CTSO

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ROYAL CANADIAN AIR FORCE

FUEL CELL REPAIR

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FUEL CELL REPAIR

SELF-SEALING CELLS

GENERAL

1 A self-sealing cell is a fuel or oil container which automatically seals holes or injuries incurred during operations. A self-sealing cell is not bullet-proof, but merely bullet or puncture sealing. This sealing action reduces the fire hazard brought about by leaking fuel or oil and keeps the aircraft fuel or oil supply intact so that it may continue the operation and reach its base.

2 The purpose of cell repair is to restore a cell to its original condition, to restore its ability to carry fuel or oil, and to renew its ability to seal future injuries.

CONSTRUCTION

3 There are three primary layers of material in a self-sealing fuel cell; the inner liner, the sealant and the retainer. Most cells now in service contain more than the three basic component parts, but each ply may be classified as being related to one of the three primary groups.

4 The purpose of the inner-liner is to contain the fuel and to keep it away from the sealant layers so that it will not bring about premature swelling or deterioration of the sealant.

5 The sealant material remains dormant in the fuel cell until the cell is ruptured or penetrated. When this occurs, it is the function of the sealant to seal the ruptured area so that no gasoline is allowed to flow through to the exterior of the fuel cell.

6 The purpose of the retainer material is to lend strength to the fuel cell and to protect the sealant and inner liner. The retainer also increases the efficiency of sealing action after the cell is penetrated.

7 In this construction, see Figure 1, the Buna-N synthetic rubber acts as the inner liner. Nylon is used as a barrier to prevent the diffusion of aromatic fuels into the sealant material. The sealant is placed on the cell in two layers, a layer of cord fabric, the retainer material being placed between the two layers of sealant, and the final layer or layers of cord fabric retainer material being placed on the exterior of the fuel cell.

FUNCTION OF THE SELF-SEALING FUEL CELL

8 The sealing function is brought about by the mechanical and chemical reactions which take place upon penetration of the fuel cell. The mechanical reaction results from the fact that rubber, both natural and synthetic, will give under the shock of impact, limiting damage to a small hole in the fuel cell. The fuel cell materials will allow the projectile to enter or leave the cell and then will closely approximate their original position. This mechanical reaction is almost instantaneous. The chemical reaction of the sealant takes place as soon as gasoline or gasoline vapours penetrate through the inner liner material and reach the sealant. The sealant, upon contact with gasoline or gasoline vapours, will extend or swell to several times its normal size, thus effectively closing the rupture and preventing the gasoline from escaping.

9 A fuel cell is self-sealing but not self-healing. Any fuel cell which has been ruptured so that gasoline is in contact with the sealant material must be repaired as soon as possible, with 72 hours as a maximum time limit.

