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AUG 81 M J DAVIS, J D ROBERTS
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DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION
AERONAUTICAL RESEARCH LABORATORIES
MELBOURNE, VICTORIA

Materials Technical Memorandum 373

PROCEDURE FOR APPLICATION OF BORON-FIBRE REINFORCED PLASTIC
PATCH TO THE MIRAGE LOWER WING SKIN FUEL DECANT REGION

M.J. DAVIS and J.D. ROBERTS

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SUMMARY

Aeronautical Research Laboratories have developed a new procedure for the repair of metallic aircraft components suffering from cracking due to fatigue or stress-corrosion; the procedure is based on the use of patches made from Boron-Fibre Reinforced Plastic which are adhesively bonded over the crack region. Crack patching using this technique has been successfully used in a number of repair applications on RAAF aircraft since 1975, and has been shown to be highly cost effective and also to have many other advantages over standard repair procedures. More recently, a 'crack patching' procedure was developed by ARL to repair fatigue cracks which have developed in the lower wing skins of some RAAF Mirage aircraft. Since this was a much more critical and complex application than any previously undertaken, involving the use of specially developed ground support equipment, a detailed specification was written as a guide for RAAF personnel, who were trained to implement the repair; this specification is presented in this Memorandum.



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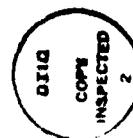
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Aeronautical Research Laboratories have developed a new procedure for the repair of metallic aircraft components suffering from cracking due to fatigue or stress-corrosion; the procedure is based on the use of patches made from Boron-Fibre Reinforced Plastic which are adhesively bonded over the crack region. Crack patching using this technique has been successfully used in a number of repair applications on RAAF aircraft since 1975, and has been shown to be highly cost effective and also to have many other advantages over standard repair procedures. More recently, a 'crack patching' procedure was developed by ARL to repair fatigue cracks which have developed in the lower wing skins of some RAAF Mirage aircraft. Since this was a much more critical and complex application than any previously undertaken, involving the use of specially developed ground support equipment, a detailed specification was written as a guide for RAAF personnel, who were trained to implement the repair; this specification is presented in this Memorandum.

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GENERAL INFORMATION RELATING TO THE USE OF THIS SPECIFICATION

A. SCOPE OF WORK

The procedure laid down here refers to the repair of the Mirage lower wing skin at the fuel decanting point, and is designated Mirage Mod. 970. All wings, except those with cracks outside the limits which may be specified by the Repair Authority, are to be repaired using this method, whether cracked or uncracked.

B. REPAIR AUTHORITY

The Repair Authority shall be:

The Chief Superintendent,
Aeronautical Research Laboratories,
P.O. Box 4331,
MELBOURNE 3001

acting through

AIRENG1,
Head Quarters Support Command,
St. Kilda Rd.,
MELBOURNE, 3004

C. MATERIALS

Only materials specified within this document or as approved by the Repair Authority may be used in the repair. Particular emphasis is placed on the necessity for use of solvents of the purity specified.

D. WORKMANSHIP

Only personnel trained and specifically authorised by the Repair Authority may be allowed to perform the repair. The essential nature of cleanliness and careful handling is essential to an effective repair.

E. QUALITY CONTROL MEASURES

At the completion of every eight (8) repairs, or at least once per month, repair teams are to submit to the Repair Authority quality control specimens, prepared as instructed during training. The Repair Authority will determine the acceptance of work on the basis of Boeing Wedge Tests performed on these specimens.

F. REPORTING SYSTEM

The results of inspection, temperature recorder charts, adhesive backing paper and a report of the repair are to be forwarded to AIRENG1A, at the above address.

INTRODUCTION

This specification covers the procedure for repair to (or preventative reinforcement of) the fuel decant point in the lower wing skin of the Mirage aircraft. The repair, developed at Aeronautical Research Laboratories, uses adhesively bonded boron-fibre reinforced plastic patches. Since the repair relies on an adhesive layer to transmit load from the crack region into the patch, it is essential that the bond is as good as possible. The procedure outlined in this specification aims to produce a suitable surface for bonding.

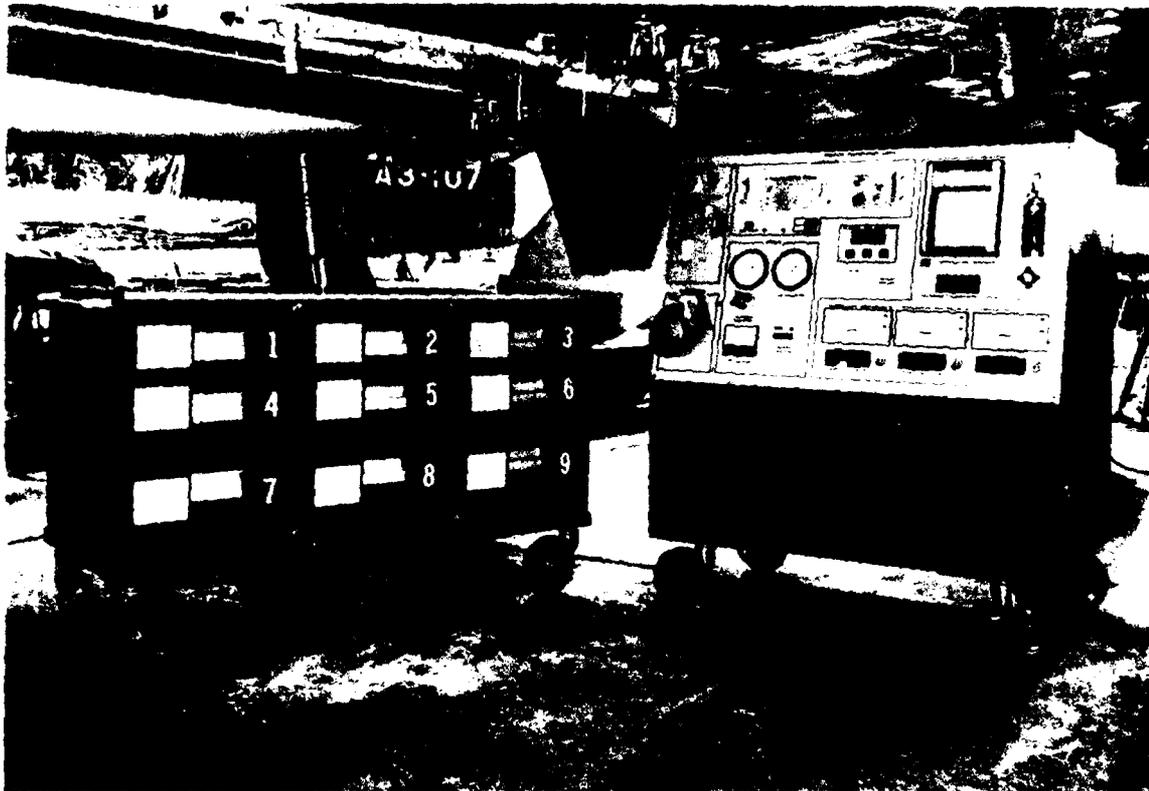


Figure 1. The ARL Crack Patching Unit, showing the instrument trolley on the right and the storage trolley on the left.

The Crack Patching Unit, Fig. 1, was developed at ARL and forms the major portion of the ground support equipment necessary for the repair. The unit consists of an instrumentation trolley and a trolley for storage of small equipment and consumables.

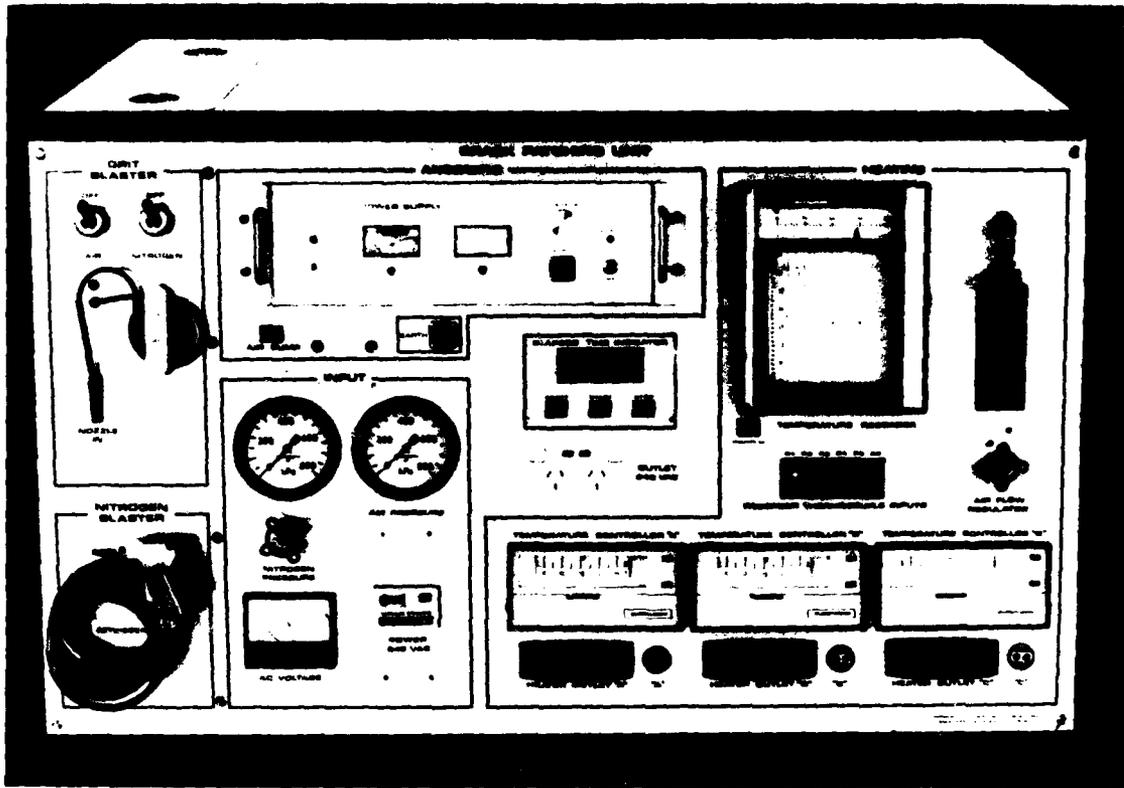


Figure 2. Front panel of the ARL Crack Patching Unit, showing equipment used in the repair.

