CHAPTER

51

STRUCTURES

CONTENT

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GENERAL

This chapter contains instructions needed for repair of metal sheet structure elements, survey of manufacturer used metal materials, survey of permitted substitutes and instructions for repair are applicable even in the other chapters of this manual.

DAMAGE REPAIRS

This section of chapter contains instructions for:
- repair of parts affected by corrosion
- repair of parts made from sheet
- repair of laminated parts.

EFFECTIVITY: All

REPAIR OF CORROSIVE PARTS

CAUTION

IN CASE THE CORROSIVE SPOTS WITH ROUGH SURFACE OF DARK COVER (INTER-CRYSTALLINE CORROSION) INDICATING THE CORROSION PENETRATION INTO THE DEPTH OF BASE MATERIAL IT IS NECESSARY TO REPLACE AFFECTED PARTS.

1) Remove paint completely from the metal surface with the 5 mm (0,20 in) access around the corrosive spots with paint remover or mechanically.

   NOTE

   Corrosion under the painted surface may be detected according to blistered paint. The corrosion may be removed with sharp tool without part surface damage.

2) Remove corrosion with emery paper No. 180 and if necessary by pumice.
   Check surface with removed paint by 6x magnifying glass.

3) Repair paint (subsection 51-72-00).

REPAIR OF SHEET PARTS

CAUTION

REPAIR OF SKIN OF FUSELAGE REAR PART, TAIL UNIT AND WINGS IS ISSUED IN SUBSECTION 57-10-00 APPROVED REPAIRS.

REPAIR OF CRACK IN THE SHEET COVER

1) Level the deformed cover by means of wooden mallet and suitable shims.
2) Drill of the ends of cracks with 1,5 mm (0,06 in) drill.
3) Make overlapping stripe:
   - the thickness of sheet should at least the same as that of repaired sheet
   - the overlapping stripe should overlap the edge of crack for at least 15 mm (0,60 in).
4) Chamfer the sheet edges and protect contact surfaces of repaired and repair sheets with pain.
5) Rivet overlapping stripe to repaired spot (Fig. 51-1):
   - use duralluminium rivets of minimum 186 MPa and 3x to 5x thicker diameter of sheet thickness
   - the lenght of rivet should be 1,5x longer than the thickness of riveted sheets
   - the rivet spacing should be the same as at the periphery of repaired part but not greater than 30 mm (1,20 in)
   - the rivet distance from the edge should at least 7 mm if used rivets are thicker than 3 mm (0,12 in).
6) Repair paint (subsection 51-72-00).

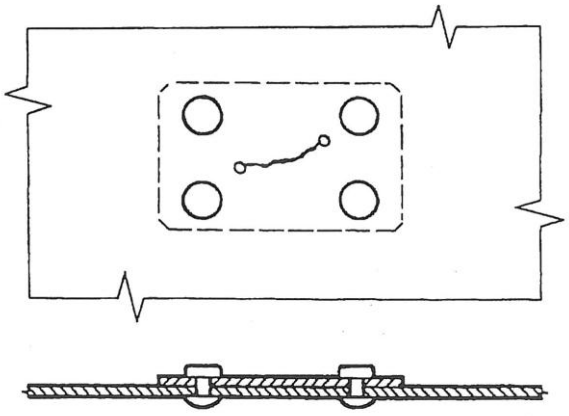


Fig. 51-1 Repair of cracks in sheet covers

REPAIR OF PUNCTURED SHEET COVER

CAUTION

REPAIR OF PUNCTURED SHEET MAY BE CARRIED OUT BY MANUFACTURER OR AUTHORIZED REPAIR SHOP.

1) Cut damaged spot (Fig. 51-2, paragraph A) to be square or rectangular (paragraph B) with round corners. Chamfer the hole edges.
2) Make out the sheet patch (1) and if necessary even the patch frame (3).
3) Rivet unsunk (paragraph C) or flush (paragraph D) patch.