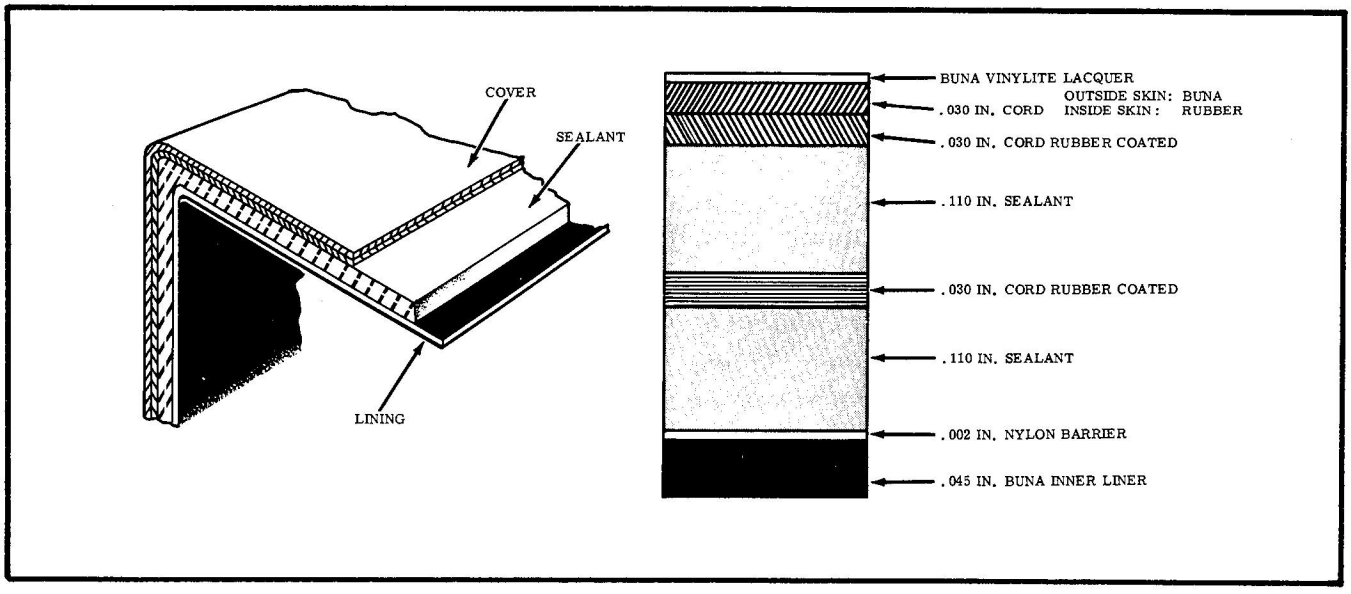

Figure 1 Fuel Cell Section

STORAGE

10 Provide adequate protected storage for non-metallic fuel cells observing the following precautions:-

(a) Cells are of rubber and must be stored where the cell will not be exposed to direct sunlight.

(b) Cells are shipped in special containers. Do not remove from these containers except as required for inspection and installation.

(c) Stacking of containers is permissible, but do not allow partial or complete collapse of the lower containers or cells.

(d) Do not place cells, whether in or out of containers, near heaters or hot pipes.

(e) Whenever a self-sealing cell has been in service and filled with fuel, spray, paint or slush the interior surfaces of the cell with engine oil (Item 3) prior to storage and within ten days of the removal of fuel from the cell. Do not permit excessive amounts of oil to remain in the cell. Where repairs are required on a cell, carry out prior to oiling. After the initial oiling, re-oil interior surfaces of cells at intervals of two months. When cells are to be put back into service, flush the oil out with cleaner (Item 2). After the first and each subsequent oiling, mark cells with a tag containing the following information: "Interior sprayed (or painted or slushed) with oil. Date."

(f) When removing cells from storage for installation, use the oldest cells first.

INSPECTION

11 Inspect visually to determine extent of serviceability. If repairs are required, the following will be observed:-

(a) If the area to be repaired is less than two inches in diameter or length, the tanks are to be shipped direct to Repair and Overhaul contractor.

(b) If the repair area is more than two inches but less than ten inches in diameter or length the tank is to be reported to AMCHQ for disposal action.

(c) If the area for repair is more than ten inches the tank is to be returned to the supply section for disposal as scrap.

HANDLING

12 Take particular care when removing cells from their containers, handling and installing. Observe the following precautions:-

(a) Do not allow cells to rest on protruding fittings or stack them unsupported one upon another.

(b) Seal all cell openings, not sealed during assembly, with covers, closed fittings or other equipment.

(c) Where installed cells, which have been filled with fuel, are to stand empty of fuel for more than ten days, oil, tag and re-oil at intervals of two months as required, refer to para. 10 (e) preceding. Tagging may be replaced by other suitable methods of marking.

(d) Carry rubber parts; do not drag or scuff along the floor. Take care to avoid knocks, distortion and damage to fittings.

(e) Do not paint rubber parts except where required for camouflage purposes. Small parts need not be masked to prevent overspray from spray painting of adjacent components. Do not paint fittings having rubber portions or inserts.