The instrumentation trolley, Fig. 2, contains the temperature recorder, three temperature controllers, an elapsed time indicator, a DC power supply for anodising, an ARL grit blaster, and gauges, valves and switches for monitoring and controlling supply services. Air, nitrogen, and 240 V power services are connected at the rear of the unit, Fig. 3. The Crack Patching Unit has been designed such that the instrumentation in the unit is suited to general field bonding applications; thus the units not necessarily restricted to the fuel decant repair, and may, with minor modification be suited to further boron repairs.

The storage trolley holds several hundred items associated with the repair, including small equipment and a supply of essential consumables. As much equipment as possible has been stored on shadow boards within the draws to minimise losses and to avoid dangers of foreign object damage (FOD) by articles being left near the aircraft after repair.

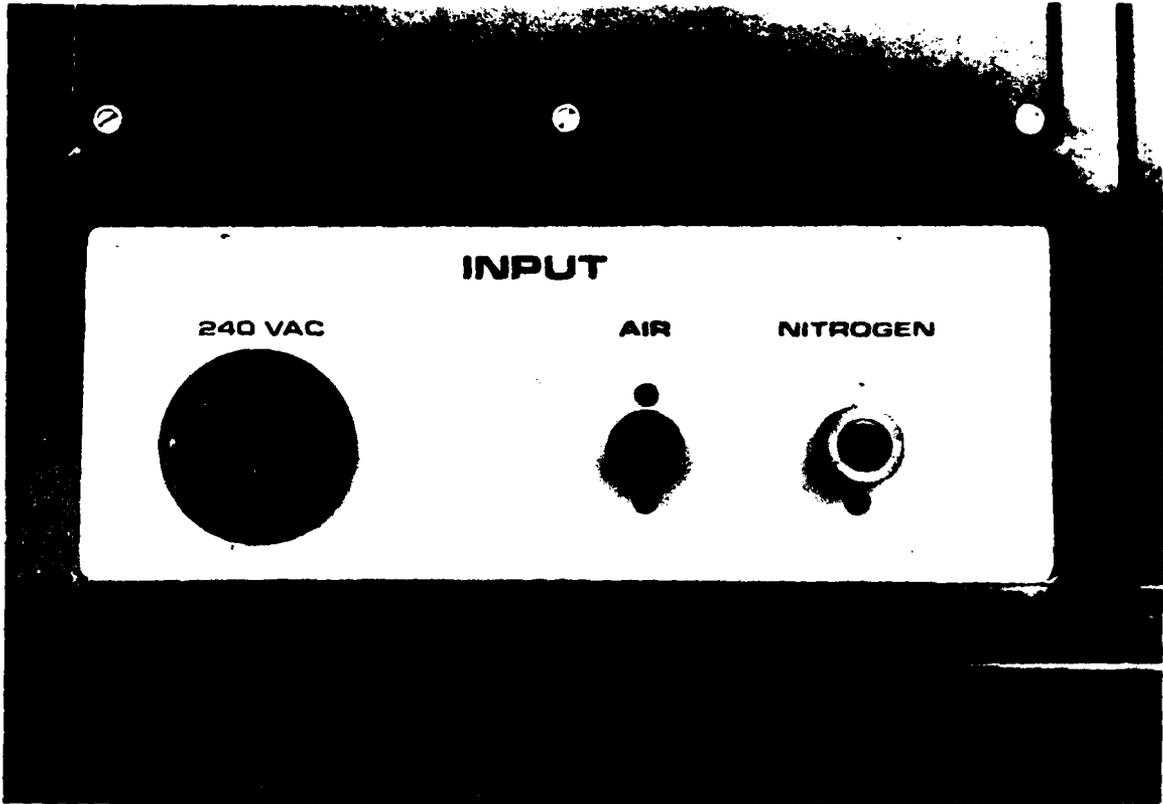


Figure 3. Rear panel of the ARL Crack Patching Unit, showing connection points for services.

The requirements for each step are listed in the specification just prior to each step. The Crack Patching Unit has facilities for the storage of most of the equipment required for the repair. Where it is known that equipment is readily available at base facilities, this may have been omitted from the supplied equipment and materials. In some cases, an initial supply of material will be provided, with future stores to be obtained through normal methods. Also some materials will be required to be stored in bulk. It will be necessary before commencing each repair to ensure that an adequate supply of consumable materials is on hand. In this specification, the location of materials and equipment is coded thus:

1,2,...,9	Storage Trolley drawers
IT	Instrument Trolley
SS	Separate Storage
NS	Not Supplied

There are eight sections in the procedure;

1. AIRCRAFT PREPARATION, in which any necessary stripping of the aircraft is performed, fuel leaks are sealed, and details of any cracks are recorded.

2. BLANKING OFF, in which the decant hole in the aircraft skin is sealed with an aluminium disk. This acts to minimise the chances of fuel attacking the adhesive during service. The effective size of the decant hole has been considerably reduced, since it has been shown that by covering most of the hole with the patch, a significantly more advantageous stress distribution is obtained.

3. PREHEAT DRYING, during which any fuel which has not been removed is evaporated. This has been found to be necessary, as any fuel which leaks over the prepared surface would lead to a failure of the bond. The fuel tanks are purged with nitrogen, which eliminates any risk of ignition of the fuel vapour.

4. MASKING OFF, when the region to be prepared is defined, and steps are taken to prevent contamination of certain regions with the acidic material used in the surface preparation.

5. GRIT BLASTING, during which the surface is thoroughly cleaned, and blasted with an abrasive powder. Laboratory tests have shown that this method of cleaning the surface provides a suitable bonding surface.

6. ANODISING the SURFACE. This step uses a phosphoric acid gel to provide optimum bonding conditions. A thin layer of oxide is produced on the surface of the metal, and this surface is known to provide a durable bond.

7. ADHESIVE CURING. This is the step in which the patch is actually bonded to the aircraft. The adhesive used requires a temperature in excess of 110 C and direct pressure. A heater system has been developed to heat the region and a jacking system provides the required pressure. Again, nitrogen is used to eliminate fire risk.

8. FINAL SEALING. Here, the cavity between the patch and the plug used to blank off the decant hole is filled with sealant, and a protective layer of aluminium is placed over the patch. This layer acts as a moisture barrier and minimises environmental degradation of the repair. A small tube is inserted into the decant hole, which also acts as a barrier to fuel, avoiding direct contact between the fuel and the adhesive layer.

Some mention of precautions in adhesive bonding is necessary. Firstly, it is essential that the steps involved in cleaning be thorough. There must be no trace of contamination left on the tissues on final cleaning. One major source of contamination of bonding surfaces is fingerprints, as these transfer sufficient oil from the skin to cause debonds.

Always wear clean disposable gloves and minimise contact with the bonding region. Take care not to brush the surface with hair. Instruments and tools should always be clean.

The adhesive used to bond the repair is an epoxy film adhesive, having the adhesive and the curing agent premixed. To stop the chemical reaction between the adhesive and the curing agent during storage, the patch system must be stored under refrigeration at a temperature below -16 C. It is important to ensure that the refrigeration system used is connected to an emergency power supply system, so that an electricity failure will not ruin the supply of patches. Adhesives are readily attacked by moisture, and therefore, the patch system is enclosed in a sealed plastic bag. Do not open this bag until just prior to the use of the patch. When the patch is removed from refrigeration, atmospheric moisture condenses on the cool surface of the bag. It is important that this moisture does not form on the adhesive, so it is essential that the patch system be allowed to reach room temperature before the bag is opened.

Care should always be exercised when handling boron-fibre reinforced plastics. The boron fibres are extremely hard and brittle, and will readily penetrate skin. Any splinters should be removed as soon as possible, using tweezers to withdraw the splinter. Do not bend or scrape splinters, as boron is brittle and the fibre will shatter, making removal difficult.

DETAILED PROCEDURE

1. AIRCRAFT PREPARATION

Materials:	Sealant PR1422 B ½	NS
	1 Bottle dry nitrogen, (200 cu. ft. minimum)	NS
	Fuel soak rags	NS
	Pencil, 2B	1
Equipment:	Decant pressure plug	3
	Pressure regulator	3
	Nitrogen hose	8
	Sealant scraper	1
	EM 3300 Eddy current inspection machine	SS
	Halec Eddy current inspection machine	NS
	Thread tap 5mm dia, 0.9 pitch	NS
	Camera	NS
	Dividers	NS
	Rule	NS
Spirit level	NS	

1.1 The aircraft should be on jacks, with the undercarriage retracted.

1.2 Adjust the jacking system such that the region to be repaired is inclined at a slight angle (1 or 2 degrees) to the horizontal, with the nose up. (Check with a spirit level). This encourages any fuel in the tank to drain away from the repair region.

