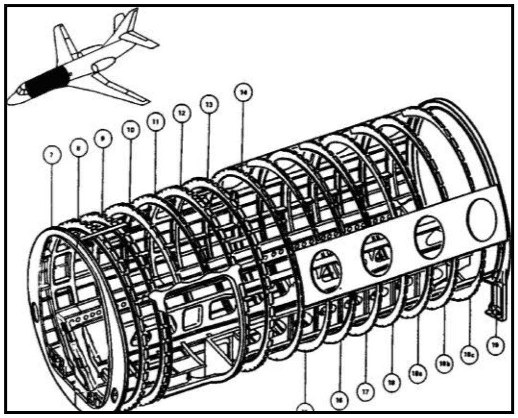
ALL-METAL AIRCRAFT



All-metal aircraft are made of very thin sheet metal, and it is possible to restore the strength of the skin without restoring its rigidity. All repairs should be made using the same type and thickness of material that was used in the original structure. If the original skin had corrugations or flanges for rigidity, these must be preserved and strengthened. If a flange or corrugation is dented or cracked, the material looses much of its rigidity; and it must be repaired in such a way that will restore its rigidity, stiffness, and strength.

Slide 6

AIRCRAFT PRINCIPAL STRUCTURAL ELEMENTS



Aircraft principal structural elements also known as PSE and joints are designed to carry loads by distributing them as stresses. The elements and joints as originally fabricated are strong enough to resist these stresses, and must remain so after any repairs. Long, thin elements are called members. Some examples of members are the metal tubes that form engine mount and fuselage trusses and frames, beams used as wing spars, and longerons and stringers of metal-skinned fuselages and wings. Longerons and stringers are designed to carry principally axial loads, but are sometimes required to carry side loads and bending moments, such as frame cutouts in metal-skinned structures. Truss members are designed to carry axial (tension and compression) loads applied to their ends only. Frame members are designed to carry side loads and bending moments in addition to axial loads.
Beam members are designed to carry side loads and bending moments that are usually large compared to their axial loads. Beams that must resist large axial loads, particularly compression loads, in combination with side loads and bending moments are called beam-columns. Other structural elements such as metal skins, plates, shells, wing ribs, bulkheads, ring frames, intercostal members, gussets, other reinforcements, and fittings are designed to resist complex stresses. These structural elements are sometimes required to carry side loads and bending moments. Truss members are designed to carry axial loads applied to their ends only.

Slide 7

UNDERSTANDING THE REPAIR

A complete understanding of aircraft structures is a key element when performing maintenance on aircraft.

Aircraft structures are engineered and designed to make allowance for stress that enters the structure. Repairs must be equal to the original structure, but not stronger or stiffer, which will cause stress concentrations or alter the resonant frequency of the structure. Improper repairs may cause aircraft structures to fall short of type and design, thus impacting the airworthiness of the structure.

Slide 8

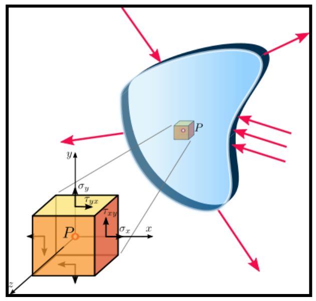
Balance Changes

Lets look at the importance of **Balance Changes**

Retaining the proper balance and rigidity of aircraft control surfaces cannot be overemphasized.
The effect of repair or weight change on the balance and center of gravity is proportionately greater on lighter surfaces than on the older heavier designs. As a general rule, repair the control surface in such a manner that the weight distribution is not affected in any way, in order to preclude the occurrence of flutter of the control surface in flight. Under certain conditions, counter-balance weight is added forward of the hinge line to maintain balance. Add or remove balance weights only when necessary in accordance with the manufacturer's instructions. Flight testing must be accomplished to ensure flutter is not a problem. Failure to check and retain control surface balance within the original or maximum allowable value could result in a serious flight hazard.

Slide 9

TRANSFER OF STRESSES WITHIN A STRUCTURE.



Understanding the transfer of stresses within a structure is important.
Proper stress levels, a very complex problem in highly redundant structures, are calculated using versatile computer matrix methods to solve for detailed internal loads.
Improper use of tooling, improper grade of materials and improper maintenance techniques are factors that may effect the ability of a structure to handle stress loads.