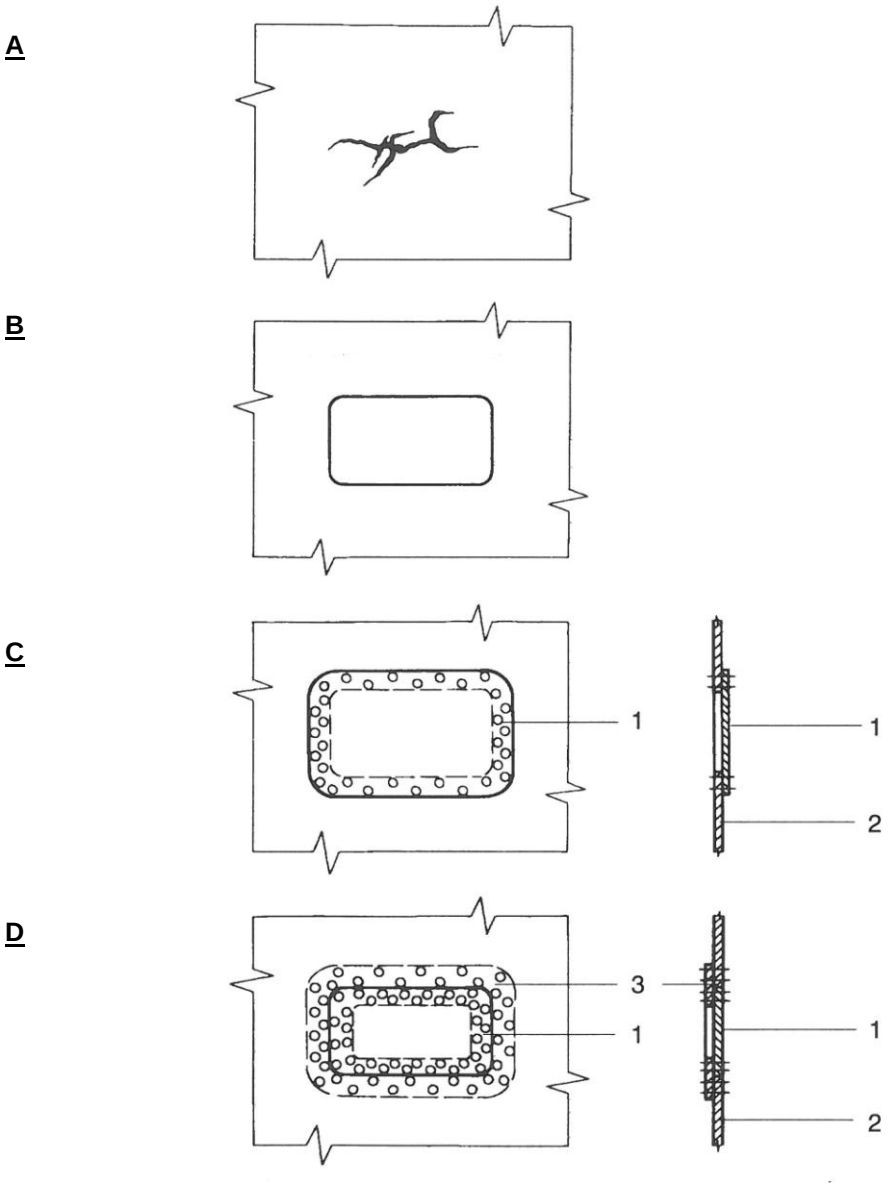
   NOTE

   Use flush patch (paragraph D) in spots demanding good aerodynamic shape.

4) Repair paint (subsection 51-72-00).

REPAIR OF BROKEN REINFORCING ANGLE

a) Broken reinforcing angle either replace as a hole or repair with shim angle taking in mind the length of shim angle should be 5x the wider angle side.
b) Rivet the shim angle at its both sides with duralluminium rivets of minimum 186 Mpa strength and diameter equal to 4x to 5x the thickness of angle. Maximum rivet diameter should be 4 mm (0,16 in).



A ... punctured cover
B ... cutting off the damaged spot
C ... unsunk patch
D ... flush patch

1 ... patch
2 ... skin
3 ... frame

Fig. 51-2 Repair of punctured sheet cover

EFFECTIVITY: All

REPAIR OF LAMINATED PARTS

General

1) The ambient air temperature suitable for repair of laminated parts should be 18 to 22 °C (64 to 72 °F).

2) Maintain following safety precautions at the workplace:
   - do not smoke and/or handle with open fire
   - do not eat ad/or smoke
   - make sure the workplace is properly vented
   - prepare the resin in fume chamber with venting in operation and face protection shield on
   - store resin, catalyst and polymerization accelerator in well closed vessels
   - protect hands with glows or suitable skin protection creme as the catalyst and accelerator should not stain the skin.