1.3 Remove lower wing fairings.

1.4 Remove captive nut and housing nearest to the spar on lower wing fillet attachment bracket.

1.5 Drain fuel from aircraft.

1.6 Remove decant plug assembly.

1.7 Using clean fuel soak rag, dry as much fuel as possible from the inside of the decant hole.

1.8 Using the appropriate thread tap, clear the threads in the captive nuts which hold the decant housing. Should any of these captive nuts give any indication of likely defective operation, they should be replaced, as they are not readily removed after the repair is bonded.

WARNING: DO NOT FORCE THE TAP THROUGH THE SEAL OVER THE TOP OF THE CAPTIVE NUTS.

1.9 Using a plastic sealant scraper, remove all sealant in the region on the outer skin of the aircraft, including along the spar and root rib.

WARNING: DO NOT SCRATCH THE SURFACE WITH REMOVAL TOOLS, AS THE SCRATCHES CONSIDERABLY INCREASE THE CHANCE OF FATIGUE CRACKING, AND MAKE THE BONDING PREPARATION DIFFICULT.

1.10 Inspect the decant hole region using the EM 3300 and/or the Halec, and record the number and location of any cracks detected. Record the aircraft and wing identification and the date of repair. Using the dividers and rule, carefully measure the location of the tips of the cracks with reference to at least two points, such as the spar bolts. These measurements will be used to monitor crack movement in service.

1.11 Mark the cracks with the 2B pencil, and take a photograph of the decant hole region. Tape a rule to the aircraft to enable scaling from the photograph. Also include on a piece of tape the aircraft number and date.

1.12 Insert the decant pressure plug into the decant hole.

1.13 Connect the nitrogen supply to the fuel pressure manifold behind the ejection seat via the low pressure regulator.

WARNING: ENSURE THE SUPPLY PRESSURE DOES NOT EXCEED THE CAPABILITY OF THE REGULATOR.

1.14 Close all fuel vents and pressurise the system.

WARNING: DO NOT EXCEED 200KPA. ON THE PRESSURE GAUGE, AS DAMAGE TO THE MANIFOLD MAY RESULT.

1.15 Note all fuel leaks within 400mm of the decant point, or which cause fuel to flow into the region.

1.16 Turn off the nitrogen and release the pressure in the tank.

1.17 Remove the decant pressure plug.

1.18 Reseal all fuel leaks noted in 1.15.

2. PREPARATION AND SEALING

Materials:	Sealant PR1422 B ½	NS
	Decant hole blanking plug	3
	MEK-Methyl Ethyl Ketone (Butanone) AR grade	9
	Tissues facial	2
	Disposable gloves, polyethylene	2
	Scouring pads (Scotchbrite A)	2
	Pencil, 2B	1
	Fuel soak rags	NS
Equipment:	Decant blanking tool screw	1
	Teflon disc	3
	Alignment spring	3
	Patch template, teflon	1
	Patch template, aluminium	1
	2 Decant housing screws	3
	Eye wash kit	9
	Garbage can	NS

WARNING: DO NOT MOVE THE AIRCRAFT, OR ALTER THE JACKING CONFIGURATION AFTER THIS STEP HAS BEEN COMMENCED, AS FUEL WILL FLOW BACK OVER THE INSIDE OF THE REGION TO BE REPAIRED. EXPERIENCE HAS SHOWN THAT FUEL INSIDE THE TANK WILL SEEP OUT THROUGH THE CRACK AND CONTAMINATE THE SURFACE. AFTER THE DECANT PLUG HAS BEEN SEALED IN PLACE THERE IS NO EFFECTIVE WAY OF DRYING THE REGION.

2.1 Using clean fuel soak rag, dry any fuel which may have seeped into the region inside the tank.

2.2 Using tissues and MEK, wipe the inside of the fuel tank thoroughly, to about 75mm along the crack line and around the decant hole. Do not touch the tissue to the bottle lip as this will contaminate the remaining solvent.

WARNING: MEK SHOULD NOT CONTACT SKIN OR EYES. WEAR DISPOSABLE GLOVES WHEN HANDLING. FOR SKIN CONTACT WASH WITH WATER. FOR EYE CONTACT WASH WITH COPIOUS AMOUNTS OF WATER AND SEEK MEDICAL TREATMENT. AVOID BREATHING THE VAPOURS, PREFERABLY BY WEARING A PROTECTIVE MASK.

WARNING: THE PROCESS OF CLEANING USES FLAMMABLE MATERIALS. THESE SHOULD BE PLACED IN THE GARBAGE CAN AND DISPOSED OF AS SOON AS POSSIBLE, TO MINIMISE FIRE RISK.

2.3 Clean the exterior surface of the region with tissues and MEK. Ensure all sealant is removed. The surface may be rubbed with a scouring pad.

2.4 Locate the teflon patch template over the decant hole, and hold in place with 2 decant housing screws.

2.5 With the 2B pencil, carefully mark the position of the ends of the new decant hole on the aircraft skin through the patch template.

2.6 Remove the template.

2.7 Assemble the teflon disk and the decant hole blanking plug on the blanking tool screw.

2.8 Insert the blanking plug into the decant hole, and check if the plug fits, the rectangular hole in the decant blanking plug is correctly aligned with the pencil marks, and the teflon disk is flush with the outer skin surface. If necessary, remove sealant on the inside of the tank and bend the retaining bar of the plug to achieve the gap between the outer skin and the surface of the plug.

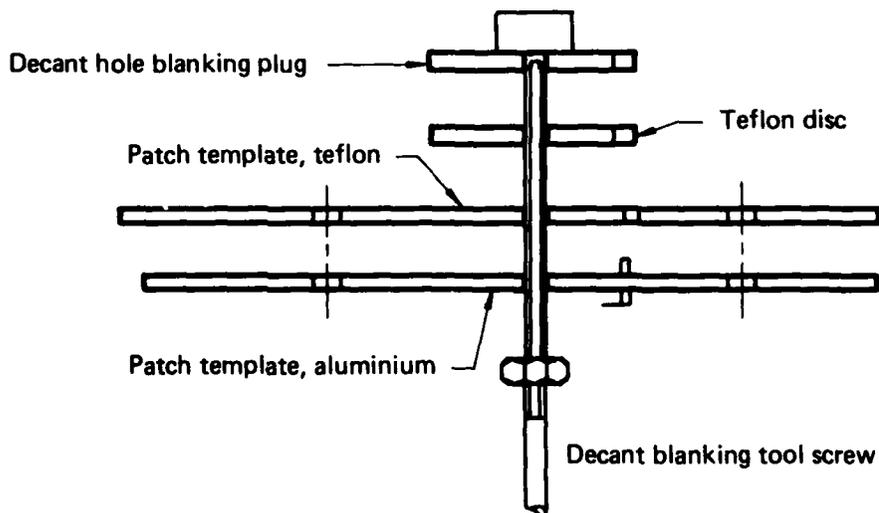


Figure 4. Assembly detail of decant blanking jig.

2.9 Remove the plug.

2.10 Assemble the aluminium and teflon patch templates, the teflon disk and the decant blanking plug on the screw of the decant blanking tool.

2.11 Apply sealant PR1422 B ½ along the inside of the tank over the crack region and over the captive nuts.

2.12 Apply sealant to the decant hole blanking plug liberally and insert into hole.

2.13 Locate the patch templates against the aircraft and hold in place with 2 decant housing screws.

2.14 Tighten the nut on the screw of the decant blanking tool until the plug is in place.

2.15 Compress the alignment spring, and insert the tips into the slot in the template. Allow the spring to expand, aligning the blanking plug.

3. PREHEAT DRYING

Materials:	Pencil, 4H	1
	MEK	9
	Tissues facial	2
	Scouring pad (Scotchbrite A)	2
	Mylar tape 12mm	2
	1 Bottle dry nitrogen, (200 cu. ft. minimum)	NS
Equipment:	Main heating block (Port or Stbd. to suit)	7
	Teflon pad	7
	Gas regulator	3
	Nitrogen purging hose	8
	5 Thermocouples or blanking plugs	3
	2 Thermocouples	8
	2 Compensating leads	3
	Sealant Scraper	1
	1 Heater extension lead	8
	Jack loading system	IT
	Earthing lead	3
	Earthing bracket	3
	Earthing screw	3
	Compensating lead support bracket	3
	Heater location rods	1
	Scissors	1
Fire extinguishers	NS	
Asbestos gloves	1	

Crack Patching Unit:

Controller A
Recorder, channel R1.

WARNING: ENSURE THAT SEALANT IS FULLY CURED BEFORE PROCEEDING TO THIS STEP, PREFERABLY LEAVING TO SET OVERNIGHT.

3.1 Using a 4H pencil mark around the teflon patch template.

3.2 Remove the decant blanking assembly and the patch templates.

3.3 Remove any excess sealant from patch region, using a plastic scraper, tissues and MEK.

3.4 Connect the nitrogen to the pressure manifold behind the ejection seat, and allow nitrogen to flow through the system for at least ten minutes, with the fuel vents open.