Slide 10

IDENTIFICATION OF METALS

Material Commercial Designation	Hardness Temper	Brinell number 500 kg. load 10 mm. ball
1100	0	23
	H18	44
3003	0	28
	H16	47
2014	0	45
	T6	135
2017	0	45
	T6	105
2024	0	47
	T4	120
2025	T6	110
6151	T6	100
5052	0	47
	H36	73
6061	0	30
	T4	65
	T6	95
7075	T6	135
7079	T6	135
195	T6	75
220	T4	75
C355	T6	80
A356	T6	70

Proper identification of the aircraft structural material is the first step in ensuring that the continuing airworthiness of the aircraft will not be degraded by making an improper repair using the wrong materials Take a moment to review the sample chart shown.

Slide 11

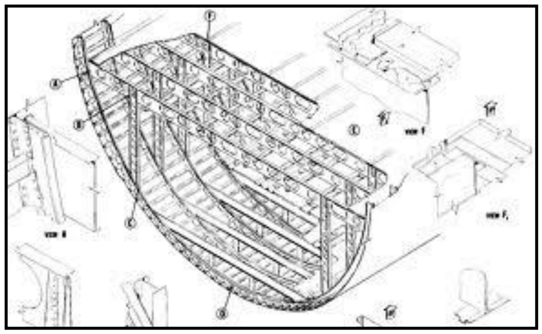
The wrong tool or the improper use of the right tool may have a direct impact on the airworthiness of an article.

Care must be taken whenever screws are removed to avoid damage to adjoining structures.   When properly used, impact wrenches can be effective tools for removal of screws; however, damage to adjoining structures may result from excessive vertical loads applied through the screw axis. Excessive loads are usually related to improperly adjusted impact tools or attempting to remove screws that have seized from corrosion. Remove seized screws by with the use of a screw extractor and drill.

Once the screw has been removed, check for structural cracks that may appear in the adjoining skin doubler, or in the nut or anchor plate.

Slide 12

SELECTION OF ALUMINUM FOR REPLACEMENT PARTS



Lets review the SELECTION OF ALUMINUM FOR REPLACEMENT PARTS.
All aluminum replacement sheet metal must be identical to the original or properly altered skin.
If another alloy is being considered, refer to the information on the comparative strength properties of aluminum alloys contained in MIL-HDBK-5.

The choice of temper depends upon the severity of the subsequent forming operations.
Parts having single curvature and straight bend lines with a large bend radius may be advantageously formed from heat-treated material; while a part, such as a fuselage frame, would have to be formed from a soft, annealed sheet, and heat-treated after forming. Make sure sheet metal parts which are to be left unpainted are made of clad (aluminum coated) material. Make sure all sheet material and finished parts are free from cracks, scratches, kinks, tool marks, corrosion pits, and other defects which may be factors in subsequent failure.

The use of annealed aluminum alloys for structural repair of an aircraft is not recommended. An equivalent strength repair using annealed aluminum will weigh more than a repair using heat-treated aluminum alloy.

Slide 13

DISASSEMBLY FOR REPAIR

Lets look at the DISASSEMBLY FOR REPAIR

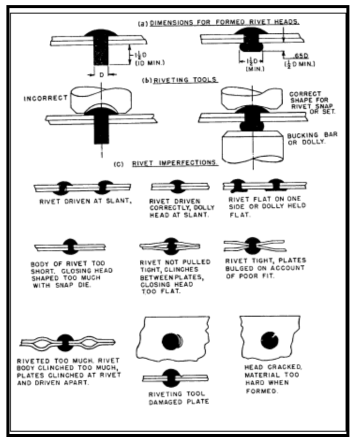
If the parts to be removed are essential to the rigidity of the complete structure, support the structure prior to disassembly in such a manner as to prevent distortion and permanent damage to the remainder of the structure. When rivets are removed, undercut rivet heads by drilling. Use a drill of the same size as the diameter of the rivet. Drilling must be exactly centered and to the base of the head only. After drilling, break off the head with a pin punch and carefully drive out the shank.

On thin or unsupported metal skin, support the sheet metal on the inside with a bucking bar. Removal of rivet heads with a cold chisel and hammer is not recommended because this may damage the skin of the aircraft and distort rivet holes.

Inspect rivet joints adjacent to damaged structures for partial failure by removing one or more rivets to see if holes are elongated or the rivets have started to shear.

Slide 14

RIVETS AND HOLES.



Rivet holes are slightly larger than the diameter of the rivet. When driven, solid rivets expand to fill the hole. The strength of a riveted joint is based upon the expanded diameter of the rivet. Therefore, it is important that the proper drill size be used for each rivet diameter.