Preparatory works

CAUTION

THE BEGINNING OF RESIN HARDENING DEPENDS UPON MUTUAL RATIO OF RESIN, CATALYST AND HARDENING ACCELERATOR. THE HIGHER IS QUANTITY OF ACCELERATOR AND HARDENER THE FASTER IS THE RESIN HARDENING.

1) Cut the glass-fiber cloth to suitable shape and dimension.

2) Pour necessary quantity of epoxy resin into the clean and dry PVC vessel, add the catalyst and mix the content thoroughly. Add accelerator to accelerate the hardening process and mix the mixture thoroughly again. Maintain the mass ratio of resin, catalyst and accelerator prescribed by resin manufacturer.

Repair procedure of laminated airplane parts

CAUTION

SINGULAR LAYERS OF GLASS FIBER CLOTH SHOULD BE THOROUGHLY SATURATED AND PRESSED TOGETHER.

THE SURFACE OF THE PART SHOULD NOT EXHIBIT THICK LAYER OF RESIN WITHOUT FIBER GLASS CLOTH AS THE RESIN ITSELF IS BRITTLE AND BRAKE WHEN LOADED MECHANICALLY.

WASH USED TOOLS WITH ACETONE AS BRUSH AND VESSEL FOR RESIN, PROPERLY IMMEDIATELY AFTER USE.

1) Level, clean grind with emery paper and degrease the laminated part in the area of damage.

2) Apply prepared epoxy resin, if possible from inside, upon faulty area and lay the first layer of glass fiber cloth so that it overlaps up to the intact area of damaged part. Push the applied fiber cloth with brush.

   NOTE

   Use suitable reinforcing template to maintain required shape and place and fix it from the external side of repaired part. Insert PE or PVC foil between template and repaired part.

3) As soon as the first layer of glass fiber is saturated with resin thoroughly apply new layer of resin, lay second layer of glass fiber cloth and push it to the first layer with brush. Proceed with laying the third fiber glass layer the same way as during the second one.

NOTE

The epoxy resin is not applied upon the last layer of glass fiber as it is saturated with resin perfectly by pressing this layer.

4) Remove reinforcing template after the resin hardening. Cement the repaired spot and spray it with lacquer (subsection 51-72-00).

Used material

This paragraphs contain names and marks of materials used in production of laminated airplane parts by airplane manufacturer.

1)	glass fiber cloth	(first layer)	EV 99 165 786
		(second layer)	EV 99 206 786
		(third layer)	V 1111 280 786
2)	polyester resin – non-extincion		ChS 109
	catalyst		P - initiator XXII
	accelerator		I / 40
3)	polyester resin – non-extincion		Viapal N 600
	catalyst		Bulamox MEK 50
	accelerator		CO 1

MATERIALS

General

a) This section contains survey of chemical composition and mechanical features of metal materials use by airplane manufacturer as well as the survey of recommended foreign equivalents of these materials.

b) In case of replacement of original material with the equivalent material compare and verify in more important cases strength characteristics of both materials. In case of welded parts compare also the welding ability features of equivalent material.
The tabulated materials in brackets are not completely equivalent to those used by airplane manufacturer. Choose the replacement equivalent material after evaluation of operation and load of repaired part with respect to procedures used during part production.

c) The materials used by airplane manufacturer:

- Fuselage is welded from L-CM3.9 steel tubes with falme quenched welded nodes to 588 up to 785 Mpa strength. The steet parts are made from L-CM3.33 material.
- The main wing spar flange plates are made from Z 42.4203.61 light alloy semi-product profile.
- The wing skin, aileron and flaps leading rdges, rudder, stabilizer, fin and rear tail section skin are made from D 16 ATV duralumin sheet.
- Rear aileron and flap and elevator skins, main wing spar web plate, elevator and rudder beams, wing and tail unit ribs and fuselage rear section bulkheads are made from Z 42.4253.61 duralumin sheets.

d) The tables contain, if not stated otherwise, minimum values.