WARNING: ENSURE THE SUPPLY PRESSURE DOES NOT EXCEED THE CAPABILITY OF THE REGULATOR.

WARNING: DO NOT EXCEED 200KPA. ON THE PRESSURE GAUGE, AS DAMAGE TO THE MANIFOLD MAY RESULT.

3.5 Turn off the nitrogen.

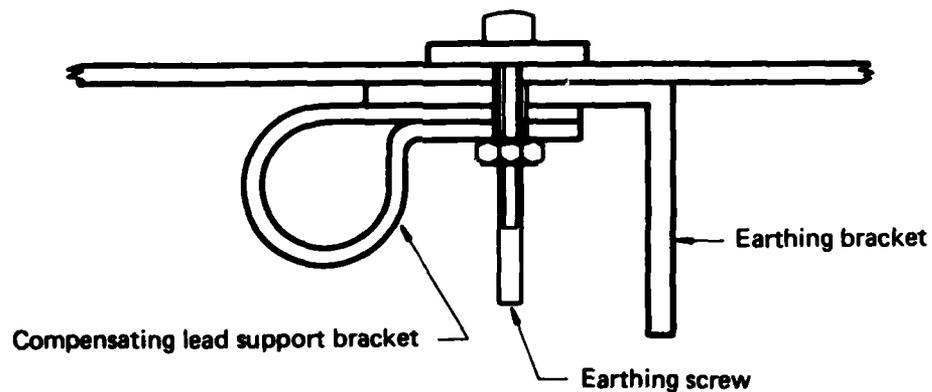


Figure 5. Earthing bracket and compensating lead support bracket assembly detail.

3.6 Connect the earthing bracket and the compensating lead support bracket to the aircraft, using the earthing screw, as shown in Fig. 5. Use an adjacent fairing attachment bolt, after abraiding the surface with a scouring pad.

WARNING: DO NOT FORCE THE SCREW THROUGH THE SEALING CAP ON TOP OF THE CAPTIVE NUT.

WARNING: THE EARTH CONNECTION MUST BE GOOD, AS THE ANODISING AND HEATING PROCESSES DEPEND ON IT. DO NOT USE THE AIRCRAFT EARTHING JACKS, AS THESE MAY NOT BE ADEQUATE.

3.7 Connect the earthing lead to the repair unit and the earthing bracket.

3.8 Assemble the jack loading system. Adjust the height such that the top of the system is about 50mm from the aircraft skin.

3.9 Using mylar tape, locate the 2 thermocouples on the aircraft skin, as shown in Fig. 6.

WARNING: DO NOT PLACE THE MYLAR TAPE INSIDE THE PENCIL OUTLINE, AS THE TAPE TRANSFERS CONTAMINANTS TO THE SURFACE, PRODUCING BONDING PROBLEMS.

3.10 Insert the heater location rods into the appropriate decant housing bolt holes.

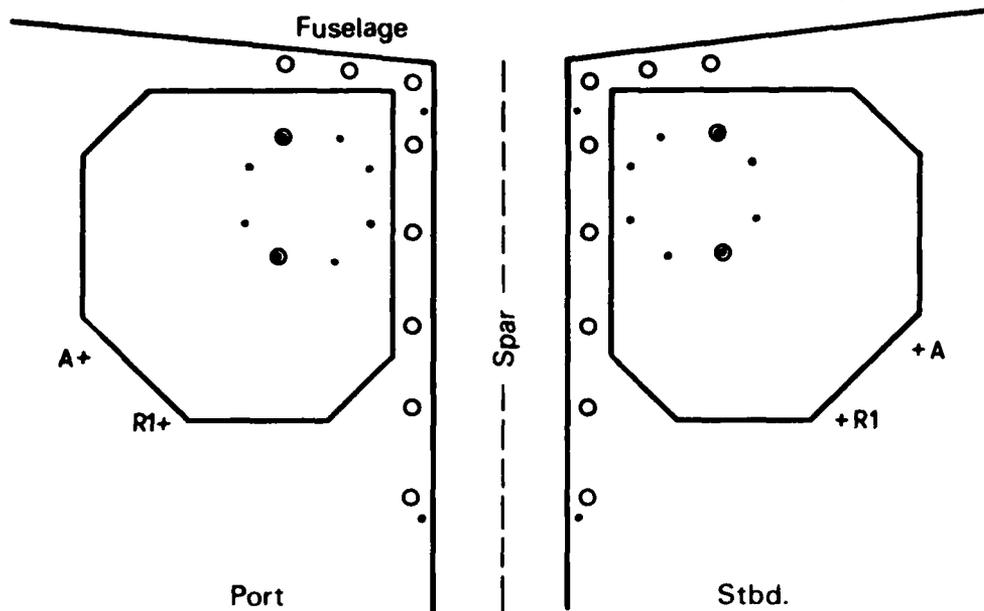
3.11 Using the heater location rods, locate the heater against the aircraft, and hold in place with the jack loading system. Apply a load until the gauge reads 320 psi. (Note that the jack has two valves. To pressurise, release the valve on the outlet pipe, close the valve on the jack body and pump the handle. When the desired pressure is indicated, close the valve. Pressure may be bled off slowly by opening the valve on the pump body and gently opening the outlet pipe valve until the desired pressure is obtained.)

3.12 Remove the heater locating rods.

3.13 Connect thermocouple 'A', Fig. 6, to the thermocouple jack for controller 'A', using a compensating lead.

3.14 Connect the other thermocouple 'R1', Fig. 6, to the temperature recorder, channel 'R1', using a compensating lead.

3.15 Blank off recorder channels 'R2' to 'R6', using the thermocouple blanking plugs or the spare thermocouples.



Heater location rod holes●
Control thermocoupleA+
Recorder thermocoupleR1+

Figure 6. Locations for thermocouples for preheat drying. Also shown are the heater location rod holes.

3.16 Set the controller 'A' to the following settings, (see Fig. 7):

Temperature120 C
Power Limit60%
Proportional Band.....5%

3.17 Connect the main heater block to the controlled outlet 'A' using the heater extension lead.

3.18 Turn on the recorder and controller 'A'.

WARNING: DO NOT MAKE OR BREAK THE CONNECTION TO THE HEATER AT THE JUNCTION NEAR THE AIRCRAFT WHILE THE POWER IS ON, AS SPARKING MAY OCCUR.

3.19 Turn on the controlled outlet from controller 'A'.

3.20 Allow the heater system to run for 1 hour at temperature. This will dry off any fuel in the repair region.

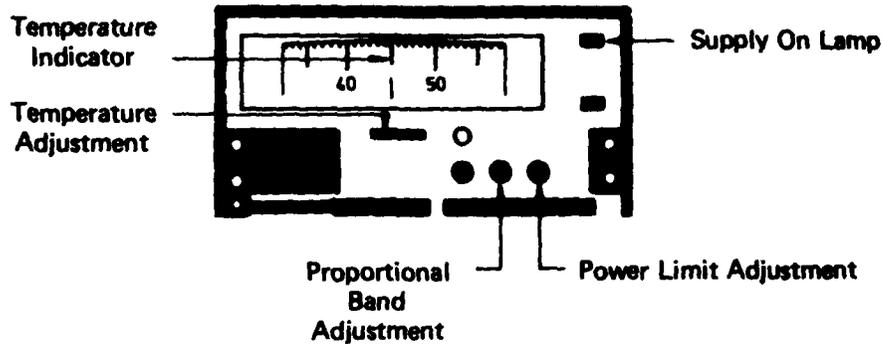


Figure 7. Temperature controller detail.

3.21 Turn off the controlled outlet switch from controller 'A', the controller, and the recorder.

3.22 Using asbestos gloves, remove the heater system.

3.23 Remove the thermocouples from the aircraft skin.

4. MASKING OFF

Materials:	1 Bottle dry nitrogen, (200 cu. ft. minimum)	NS
	Masking tape 50mm	2
	Tissues facial	2
	Disposable gloves, polyethylene	2
	Scouring pads (Scotchbrite A)	2
	MEK	9
Equipment:	Gas regulator	3
	Nitrogen purge line	8
	Spar and root rib heaters	7

4.1 Using masking tape, mask the region 200mm x 200mm out from the corner of the spar and root rib bolt lines. This will be the region for surface preparation, (see Fig. 8).

4.2 Mask off where the spar enters the fuselage, (see Fig. 8), such that any spillage during the washing process will not run down the spar into the fuselage.

4.3 Mask off the fairing attachment bolt holes for 400mm from the spar, (see Fig. 8), to prevent contamination during washing.

4.4 Offer the spar and root rib heater systems up to the aircraft. Check that the heaters along the spar and root rib come in contact with the aircraft skin, and that there is no sealant under them.

4.5 Clean the region within the masking tape, using a scouring pad and MEK to remove paint. Finish off with MEK and tissues. If the pencil line is removed, locate the patch template and mark the outline, using a 4H pencil.



Figure 8. Masking detail.

WARNING: DO NOT START THE NEXT STEP UNLESS THERE IS SUFFICIENT TIME TO COMPLETE THE PROCEDURE FAST STEP 7 (ABOUT 4 HOURS). IT IS IMPORTANT THAT ONCE COMMENCED, THE CLEANING, GRIT BLASTING AND ANODISING PROCESSES SHOULD NOT BE DELAYED OR INTERRUPTED. THE PROCESS SHOULD BE CONTINUOUS, WITH EACH STEP, FOLLOWING AS SOON AS POSSIBLE.