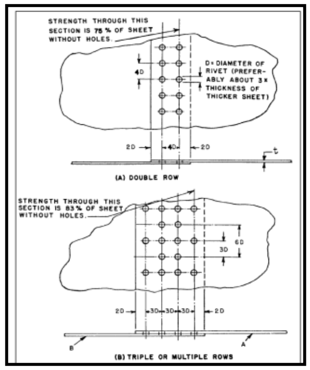
The acceptable drill size for rivets may be found in Metallic Materials and Elements for Flight Vehicle Structure, refer to MIL-HDBK-5 for detailed information.

Avoid drilling oversized holes or otherwise decreasing the effective tensile areas of wing-spar cap strips, wing, fuselage, fin longitudinal stringers, or highly-stressed tensile members. Make all repairs, or reinforcements, to such members in accordance with factory recommendations or with the specific approval of an FAA representative.

Replace rivets with those of the same size and strength whenever possible. If the rivet hole becomes enlarged, deformed, or otherwise damaged; drill or ream the hole for the next larger size rivet. However, make sure that the edge distance and spacing is not less than minimums.

Slide 15

RIVET EDGE DISTANCE



Rivet edge distance is defined as the distance from the center of the rivet hole to the nearest edge of the sheet.

Rivet spacing is the distance from the center of the rivet hole to the center of the adjacent rivet hole. Unless structural deficiencies are suspected, the rivet spacing and edge distance should duplicate those of the original aircraft structure. If structural deficiencies are suspected, the following may be used in determining minimum edge distance and rivet spacing.

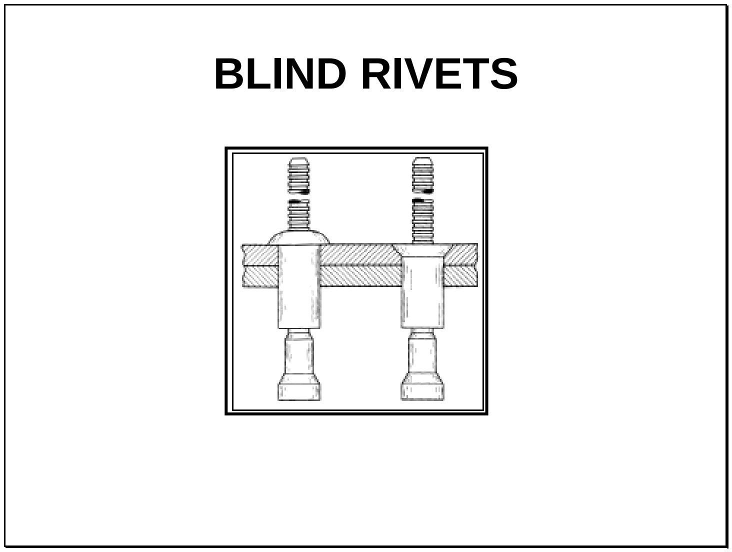
The following points are important:

(1) For single row rivets, the edge distance should not be less than 2 times the diameter of the rivet and spacing should not be less than 3 times the diameter of the rivet.

(2) For double row rivets, the edge distance and spacing should not be less than the minimums

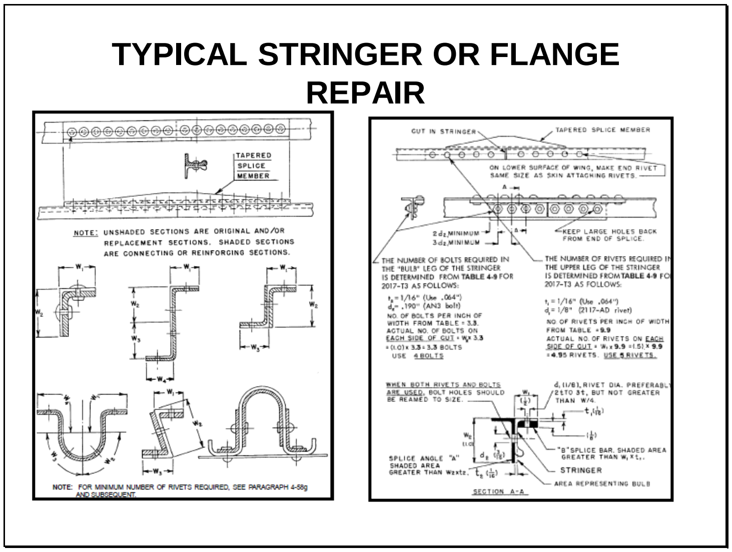
(3) For triple or multiple row rivets, the edge distance and spacing should not be less than the minimums