Comparision of materials

Czech republic ČSN	Germany DIN	France NF	Great Britain BS	USA AISI, ASTM	International ISO
L-CM3	25CrMo4	25CD4	708A25 (CDS110)	(4130H) (4125)	25CrMo4
Z42 4203	AlCuMg2 (3.1355)	2024 (A-U4G)	2024 (L97)	2024	AlCu4Mg1
Z42 4253 plátovaný Al 99,5	---	(A-U4F1)	CLAD 2024	Al CLAD 2024	---
Z42 4400	AlMgSi1 (3.2315)	60S2 (ASGM)	6062 (L111)	(6061)	AlSi1MgMn
D 16 ATV	DIN1745	---	CLAD 2024	Al CLAD 2024	---

Chemical composition of materials

Material mark		Admixtures (%)								
		C	Cr	Cu	Mn	Mo	Ni	P	S	Si
L-CM3	min	0,22	0,90		0,50	0,15				0,17
	max	0,29	1,20	0,25	0,80	0,25	0,30	0,030	0,030	0,37

Material mark		Admixtures (%)									Al%
		Cu	Mg	Mn	Fe	Ni	Si	Ti	Zn	Ostatní	
Z42 4203	min	3,8	1,2	0,4	---	---	---	---	---	---	remnant
	max	4,8	1,8	1,1	0,5	0,1	0,5	0,2	0,2	0,15	
Z42 4253	min	3,8	1,2	0,4	---	---	---	---	---	---	remnant
	max	4,8	1,8	1,1	0,5	0,2	0,5	0,2	0,2	0,15	
Z42 4400	min	---	---	0,4	0,7	---	0,7	---	---	---	remnant
	max	0,05	0,5	1,0	1,2	---	1,4	0,2	0,2	0,15	
D 16 ATV	min	3,8	1,2	0,3	---	---	---	---	---	---	remnant
	max	4,9	1,8	0,9	---	---	0,5	---	0,3	---	

NOTE

Z 42 4253 and D 16 ATV materials are both sides aluminium clad.

Mechanical features of material

Material mark	Semi-product	R_m MPa	R_p 0,2 MPa	A 10 %	HB	Note
L-CM 3.9 .33	tube sheet	590 až 900 max. 700	440	17	max. 199	
Z42 4203.61	sheet	430	275	13	---	
Z42 4253.61	sheet	440	295	13	---	Al clad
D 16 ATV	sheet	407	270	13	---	Al clad

EFFECTIVITY: All

Marking of mechanical features

R_m - the tensile strength is the greatest stress F_m the test bar of S_o diameter can bear without tearing

$$R_m = \frac{F_m}{S_o} \quad \text{(MPa)}$$

R_p - the yield point is the tension at which the plastic deformation of test bar attains prescribed value expressed in percentage of initial test bar length. The magnitude of yield is stated by number behind mark, e.g. R_p 0,2).

A - the ductility is the ratio between initial length of test bar and length of that bar at the moment of tearing expressed in percentage as follows:

$$A = \left(\frac{L_u - L_o}{L_o}\right) \cdot 100$$

The ductility measured upon the long test bar is marked A10.

HB - the Brinell hardness number is expressed as the ratio of acting test load to the spherical area of ball dent.

REPAIRS

This subsection contains instructions for repairs valid even for other chapters of this manual.

EFFECTIVITY: All

REPAIR OF RIVETED JOINTS

Fault	Remedy
1) The corrosive rivet heads (except countersunk rivet heads).	Remove corrosion with emery paper. Do not reduce rivet head height for more than 10%. The difficult accessible rivet head height may be reduced for maximum 20% of original height. Replace rivet if its height is less than allowed.
2) Corrosive, released and/or damaged rivets.	Replace all faulty rivets.

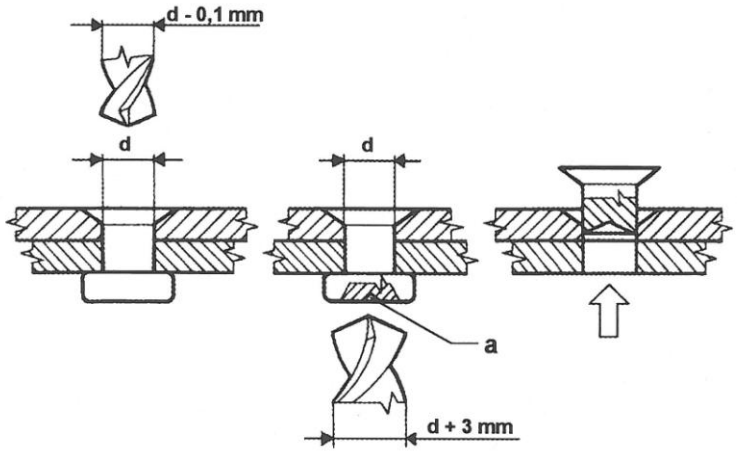
Rivets changing:

CAUTION

BE CAREFUL WHEN DRILLING THE RIVETS OFF NO TO ENLARGE ORIGINAL HOLE AS IT IS NECESSARY TO USE THE RIVET WITH ORIGINAL DIAMETER.