FOLDING OF CELLS

13 Fold self-sealing cells for installation only when necessary, observing the following precautions:-

(a) If the self-sealing cell is folded and/or strapped to aid installation, fold and/or strap just before the cell is to be installed. Do not keep cells folded any longer than is absolutely necessary.

(b) Ensure that fittings are not damaged or torn loose from the cell during folding.

CONNECTING FITTINGS

14 In connecting fittings, proceed as follows:-

(a) Bring the parts into the best possible alignment so that the screws or bolts can be started with minimum torque.

(b) Inspect fittings and threaded parts prior to installation to ensure freedom from foreign matter, damaged threads or other defects.

(c) Tighten a sufficient percentage of the bolts, distributed uniformly about the fittings, to a value close to but below the specified final torque value, in such a manner that the fitting is evenly seated.

(d) Install the remainder of the bolts and torque all bolts to the specified value. After the bolts have been torqued, a drop in torque value may occur. Do not retighten. If retorquing is necessary, loosen all bolts and completely retorque the fitting.

15 If a fitting is found to be leaking after the application of correct torque, remove and examine the mating surfaces carefully. Examine the bolts and bolt holes for damaged threads or foreign matter. If no defects are found install the fitting again. Repeated tightening of bolts will only distort the metal insert, tear the rubber and contribute to further leakage.

16 Torque requirements for installation must be as specified on the applicable assembly drawing or Engineering Order. Disregard any torquing instructions stencilled on the fuel cell or cell door.

17 Upon installation of fuel cell fittings, maximum specified bolt or screw torque is sometimes attained before fitting is securely sealed to the cell. This may be caused by misalignment of matching holes or foreign matter on the bolts, screws or in tapped inserts. To obtain the same compression achieved by direct torque measurement, the following alternate method of installing cell fittings may be used:-

(a) Align fitting on cell in proper position.

(b) Insert and tighten bolts or screws diametrically opposite each other until all bolts or screws have drawn fitting down just flush with cell.

(c) From this position, tighten each bolt or screw, in the same order, an additional one-third (120°) turn. This should securely seal fitting to the cell.

INSTALLATION

CAUTION

The use of sharp edged tools such as screwdrivers, punches, drift pins, etc., to align fitting is strictly prohibited. Use only round wooden bars.

NOTE

For further information regarding inspection and maintenance cycles, packing, storage and salvage, refer to EO 05-1-2L.

18 Apply talc (Item 4) to the outside of all cells before installation. Treat cells, which are to be installed in bays which are finished with only zinc chromate primer or interior green tinted primer, with talc by any convenient method. Treat cells, which are to be installed in bays which are finished with other than zinc chromate primer or interior green tinted primer (e.g. purged bays), with an aqueous suspension of talc to aid in installation and to prevent sticking to the painted surfaces of the bay during service.

19 Brush or spray two coats of the talc suspension on the exterior surface of the cells. Make the talc suspension as follows:-

1.5 pounds talc (Item 4).
3.5 quarts water.
1.5 ounce Bentonite Clay (Item 5).

NOTE

Before using, stir material thoroughly. Continue agitation if the material is to be sprayed.

20 Apply the talc uniformly to the outside of the cell and if the suspension is used, allow the film to dry completely before the cell is installed. Take care to ensure that no talc gets on the interior surface of the cell. After application of the talc, keep handling of the tank at a minimum to prevent rubbing off the coating before installation. Dust accessible surfaces of fuel bays which contact the cells with talc.

REPAIR OF SELF-SEALING CELLS

GENERAL

21 The time and effort required for making temporary repairs is as great as that necessary for permanent repairs, and the results are not satisfactory. Therefore, all repairs made are to be of the permanent type.

REPAIR PRECAUTIONS

22 When repairing self-sealing cells, observe the following:-

(a) If leakage from access door or fittings is suspected, torque access door and fitting bolts in accordance with applicable Engineering Orders of affected aircraft.

(b) Inspect cells thoroughly before repairs are begun. Much time is wasted making one repair at a time when several could be made concurrently.