Slide 16



Lets review the use of Blind Rivets
When solid shank rivets are impractical to use, then special fasteners are used.
Special fastening systems used for aircraft construction and repair are divided into two types, special and blind fasteners.
Special fasteners are sometimes designed for a specific purpose in an aircraft structure. The name “special fasteners” refers to its job requirement and the tooling needed for installation. Blind rivets are used under certain conditions when there is access to only one side of the structure. Typically, the locking characteristics of a blind rivet are not as good as a driven rivet.
Therefore, blind rivets are usually not used when driven rivets can be installed.
Blind rivets shall not be used: in fluid-tight areas; on aircraft in air intake areas, where rivet parts may be ingested by the engine, on aircraft control surfaces, hinges, hinge brackets, flight control actuating systems, wing attachment fittings, landing gear fittings, on floats or amphibian hulls below the water level, or other heavily-stressed locations on the aircraft;
CAUTION: For metal repairs to the airframe, the use of blind rivets must be specifically authorized by the airframe manufacturer or approved by a representative of the FAA.
Self plugging friction-lock cherry rivets. This patented rivet may be installed when there is access to only one side of the structure. The blind head is formed by pulling the tapered stem into the hollow shank. This swells the shank and clamps the skins tightly together. When the shank is fully upset, the stem pulls in two. The stem does not fracture flush with the rivet head and must be trimmed and filed flush for the installation to be complete. Because of the friction-locking stem, these rivets are very sensitive to vibrations. Inspection is visual, with a loose rivet standing out in the standard “smoking rivet” pattern.

Slide 17



TYPICAL STRINGER OR FLANGE REPAIR

To avoid concentration of load on the end rivet and consequent tendency toward progressive rivet failure, the splice is tapered at the ends by tapering the backing angle and by making it shorter than the splice bar. (See figure above.) The preceding principles are especially important in splicing stringers on the lower surface of stressed skin wings, where high-tension stresses may exist. When several adjacent stringers are spliced, stagger the splices if possible.

Size of Splicing Members.

When the same material is used for the splicing members as for the original member, the cross-section area (i.e., the shaded areas in figure above), of the splice material will be greater than the area of the section element which it splices. The area of a section element (for example each leg of an angle or channel) is equal to the width multiplied by the thickness. For example, the bar "B" in figure above is assumed to splice the upper leg of the stringer, and the angle "A" is assumed to splice the bulbed leg of the stringer. Since the splice bar "B" is not as wide as the adjacent leg, its thickness must be increased such that the area of bar "B" is at least equal to the area of the upper leg of the stringer.

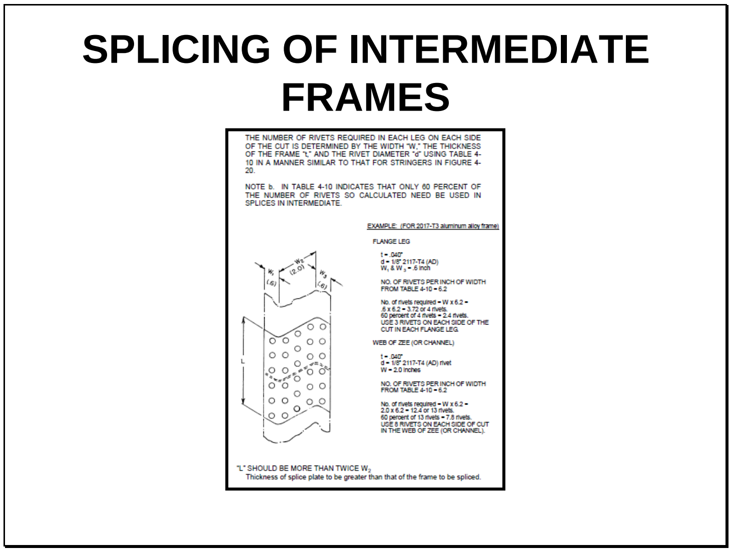
The Diameter of Rivets in Stringers.

The diameter of rivets in stringers might preferably be between two and three times the thickness "t" of the leg, but must not be more than 1/4th the width "W" of the leg. Thus, 1/8-inch rivets are chosen in the example, figure above. If the splices were in the lower surface of a wing, the end rivets would be made the same size as the skin-attaching rivets, or 3/32 inch.

The Number of Rivets.