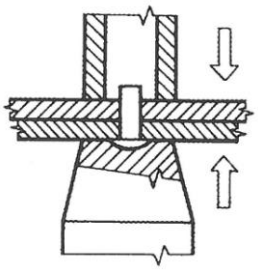
IN CASE THE HOLE FOR RIVET IS DENTED OR DAMAGED IT IS NECESSARY TO DRILL IT TO HIGHER DIAMETER AND USE RIVET WITH CORRESPONDING THICKER SHANK.

a) Drill off the rivet head that is better accessible and hammer the drilled rivet off the hole.



a ... center punch for drill fitting
d ... rivet diameter

b) Remove dirt and drilling chips and blow the hole with compressed air.
Join riveted parts properly together.



c) Rivet over the rivet directly (Fig. 51-3, paragraph A) or indirectly (paragraph B).

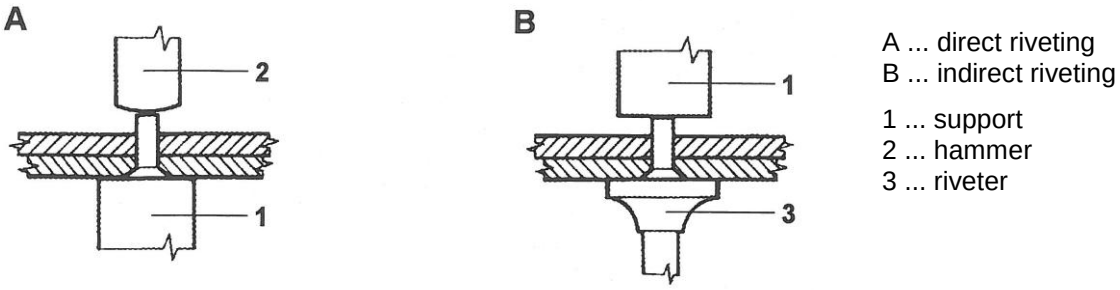


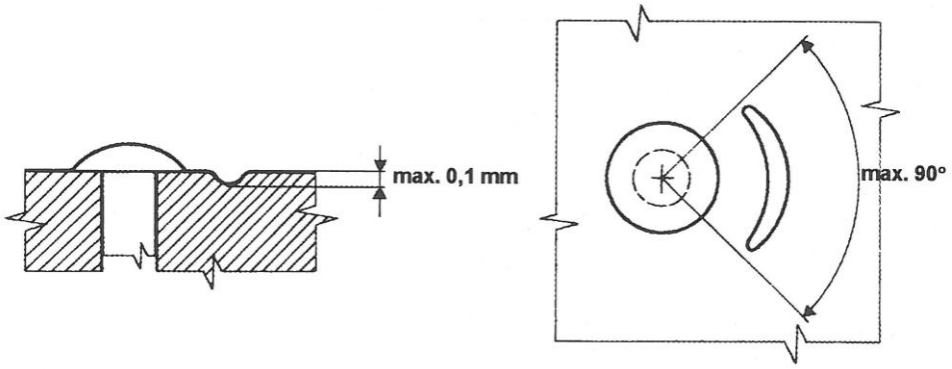
Fig. 51-3 Riveting

When riveting the skin sheets maintain support mass (Fig. 51-3, item 1) according to table:

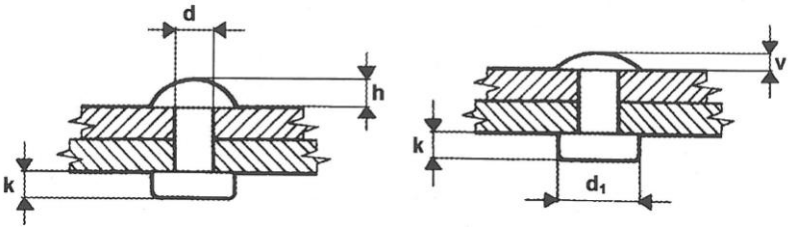
Rivet diameter (mm)			2,0	3,0	3,5	4,0	5,0
Minimum support mass (kg)	Direct riveting	Al alloys and steel	5,0	6,0	7,0	8,0	10,0
	Indirect riveting	Al alloys	1,3	1,5	1,75	2,0	2,5
		Steel	2,6	3,0	3,5	4,0	5,0

d) Check quality of riveted joint as follows:

- Permissible eccentticity of snap head with respect to rivet shank axis:
  - for rivets from 2 to 3,5 mm diameter .. max. 0,4 mm
  - for rivets of 4 mm and higher diameter ... max. 0,6 mm.
- The single-sided 0,1 mm untaught snap head fitting of 5% of rivets is allowed providing the gap between the snap head and the sheet surface is not exceeding 0,1 mm and the untaught fitting is not greater than half of the rivet snap head periphery.
- The shallow denting of tool according to figure is allowed:



- The height and diameter of snap head should meet dimensions issued in following table:

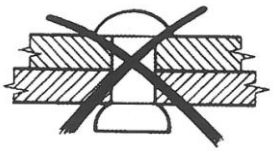


d ... rivet diameter
d_1 ... snap head diameter
h ... height of button head
v ... height of oval head
k ... height of snap head

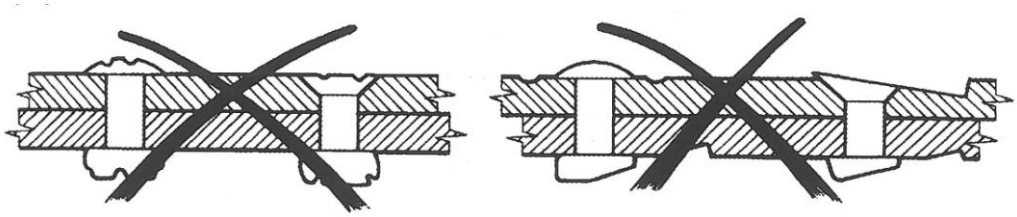
Rivet diameter (mm)		2	2,6	3	3,5	4	4,5
Rivet head	h (mm)	1,2 to 1,3	1,6 to 1,7	1,8 to 1,95	2 to 2,15	2,3 to 2,5	2,9 to 3,1
	v (mm)	0,9 to 1,0	1,2 to 1,3	1,4 to 1,55	1,7 to 1,85	1,9 to 2,1	2,4 to 2,6
Snap head	d_1 (mm)	3 to 3,2	3,9 to 4,15	4,5 to 4,8	5,2 to 5,5	5,9 to 6,4	7,2 to 7,8
	k (mm)	0,8	1,0	1,2	1,4	1,8	2,2

Fig. 51-4 Dimension of rivet heads

- Insufficiently riveted head is not allowed.



- The dents and cracks of rivet heads, tapering of rivetheads and excessive traces of riveting tools are not allowed.



Rivets

This section contains rivet materials and marking as used by airplane manufacturer. This rivets may be replaced by rivets produced according to other standards but minimum shear strength should be maintained.

- Material of rivets (according to ČSN)

1) Button head rivets

a) ČSN 02 2302.5 standard
Material: CSN 42 4208 duralumin with minimum 245 MPa shear strength
Use: rear fuselage section, wing structure, ailerons, wing flaps, stabilizer, control pushrods.

b) ČSN 02 2302.0 standard
Material: ČSN 42 4204.6 duralumin with minimum 186 MPa shear strength.
Use: rear fuselage section.

2) Oval head rivets
ČSN 02 2304.0 standard
Material: ČSN 42 4204.6 duralumin with minimum 186 MPa shear strength
Use: rear fuselage section external fuselage panels, wing skin, tail unit skin.

3) Oval countersunk head rivets

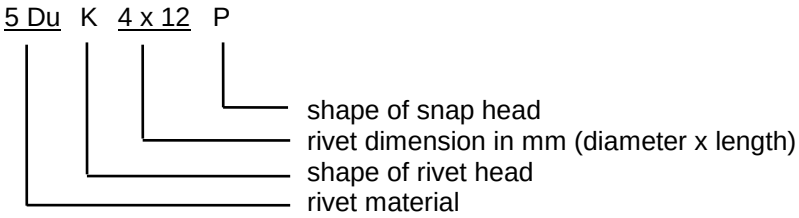
a) ČSN 02 2320.5 standard
Material: ČSN 42 4208 duralumin with minimum 245 MPa shear strength.
Use: rear fuselage section, wings, tail unit.

b) ČSN 02 2320.0 standard
Material: ČSN 42 4204.6 duralumin with minimum 186 MPa shear strength.
Use: rear fuselage section, tail unit.

4) Countersunk head rivets
3549 A standard
Material: D 18 P duralumin with minimum 186 MPa shear strength.
Use: engine cowlings, firewall.