4.6 If more than 6 hours has elapsed since the aircraft was purged with nitrogen, allow nitrogen to flow through the system for at least ten minutes, with the fuel vents open.

WARNING: ENSURE THE SUPPLY PRESSURE DOES NOT EXCEED THE CAPABILITY OF THE REGULATOR.

WARNING: DO NOT EXCEED 200KPA. ON THE PRESSURE GAUGE, AS DAMAGE TO THE MANIFOLD MAY RESULT.

5. GRIT BLASTING

BEFORE commencing this step remove one patch assembly from cold storage. The patch should be at room temperature before opening the protective packet, so as to avoid condensation of moisture on the adhesive. This would usually take about 1 hour. Check that the patch is the correct type for the wing to be repaired - Port or Starboard. DO NOT OPEN THE PLASTIC BAG AROUND THE PATCH UNTIL JUST PRIOR TO APPLICATION, DURING STEP 7.

WARNING: DO NOT BEND THE PATCH, AS IT IS READILY SPLIT BETWEEN THE FIBRES.

Materials:	1 Bottle dry nitrogen (200 cu. ft. minimum)	NS
	MEK	9
	Tissues facial	2
	8 Rubber plugs, tapered 4-8mm dia.	3
	Disposable gloves, polyethylene	2
	Disposable gloves, cotton	2
	Alumina grit (50 micron)	IT
Equipment:	Gas regulator	3
	Scalpel	1
	4 Limpet clamps (or clamping bracket)	5
	2 Elastic retaining straps	5
	Grit blasting box, glove and retaining ring	8
	Grit box vacuum fitting	5
	Vacuum cleaner	NS
	Garbage can	NS

Crack Patching Unit:

Grit blaster
Nitrogen blaster

WARNING: THE ALUMINA GRIT IS HIGHLY ABRASIVE AND MAY CAUSE DAMAGE TO ANY MOVING PARTS. CONTACT WITH SUCH PARTS SHOULD BE AVOIDED WHEREVER POSSIBLE. CONTAMINATED REGIONS SHOULD BE CLEANED AFTER COMPLETION OF THE REPAIR, BUT BEFORE USE OF THE COMPONENT.

5.1 Wearing clean disposable gloves, thoroughly wipe the region with tissues and MEK. Repeatedly wipe the area, finishing with a new tissue each pass. Continue to wipe until a clean tissue remains clean after use. It is essential that this surface be thoroughly clean.

WARNING: THIS SURFACE MUST NOT NOW BE TOUCHED, ESPECIALLY WITH ANY BARE HAND, OR BE ALLOWED TO COME IN CONTACT WITH ANY GREASES OR GREASY VAPOURS. THERE SHOULD BE NO SPRAYING OPERATION OR RUNNING INTERNAL COMBUSTION ENGINES WITHIN 10 METRES.

5.2 Wearing clean disposable gloves, insert the rubber plugs in the decant cap retaining bolt holes. Ensure the plugs are not protruding more than 3 mm from the surface, or they will foul the anodising system. (The plugs are readily trimmed with a scalpel, but do not cut them in place, as the surface will be contaminated.)

5.3 Connect the nitrogen bottle to the input jack on the back of the repair unit, using the regulator and nitrogen supply line.

WARNING: ENSURE THE SUPPLY PRESSURE DOES NOT EXCEED THE CAPABILITY OF THE REGULATOR.

5.4 Connect the air supply to the air input jack on the back of the repair unit.

5.5 Connect the vacuum fitting on the side of the grit box.

5.6 Install grit blasting box, using the limpet clamps and elastic straps to hold it in place, as shown in Fig. 9.

5.7 Connect the vacuum cleaner and turn it on.

5.8 Set the air flow rate to 4-5 c.f.m.

5.9 Set the nitrogen pressure to 500 KPa and turn on the nitrogen control valve.

5.10 Carefully blast the entire surface inside the pencil outline of the patch, ensuring no gaps are left. Aim to obtain a uniform mat surface. Pay particular care to corrosion pits. These must be thoroughly blasted to remove all corrosion products. This step is critical and the finish must be good.

WARNING: WHILST IT IS IMPORTANT TO BLAST THE SURFACE CAREFULLY, EXCESSIVE BLASTING REDUCES THE SKIN THICKNESS. AVOID MOVING THE BLASTING NOZZLE TOO SLOWLY OR HOLDING THE NOZZLE TOO CLOSE. (ABOUT 30 MM APPEARS TO BE IDEAL.)

5.11 Using the nitrogen blaster, blow the surface with nitrogen to remove excess grit.

5.12 Observe the surface from two directions at right angles. If any regions are observed which are not completely blasted, or any corrosion pits are found, these must be blasted.



Figure 9. Grit blasting box assembled on aircraft skin.

5.13 Remove the grit blast box, but leave the limpet clamps in place, as these will be used during the anodising process.

WARNING: THE ANODISING STEP SHOULD BE COMMENCED AS SOON AS POSSIBLE, TO AVOID CONTAMINATION AND OXIDATION OF THE FRESH SURFACE. DO NOT EXCEED 30 MINUTES BETWEEN COMPLETING GRIT BLASTING AND COMMENCING ANODISING.

6. ANODISING SURFACE

Materials:	Phosphoric acid gel	9
	3 Pieces Rymple cloth (size of anodising screen)	9
	Surgical gloves	9
	Sodium bicarbonate solution 5 Litres	9
	Eye-wash bottle	9
	Scouring pad (Scotchbrite A)	2
Equipment:	Anodising screen	4
	Backing plate	4
	Bolt protection system (Port or Stbd.)	4
	Support bracket (Port or Stbd.)	4
	Rubber air hose	5
	Hot air gun	4
	Protective clothing	NS
Face shield	8	

Fluorescent lamp, white daylight	NS
Polarising plate	4
Hose, connected to a reliable water supply	IT
Wash box (Port or Stbd.)	8
Wash box fitting	5
Large bucket	NS
Tweezers	1
2 Elastic retaining straps	4
4 Limpet clamps (or clamping bracket)	4
Anodising lead	4
Spatula	1
Scissors	1
1 Decant cap retaining bolt	3

Crack Patching Unit:

DC Power supply
Air pump
Time clock

WARNING: THE ANODISING GEL IS ACIDIC AND CONTACT WITH SKIN AND EYES MAY CAUSE INJURY. FOR SKIN CONTACT, WASH WITH A SOLUTION OF SODIUM BICARBONATE, (50g per 5 litres of water), FOLLOWED BY WASHING WITH COPIOUS AMOUNTS OF WATER. THE SOLUTION SHOULD BE PREPARED BEFORE STARTING THIS STEP, AND LABELLED CLEARLY 'ACID NEUTRALISER'. IT SHOULD BE KEPT IN A HANDY LOCATION, TOGETHER WITH THE EYE WASH BOTTLE. FOR EYE CONTACT FLUSH WITH COPIOUS AMOUNTS OF WATER AND SEEK MEDICAL TREATMENT.

6.1 Turn on the DC power supply in the patching unit to allow it to warm up (minimum time 5 minutes).

6.2 Locate the spar and root rib bolt protection system over the spar and root rib bolts. Hold the system in place with the support bracket, and the decant cap bolt, as shown, Fig. 10.

6.3 Using the rubber air hose, connect the air pump in the repair unit to the bolt protection system and turn it on.

6.4 Wearing clean surgical gloves, cut 3 pieces of Rymples cloth the size of the anodising screen.

WARNING: CUT THE RYMPLE CLOTH ON A CLEAN SURFACE, AND WITH CLEAN SCISSORS, AS CONTAMINATION OF THE RYMPLE CLOTH WILL RESULT IN A FAILURE TO ANODISE.

6.5 Wearing surgical gloves and protective clothing, place three layers of the gauze cloth over the anodising screen, spreading gel between each layer and over the last layer. Use a spatula to apply the gel. Apply the anodising gel liberally, ensuring it completely

soaks through the gauze. Ensure there is a surplus of gel over the area normally covered by the decant housing. This will allow for the height of the rubber plugs above the aircraft skin. The electrical connection tab should be outboard.



Figure 10. Spar and root rib bolt protection assembly detail.

6.6 Turn the voltage control of the power supply down to zero.

6.7 Using the anodizing lead, connect the DC power supply to the anodizing screen, see Fig. 11.

6.8 Place the screen on the backing plate, holding the system level.

6.9 Place the screen and gauge over the bond region, with the electrical connection tab outboard, ensuring the edge of the screen is against the bolt protection system along the spar direction as shown in Fig. 11.