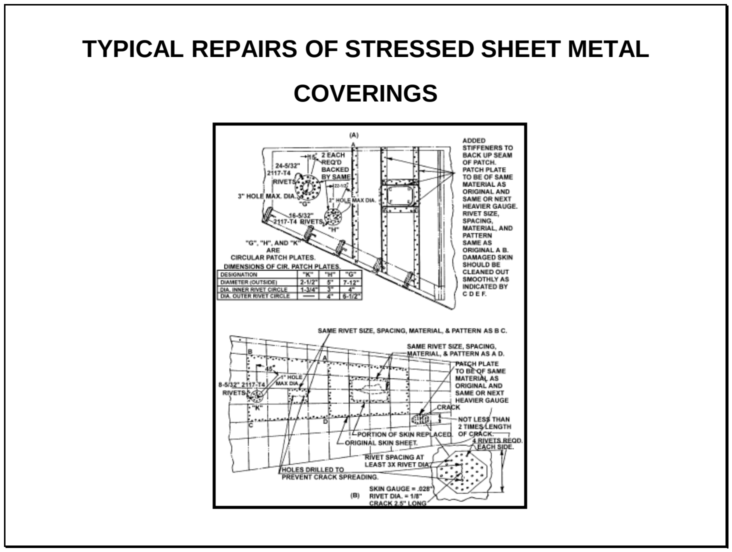
The number of rivets required on each side of the cut in a stringer or flange may be determined from standard text books on aircraft structures manual.. (1) In determining the number of rivets required in the example, figure above, for attaching the splice bar "B" to the upper leg, the thickness "t" of the element of area being spliced is 1/16 inch (use 0.064), the rivet size is 1/8 inch, and table 4-9 shows that 9.9 rivets are required per inch of width. Since the width "W" is 1/2 inch, the actual number of rivets required to attach the splice bar to the upper leg on each side of the cut is 9.9 (rivets per inch) x 0.5 (inch width) = 4.95 (use 5 rivets). (2) For the bulbed leg of the stringer "t" = 1/16 inch (use 0.064); AN-3 bolts are chosen, and the number of bolts required per inch of width = 3.3. The width "W" for this leg, however, is 1 inch; and the actual number of bolts required on each side of the cut is 1 x 3.3 = 3.3 (use 4 bolts). When both rivets and bolts are used in the same splice, the bolt holes must be accurately reamed to size. It is preferable to use only one type of attachment, but in the above example, the dimensions of the legs of the bulb angle indicated rivets for the upper leg and bolts for the bulb leg.

Slide 18



Splicing of Intermediate Frames.
The same principles used for stringer splicing may be applied to intermediate frames when the following point is considered. Conventional frames of channel or Z sections are relatively deep and thin compared to stringers, and usually fail by twisting or by buckling of the free flange. Reinforce the splice joint against this type of failure by using a splice plate heavier than the frame and by splicing the free flange of the frame with a flange of the splice plate. (See figure above.) Since a frame is likely to be subjected to bending loads, make the length of splice plate "L" more than twice the width "W2," and the rivets spread out to cover the plate.

Slide 19

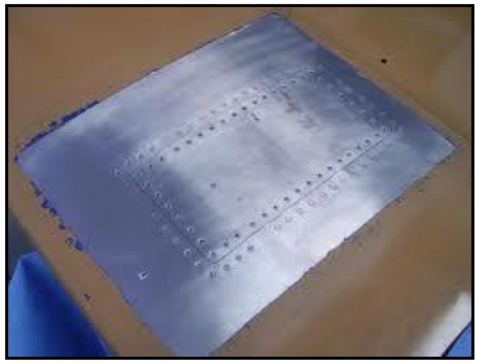


TYPICAL REPAIRS OF STRESSED SHEET METAL COVERINGS

Add reinforcement to carry the stresses across the damaged portion and to stiffen the joints. (See figures above) The condition causing cracks to develop at a particular point is stress concentration at that point in conjunction with repetition of stress, such as produced by vibration of the structure. The stress concentration may be due to the design or to defects such as nicks, scratches, tool marks, and initial stresses or cracks from forming or heat-treating operations. It should be noted, that an increase in sheet thickness alone is usually beneficial but does not necessarily remedy the conditions leading to cracking. Cracking can be stopped with very small hole .015 -.032 as an example for drill diameter, diameter depends on the size of the crack, and the end of the crack

Slide 20

**REPAIR METHODS AND PRECAUTIONS
FOR ALUMINUM STRUCTURE**



**REPAIR METHODS AND PRECAUTIONS
FOR ALUMINUM STRUCTURE.**

Carefully examine all adjacent rivets outside of the repair area to ascertain that they have not been harmed by operations in adjacent areas. Drill rivet holes round, straight, and free from cracks. Deburr the hole with an oversize drill or deburring tool. The rivet-set used in driving the rivets must be cupped slightly flatter than the rivet head. (See figure Rivet and holes.) Rivets are to be driven straight and tight, but not overdriven or driven while too hard, since the finished rivet must be free from cracks. Information on special methods of riveting, such as flush riveting, usually may be obtained from manufacturer’s service manuals.