- Rivet marking

Example:



Rivet material:

5 Du ... ČSN 42 4208 material

Du ..ČSN 42 4204 material

Shape of rivet and snap heads:

K ... button head

V ... oval head

Z ... countersunk head

P ... flat head

REPAIR OF PAINT

General

CAUTION

MIX PAINTS AND LACQUERS BEFORE USE THOROUGHLY.

WASH USED TOOLS AS BRUSHES, SPRAY GUNS AND PAIN VESSELS IMMEDIATELY AFTER USE BY ACETONE.

1) The ambient air temperature when repairing the painted surfaces should be at least +18 ^{o}C (64 ^{o}F) and relative humidity should not exceed 75 %.
2) The paint repair or renewal should not be carried out in dusty or chemical agent contaminated environment that may cause paint film contamination.
3) The surrounding areas of painted surfaces should be protected (covered), e.g. by cover paste, paper, PVC foil. The cover paper or foil should be stuck to the structure by sticking tape
Choose for repair the same paint shades as the original ones.
4) Maintain during painting similar safety measures as during laminating (subsection 51-13-00, REPAIR OF LAMINATED PARTS).

Paint repair of sheet parts

1) Clean, wash and grind with emery paper No. 180 the faulty or corrosive spot and its vicinity. In case of excessive paint damage it is necessary to remove paint completely.
Roughen the intact paint 10 to 20 mm (0,4 to 0,8 in) round the faulty spot according to range of damage with emery paper. Remove remain dust after grinding with dry brush and degrease all the area with suitable degreaser, e.g. trichloroethylene etc.
2) In case of complete paint removal it necessary to paint cleaned metal surface with primer and after primer drying level the surface if necessary with cement. Grind the cement after its hardening to make the surface flush with surrounding parts.
3) Paint or spray the repaired spot including roughened surrounding paint with lacquer. Cover the surrounding area before painting if necessary.
4) Apply second layer of paint if necessary as soon as the first lacquer layer is dry. In case of rough or uneven surface it is possible to grind the dry painted surface with fine emery paper, remove paint dust thoroughly with clean brush and apply third paint layer.

Paint repair of laminated parts

1) Wash, dry and grind the faulty spot with fine emery pper and if necessary cement the surface with polyester cement to be flush (e.g. B 5010/0110 cement). Grind the hardened cement to be flush.
2) Paint cemented spot with single layer of primer, e.g. S 2008 and than with polyester lacquer, e.g. B 2030/1000 containing 100 mass parts of lacquer, 2 to 3 mass parts of B 7001 catalyst and 1,5 to 2 mass parts of B 7300 accelerator.
3) Paint second and if necessary even the third layer of lacquer after the first (second) layer gelatinizing.

Coating compositions

This section contains names.and marks of coating compositions (paints) used by airplane manufacturer. These material may be substitutes by other suitable coating material during airplane repair.
Choose the paint shade according to color of repaired part.

1) Internal parts (in cockpit, in wings, etc., except seats, tanks, plumbing, instrument panel and console under the instrument panel)

1x primer	S 2008
1x nitrocellulose enamel	C 2001

2) Fuselage brace structure

1x primer	S 2008
1x synthetic enamel	S 2043

3) Seats, seat and backrest frame

1x synthetic baking primer	S 2001
1x synthetic baking enamel	S 2046

4) Main fuel tanks, plumbing

1x primer	S 2003
1x nitrocellulose enamel	C 2001

5) Main landing gear leg (paint renewal)

1x primer	S 2008
1x semiglossy epoxy enamel	S 2322
1x epoxy enamel	S 2321

6) The instrument panel and console under the instrument panel are sprayed with DU PONT (CENTARI 500 / RAL 8019 + AK 119 bonding agent) coating composition.

External airplane paints

CAUTION

VERIFY THE AIRPLANE WEIGHT AND C-G POSITION AFTER THE AIRPLANE PAINT RENEWAL (section 08-10-00) AND STATIC BALANCING OF RUDDER AND ELEVATOR (section 55-20-00 and 55-40-00).

Renew external airplane paint completely in case of overall paint oxidizing and cracking or upon the customer instructions.