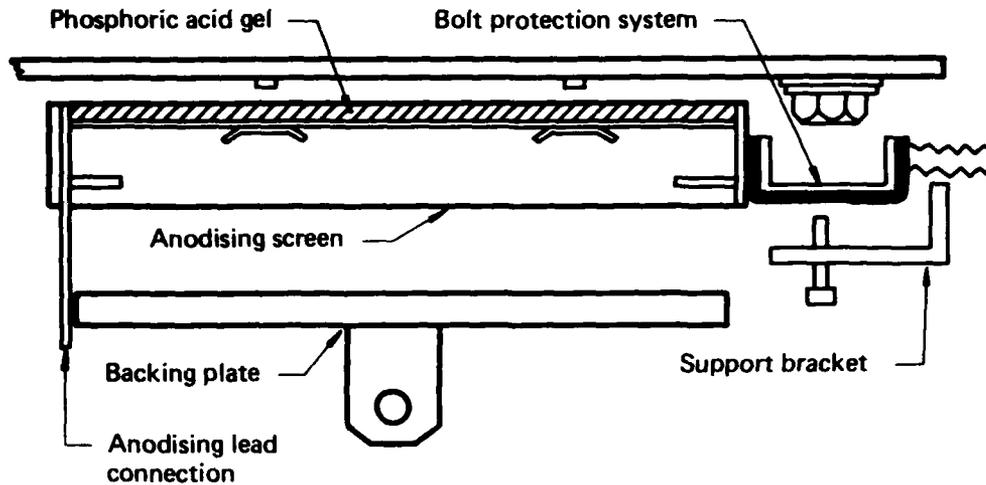


Figure 11. Anodising system assembly detail.

WARNING: THE PHOSPHORIC ACID WILL NOW BE ETCHING THE SURFACE, SO IT IS IMPORTANT TO HAVE THE ELECTRICAL CURRENT ON AS SOON AS POSSIBLE.

6.10 Hold the system in place with the two elastic straps, connecting them to the limpet clamps.

6.11 Simultaneously adjust the voltage on the power supply to give a potential of 1 volt, and start the time clock.

WARNING: SHOULD THE SYSTEM INDICATE A HIGH AND CONTINUOUS CURRENT, THERE WILL BE A SHORT CIRCUIT. IT WILL BE NECESSARY TO PROCEED IMMEDIATELY TO THE WASH STEP, STEP 6.14. WHEN THE WASHING AND DRYING IS COMPLETED, CHECK THE EQUIPMENT TO DETERMINE THE CAUSE OF THE SHORT CIRCUIT. THE PROCESS MAY BE RECOMMENCED AT STEP 6.1.

6.12 After 1 minute, carefully increase the voltage by 1 volt, and continue to increase the voltage gradually by 1 volt each minute until a voltage of 6 volts is obtained.

6.13 Hold the system at 6 volts for 10 minutes, then turn off the power.

WARNING: THE PHOSPHORIC ACID GEL WILL NOW BEGIN TO ETCH THE ANODISED SURFACE, SO IT IS IMPORTANT TO HAVE THE WASHING (STEP 6.18) COMPLETED WITHIN ONE MINUTE.

6.14 Disconnect the power supply lead from the anodising screen.

6.15 Remove the anodising screen, and place it in the large bucket.

WARNING: DO NOT WIPE THE SURFACE, AS ABRASION DAMAGES THE ANODISED LAYER.

6.16 Locate the wash box over the region.

6.17 Place the large bucket below the outlet of the wash box.

6.18 Rinse the anodised surface with copious amounts of water (not above 40 C).

WARNING: ENSURE ALL ACID GEL IS REMOVED.

6.19 Remove the wash box.

6.20 Dry the surface with a hot air gun for 5 to 10 minutes, using setting 3. Note how the surface dries. If the surface water does not dry as a uniform film, and breaks up into small streams, the anodising process was not successful, and it will be necessary to return to 6.1, after locally grit blasting any such region. Drive any water toward the spar and root rib edges of the anodised area.

WARNING: AVOID CONCENTRATED HEATING OF SPOTS, AS THIS WILL DESTROY THE ANODISED LAYER.

6.21 Reset the time clock. This will determine the time between having a dry surface and having the adhesive in contact with the surface.

WARNING: THE BORON PATCH SHOULD BE IN CONTACT WITH THIS SURFACE AS SOON AS POSSIBLE, BUT DEFINITELY WITHIN 30 MINUTES OF OBTAINING A SATISFACTORY DRY SURFACE. IF THE PATCH IS NOT ON THE SURFACE WITHIN 30 MINUTES, GO BACK TO STEP 6.1 AND START AGAIN.

6.22 Turn off the air pump and remove the bolt protection shield.

6.23 Using tweezers, carefully withdraw the rubber plugs from the decant bolt holes.

WARNING: DO NOT TOUCH THE ANODISED SURFACE.

6.24 Position the fluorescent light such that light from it makes an angle no greater than 5 degrees to the anodised surface.

6.25 Place the polarising plate between the observer and the reflected light from the surface.

6.26 Observe the colour of the surface surrounding the grit blasted region, using one side of the polarising screen, from two directions at right angles. The colours will mostly be purple yellow and green, but may differ for each wing.

6.27 Alternately view the surfaces with each segment of the polarising plate. The presence of the anodic coating is verified by an observed change of the colours to the complementary colour, (e.g. purple to a yellow green). Where regions are observed which do not change colour, return to step 6.1 and repeat the process.

6.28 Using the same process, observe the grit blasted surface, and note any abrupt changes in colour from the background colour. Where these are due to such causes as fingerprints or abrasion after anodising, the process must be repeated from step 6.1, after local grit blasting.

WARNING: THE LONG TERM DURABILITY OF THE REPAIR IS STRONGLY INFLUENCED BY THE QUALITY OF THE ANODISED SURFACE. ENSURE THAT IT IS SATISFACTORY BEFORE CONTINUING.

7. CURING ADHESIVE

Materials:	Mylar tape 12mm	2
	Disposable gloves, polyethylene	2
	Disposable gloves, cotton	2
	Pencils, 2H,4H (Staedler)	1
Equipment:	Jack loading system	IT
	9 Thermocouples (5 flat type, 4 wire)	7
	2 Heater location rods	1
	2 Teflon plugs, 20mmx5mm dia. 0.9 pitch	3
	Main heating block (Port or Stbd.)	7
	Spar heater (Port or Stbd.)	7
	Root rib heater (Port or Stbd.)	7
	0.5 mm Patch template	1
	Silicone rubber pressure pad (Port or Stbd.)	7
	Three point loading jig	7
	Heater cooling ducts	1
	Tweezers	1
	Asbestos gloves	1
	Fire extinguishers	NS

Crack Patching Unit:

Controllers 'A', 'B' and 'C'
Temperature recorder, all channels

WARNING: ENSURE THE SURFACE IS COMPLETELY DRY BEFORE COMMENCING THIS STEP.

7.1 Carefully screw the two heater location rods for the heater alignment into the appropriate decant cap retaining nuts.

7.2 Check the time indicated on the elapsed time clock. Should the time exceed 30 minutes, it will be necessary to return to the anodising step, Step 6.

7.3 Wearing clean disposable cotton gloves, remove the patch from the sealed packet. Ensure that the patch has been out of storage for long enough to reach room temperature (about 1 hour).

WARNING: DO NOT BEND THE PATCH, AS IT IS READILY SPLIT BETWEEN THE FIBRES.

WARNING: THE BORON FIBRES IN THE PATCH ARE EXTREMELY HARD AND SHARP, AND READILY PENETRATE SKIN. ANY SPLINTERS SHOULD BE REMOVED AS SOON AS POSSIBLE, TAKING CARE NOT TO BEND THE FIBRE. SEEK MEDICAL ATTENTION FOR ANY SPLINTERS WHICH ARE NOT READILY REMOVED.

7.4 With tweezers, carefully remove the backing paper from the adhesive, see Fig. 12. Keep this paper as proof that it has been removed.



Figure 12. Removal process of backing paper from adhesive and patch.

WARNING: DO NOT TOUCH THE ADHESIVE AS THE DISPOSABLE GLOVES WILL STICK TO IT. SHOULD THE ADHESIVE COME IN CONTACT WITH ANY FOREIGN SUBSTANCE, IT WILL BE NECESSARY TO DISCARD THE PATCH AND RESUME THE PROCESS FROM STEP 6.1, SINCE THE TIME FOR THE PATCH TO REACH ROOM TEMPERATURE WILL EXCEED THE TOLERABLE TIME FOR THE LIFE OF THE ANODISED SURFACE.

7.5 Assemble the silicone rubber pressure pad and the patch on the heater block, and locate the patch against the wing, Fig. 13 using the long rods as guides.

WARNING: CARE IS NEEDED THAT THE PATCH DOES NOT CONTACT THE SURFACE IN AN INCORRECT ALIGNMENT, AS ADHESION TO THE BOND SURFACE IS INSTANTANEOUS. SHOULD MISSALIGNMENT AND ADHESION OCCUR, IT WILL BE NECESSARY TO GENTLY REMOVE THE PATCH, DISCARD IT, AND RESUME AT STEP 4.