1) Grind old paint from the laminated parts by means of suitable emery paper.
2) Remove old paint from the metal parts utilizing suitable paint remover. Mix the paint remover thoroughly and apply it upon old paint with brush.
3) Remove softened old paint from the surface with wooden scraper. In case the softening is insufficient apply another layer of paint remover.
4) Remove remains of old paint with rag soaked in solvent.
5) Spray the surface with primer, level if necessary the surface with cement, grind the cemented surface to be flush and spray the surface with enamel.
   Paint bolt heads with polyurethane enamel and leveling points with nitrocellulose enamel.

   NOTE

   The airplane manufacturer uses for airplane external painting the DU PONT coating composition. Repair of external paint should be made according to procedure of DU PONT, CENTARI 600 system.

ELECTRIC BONDING

This section contains Table of transition resistance and insulation strength including the measuring spots that is used for measurement of transition resistance and insulation strength purposes.

TABLE OF TRANSITION RESISTANCE AND INSULATION STRENGTH

No.	Measured between parts	Type of bonding	Resistance	
			specified	actual
	TRANSITION RESISTANCE:		μΩ (max.)	μΩ
1	Wing to fuselage brace structure	direct	2000	
2	Engine mount to fuselage brace structure		1000	
3	Rear fuselage section to fuselage brace structure		600	
4	Aileron to wing		2000	
5	Wing flap to wing		2000	
6	Elevator to stabilizer		2000	
7	Rudder to fin		2000	
8	Stabilizer to rear fuselage section		2000	
9	Engine to engine mount		1000	
10	Starter motor to engine		600	
11	Magneto to engine		600	
12	Voltage regulator to firewall		600	
13	Firewall to fuselage brace structure		600	
14	Instrument panel to fuselage brace structure		2000	
15	Control stick to control stick mechanism	indirect	4000	
16	Fwd, rear control stick mechanism to L, R rudder pushrod		4000	
17	L, R rudder pushrod to intermediate bell crank		4000	
18	Intermediate bell crank to fuselage brace structure		4000	
19	Manual control pushrods to fuselage brace structure		4000	
20	Main fuel tank to wing	direct	2000	
21	Main fuel tank filler port to grounding pin	indirect	200 000	
22	Auxiliary fuel tank to wing	direct	2000	
23	Auxiliary fuel tank fillerr port to grounding pin	indirect	200 000	
24	Fuel system to fuselage brace structure	direct	2000	
25	Nose landing gear to fuselage brace structure	indirect	2500	
26	Main landing gear leg to fuselage brace structure	---	2000	
	INSULATION STRENGTH		MΩ(min.)	
27	Board electric systém to fuselage brace	---	20	

NOTE

Explanations with measuring spot designation are upon the following page.

Measure the transition resistance with appliances off and 70%. maximum relative humidity. The measuring current should not exceed 5A.

Explanation to Table of transition resistance and insulation strength

No.	Spot of measurement
1	Main wing spar to upper wing mount upon the beam of brace fuselage structure (measure both port and starboard wing).
2	Left bottom engine mount to left bottom mount of fuselage brace structure.
4	Aileron skin to wing skin at the inboard aileron hinge of port and starboard ailerons.
5	Flap skin to outboard flap suspension of both flaps.
6	Elevator skin to stabilizer skin at the port elevator hinge.
7	Rudder skin to fin skin at the root above the fuselage.
8	Stabilizer skin to rear fuselage section skin at the port mount.
9	Engine to engine mount at the left bottom damper.
10	Starter motor frame to engine.
11	Magneto frame to engine at both magnetos.
13	Left bottom corner of firewall to lower fwd brace of fuselage brace structure.
14	Left instrument panel side to transversal tube under the instrument panel.
15	Lower side of control stick to left side of control stick mechanism.
16,17	In the spot of bonding.
18	Left hinge of intermediate bell crank to left lower suspension upon the fwd brace of brace fuselage structure.
19	Manual control pushrod to left lower suspension upon the fwd brace of brace fuselage structure.
20	Main fuel tank to rib.
22	Auxiliary fuel tank to wing skin (the distance of measuring pins is about 60 mm (2,4 in)).
24	Outlet pipe from fuel booster pump to left lower suspension upon the fwd brace of brace fuselage structure.
25	Nose landing gear brace to left lower suspension upon the fwd brace of brace fuselage structure.
26	Main landing gear legs at brace fuselage structure to left lower suspension upon the fwd brace of brace fuselage structure.
27	a) Measure insulation strength between terminal board (Fig. 91-1, item A 11) and brace fuselage structure. b) Choose 20 cables of fuselage harness that are not earthen or not connected to relay solenoid and measure insulation strength. Record average insulation strength.