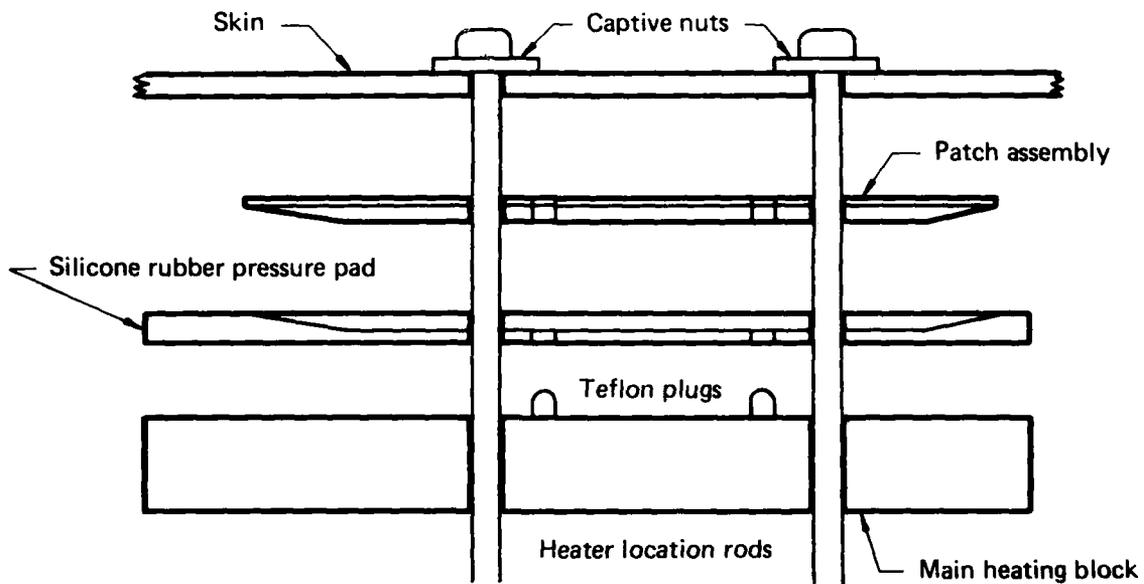
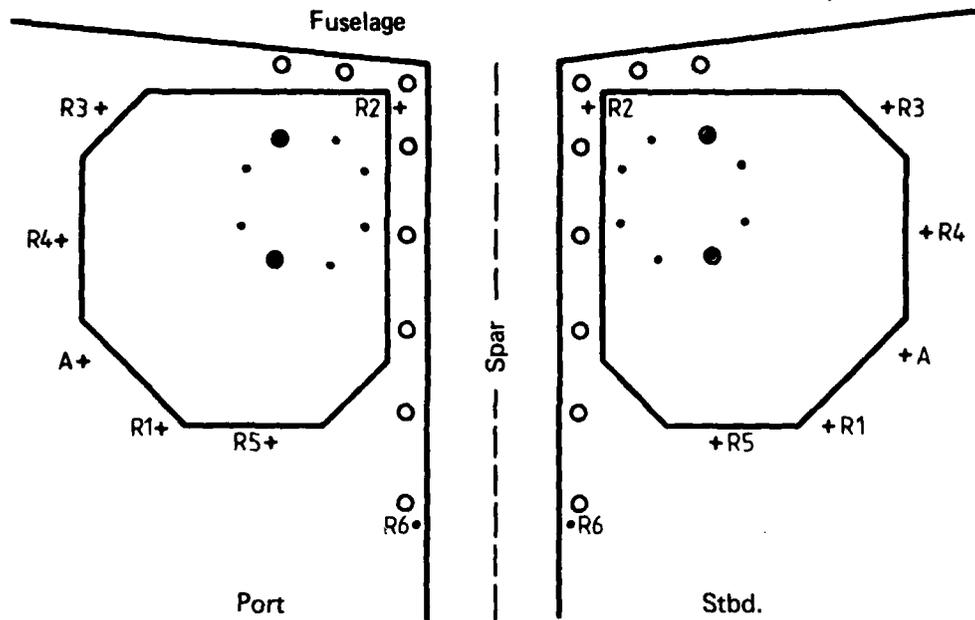


Figure 13. Assembly detail for patch application.

7.6 Withdraw the heater and rubber pad.

7.7 Using mylar tape, place the six thermocouples near the edge of the patch on the skin, as shown in Fig. 14.

7.8 Connect the thermocouples as shown in Fig. 14, using the compensating leads. The leads must be supported by the bracket on the earthing connection.



Heater location rod holes ●
Control thermocouples A+
Recorder thermocouples R1+

Figure 14. Location detail for thermocouples during bonding process.

7.10 Assemble the rubber pad and the heater and locate over the patch.

7.11 Locate the jacking system such that the pressure is applied on the region marked on the heater block, and perpendicular to the heater block. Apply load until the gauge on the jack indicates 320 psi. (Note that the jack has two valves. To pressurise, release the valve on the outlet pipe, close the valve on the jack body and pump the handle. When the desired pressure is indicated, close the valve. Pressure may be bled off slowly by opening the valve on the pump body and gently opening the outlet pipe valve until the desired pressure is obtained.)

7.12 Remove the heater location rods and replace them with the 2 teflon plugs.

7.13 Locate the spar and root rib heaters against the aircraft and hold them in place by tightening the screws on the heater backing plate finger tight only.

7.14 Plug the heater block into the controller 'A', by plugging the heater extension lead into the controlled outlet marked 'A'.

WARNING: DO NOT MAKE OR BREAK THE CONNECTION TO THE HEATERS AT THE JUNCTION NEAR THE AIRCRAFT WHILE THE POWER IS ON, AS SPARKING MAY OCCUR.

7.15 Using a heater extension lead, connect the spar heater to the controlled outlet from temperature controller 'B'.

7.16 Using a heater extension lead, connect the root rib heater to the controlled outlet from temperature controller 'C'.

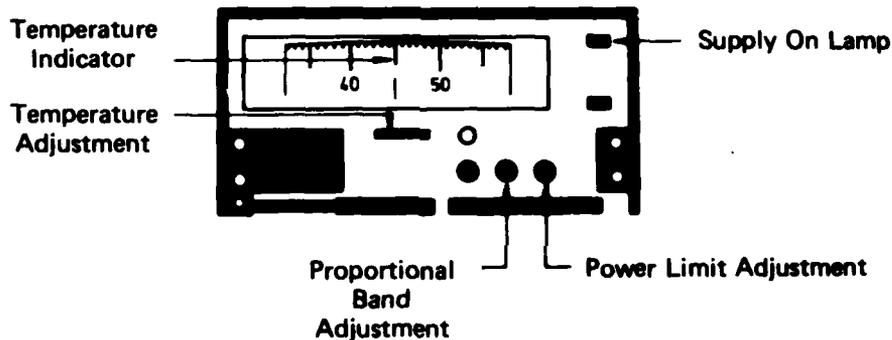


Figure 15. Temperature controller control details.

7.17 Set the controller 'A', to the following settings (see Fig. 15):

Temperature	100 C
Power Limit	100%
Proportional Band	5%

7.18 Set the controller 'B', to the following settings:

Temperature	100 C
Power Limit	100%
Proportional Band	0%

7.19 Set the controller 'C', to the following settings:

Temperature	100 C
Power Limit	60%
Proportional Band	0%.

7.20 Turn on controllers 'A', 'B', and 'C', and the temperature recorder.

7.21 Turn on the power to the main heater block by turning on controlled outlet switch 'A'.

7.22 Turn on the power to the spar heater, controlled outlet switch 'B'.

7.23 Turn on the power to the root rib heater, controlled outlet switch 'C'.

WARNING: JACK PRESSURE MAY INCREASE AS TEMPERATURE INCREASES. MONITOR THE PRESSURE CAREFULLY, ENSURING THE PRESSURE STAYS BETWEEN THE LIMITS OF 300 TO 350 PSI.

7.24 Allow the system to heat up until all controllers indicate the set temperatures, then make the following adjustments:

Controller A	Temperature 122 C
Controller C	Temperature 120 C

WARNING: THE PRESSURE MAY FALL AT ABOUT 100 C AS THE ADHESIVE FLOWS, AND IT WILL BE NECESSARY TO ADJUST THE LOAD.

7.25 Allow the system to heat up, constantly checking that the jack pressure remains between 300 and 350 psi. Note the time when the minimum reading on the temperature sensors is 100 C. Allow 4 hours after this time for the adhesive to cure. Provided the minimum temperature of the system reaches 110 C, the curing time may be reduced to 2 hours at that temperature.

WARNING: SHOULD THE SYSTEM INDICATE TEMPERATURES MORE THAN 10 DEGREES ABOVE THE TEMPERATURE SETTINGS OF THE CONTROLLERS, IT WILL BE NECESSARY TO REPLACE THE CONTROL THERMOCOUPLE WITH AN ADJACENT THERMOCOUPLE.

7.27 After the curing time has elapsed, turn off the power to the heaters. Allow the system to cool to 80 C before removing the jack pressure and the heater system. Asbestos gloves may be required. The jack pressure may be allowed to gradually fall off as the system cools.

7.28 Using the 2H and 4H pencils, inspect the adhesive flash around the patch. The 2H pencil should leave a pencil mark on the adhesive while the 4H pencil indents the surface. Any region where the 2H pencil does not leave a mark, but indents the surface is uncured, and the heating process should be resumed for a further hour as soon as possible. DO NOT LEAVE THIS STEP OVERNIGHT.

8. FINAL SEALING

Materials:	Sealant PR1422 A ½	NS
	MEK	9
	Tissues facial	2
	Disposable gloves, polyethylene	2
	Decant tube	3
	Aluminium foil protective layer	SS
	Paint brush 30mm	6
	Warning decal	SS
	Pipe cleaner	6
	Syringe	6
Equipment:	Heater location rods	1
	Main heater block (Port or Stbd.)	7
	Silicone rubber pad (Port or Stbd.)	7
	Jack loading system	IT
	Ultraviolet lamp	5
	Thread tap 5mm dia, 0.9 pitch	NS
	Drill bit 5mm	NS
	Hand drill	NS

8.1 Remove the thermocouples, the limpet clamps, the earthing bracket and the compensating lead support bracket, and any masking and mylar tape.

WARNING: ANY FAILURE TO MEET INSPECTION REQUIREMENTS IN SECTIONS 8.2 TO 8.4 INCLUSIVE, IS TO BE NOTIFIED TO AIRENGLA, AND THE WING DECLARED UNSERVICABLE.

8.2 Inspect the repair for debond by tapping with a coin.

8.3 Inspect the edges of the patch for discontinuities in the adhesive, using the ultraviolet light.

8.4 Inspect the repair using the EM3300 eddy current machine, to determine the location of the crack tip. Report any change in location of the crack tip to AIRENGLA.

8.5 Carefully drill out the small plug of sealant in the hole in the decant blanking plug. Take care not to damage the patch, or to get loose sealant in the tank. Check that the decant tube fits into the new decant hole.

8.6 Using the appropriate thread tap, carefully clean any adhesive out of the threads of the decant housing retaining nuts.

8.7 Insert the syringe nozzle in the cavity between the patch and the decant hole blanking plug and fill the cavity with sealant. Keep the nozzle against the edge of the original decant hole and allow the sealant to flow around the edge of the hole to ensure that the sealant reaches the extremities of the cavity, (see Fig. 16).

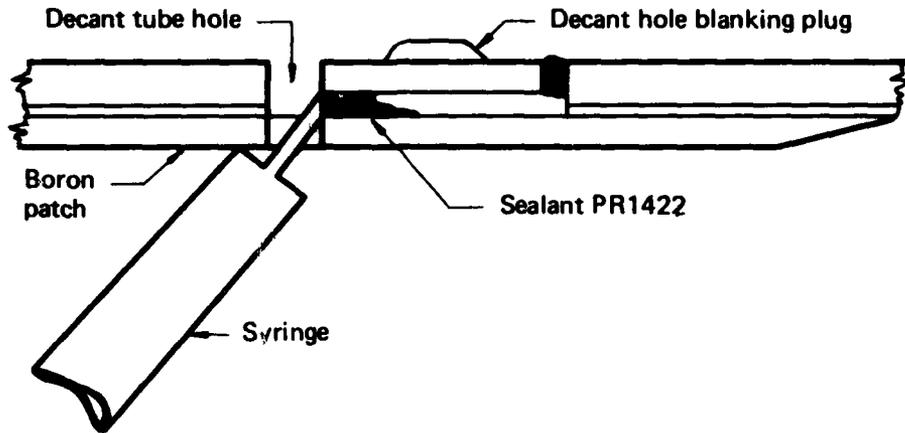


Figure 16. Sealant injection method.

8.8 Using a brush, clean the surface of the patch with MEK.

8.9 Brush an even layer of sealant over the surface of the patch and cover a region up to 10mm around the patch.

8.10 Carefully screw the heater location rods into the appropriate decant housing bolt holes.

8.11 Assemble the heating block and silicone rubber pad, as shown, Fig. 17.

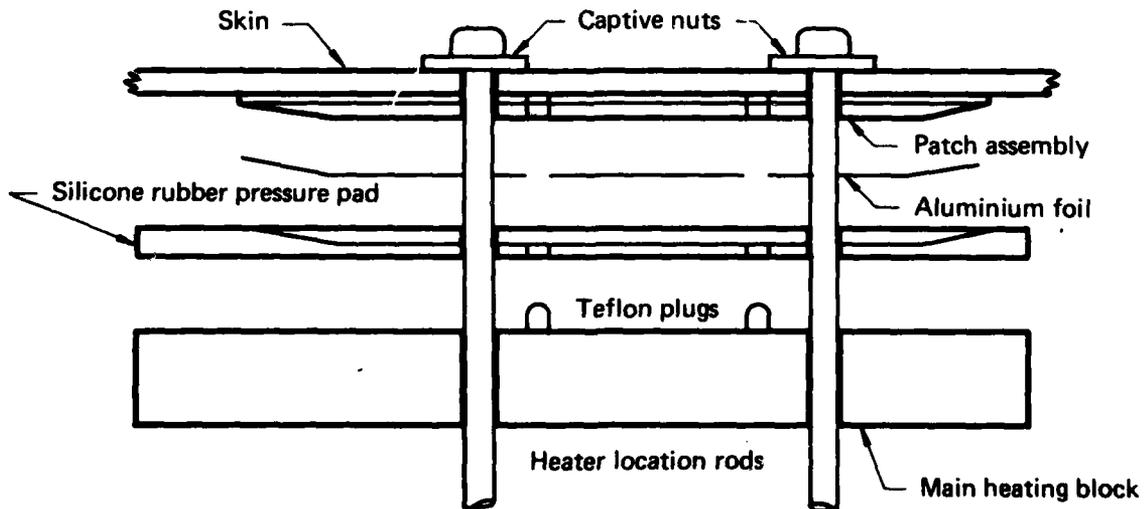


Figure 17. Pressurising assembly for application of the aluminium protective foil.

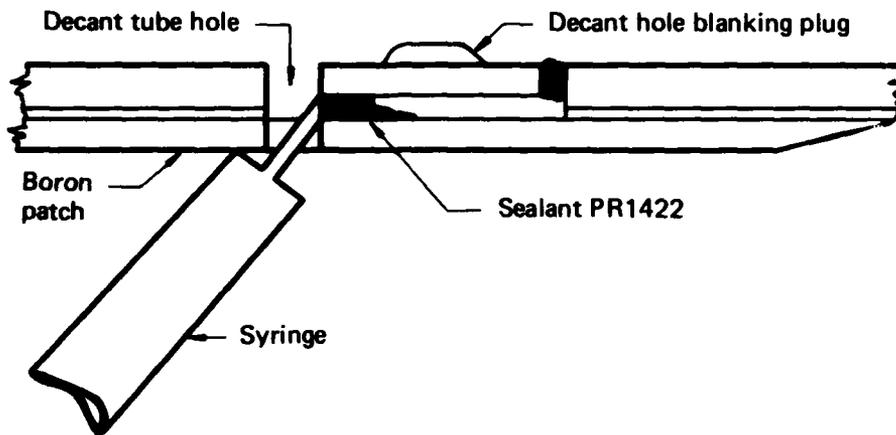


Figure 16. Sealant injection method.

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8.11 Assemble the heating block and silicone rubber pad, as shown, Fig. 17.

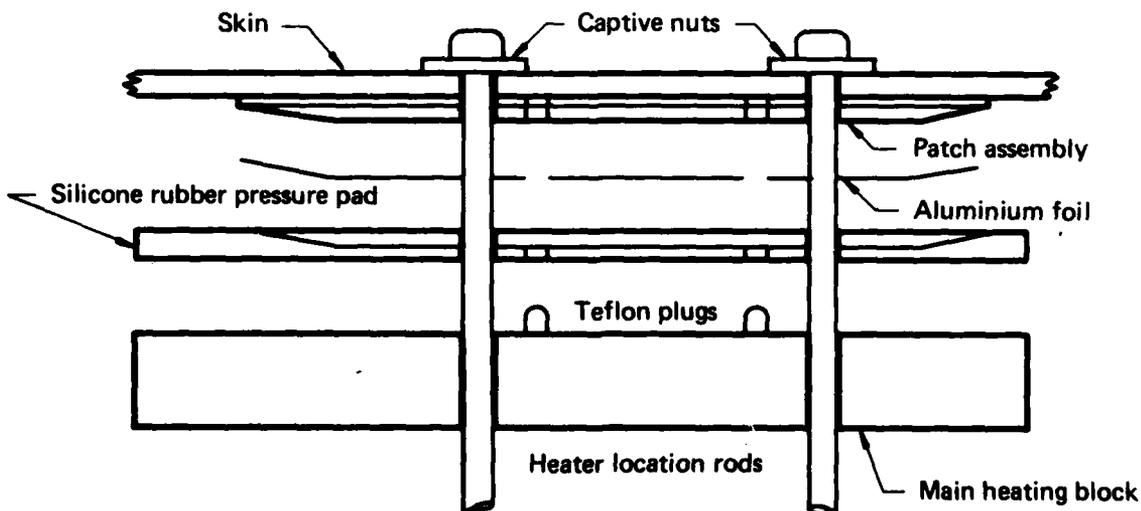


Figure 17. Pressurising assembly for application of the aluminium protective foil.

8.12 Locate the aluminium foil over the silicone rubber pad, and place in position over the patch.

8.13 Apply jack pressure until the indicator shows 320 psi. Allow to stand for 5 minutes, then remove the jack, heater block and pressure pad.

8.14 Coat the outer surface of the decant tube with sealant and insert it into the hole in the patch. Gently push the tube home.

8.15 Clear the decant tube with a pipe cleaner.

8.16 Remove excess sealant from the region using tissues and MEK.

8.17 Bolt the decant plug housing back on the aircraft, sealing this in the usual manner.

8.18 The area may now be painted after the sealant has cured, taking note of the warnings on the warning decal.

8.19 Apply the warning decal to the aircraft under the fairing region, adjacent to the patch.

8.20 Refit the captive nut on the lower wing fillet attachment bracket.

8.21 Refit the lower wing fairings.

8.22 A report of the repair should be forwarded to AIRENGLA. This report should include copies of the photograph of the cracked region, the inspection report for both before repair and after, including the aircraft flying hours, and the temperature recordings taken during the repair. The backing paper from the adhesive should also be enclosed.

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