(c) The limit to the number of repairs and fitting replacements is left to the discretion of engineering authority. Obviously, a cell could have several small injuries and be repaired safely, while the same number or fewer large injuries would be impractical and unsafe to repair. Reparability of a cell can be determined only by the number and location of the injuries. Do not repair large injuries located where the cell is folded sharply during installation.

(d) Inspection of repaired cells, except nylon Pliocel, must not be performed until 24 hours have elapsed after draining.

(e) Clean fuel and oil cells, except nylon Pliocel, inside and outside to remove any oil or foreign substance by the use of aircraft cleaning equipment with soap paste (Item 6) and hot water not to exceed 200°F. After cleaning, remove all soap residue with clean hot water not to exceed 200°F. If this equipment is not available, clean by hand using detergent (Item 30) mixed with warm water. Apply with lintless cloth and rinse with warm water.

NOTE

Pay strict attention to the choice of materials and methods.

REPAIR MATERIALS

23 The outside repair material is a fabric, coated on both sides with Buna-N synthetic rubber (Item 7), obtained in gauges .038 to .062 inch. The .020 inch gauge material (Item 8) is used for corner repair chafing strips, fitting wraps and in other instances where a lighter gauge material is suitable.

24 The inside repair material is sheet Buna-N synthetic rubber, cured on both sides, of .045 inch gauge (Item 9).

25 Apply cement (Item 10) evenly and thinly, and allow to dry between coats. When two surfaces are to be joined, apply at least two coats to each. Use 40 to 80 grit emery cloth (Item 11) when hand buffing Buna materials.

26 Use solvents (Item 12) for washing buffed surfaces and for freshening or re-activating cemented surfaces of the type specified for the cement being used. Use of incorrect solvent can be detrimental to the adhesion of surfaces to be cemented.

PREPARATION OF CELL FOR REPAIR WORK

27 Carry out repair work on fuel cells in a dry place. High humidity, especially in combination with low temperature, will cause condensation to form on cemented surfaces and will make adhesion of repair patches impossible.

28 Drain cells and dry thoroughly as soon as possible after injury. Drying may be speeded up by keeping the cell in a warm place and by using an air hose on the inside. Do not keep the cell warm for long periods of time and never at a temperature over 120°F. Higher temperatures will dry out the gasoline-soaked sealant next to the injury, but will trap gasoline in the sealant farther away from the injury. If gasoline is trapped in this way, it will cause separation and breakdown in the sealant material. To prevent this, spread the edge of the injury slightly with a small stick or pencil long enough to allow all gasoline to escape from the sealant material. Drying may require several days. Begin repair work as soon as the sealing gum has resumed its normal appearance and no longer is swollen.

29 Make repairs on the inside of the cell before repairs on the outside. Inside injuries may be reached through the cell access doors or filler openings. In some cases it is necessary to use a mirror and a safety light inside the cell to see the injury.

CAUTION

Do not lay unguarded light bulb on cell inner liner.

WARNING

The vapours from aircraft fuel, rubber and solvent are dangerously toxic, even if inhaled for only a short period. Before work is begun, drain all fuel from the cell and dry thoroughly. Attach a flexible hose to a blower and place inside the cell to displace the fuel vapour by circulating air at low pressure. When it is necessary to work on the inside of cells, two persons should be assigned to the work. The person entering the cell must wear a respirator equipped with a remote breathing line for fresh air, see Figure 2, or a respirator designed for organic vapours and a safety line, refer to EO 00-80-4/7. The second person must remain outside the cell in such a position that he can observe any sign of distress shown by the person inside the cell.

REPAIR OF CLOSE HOLE OR SLIT-TYPE INJURIES

30 A closed hole or slit-type injury is an injury extending through one or more layers of the cell but with no displacement of material. If the slit does not extend through the cell wall, the undamaged side need not be repaired. If the slit extends through the cell, patches on both sides are necessary.

INSIDE REPAIRS UNDER TWO INCHES

31 When the cell is ready for repair, proceed as follows:-

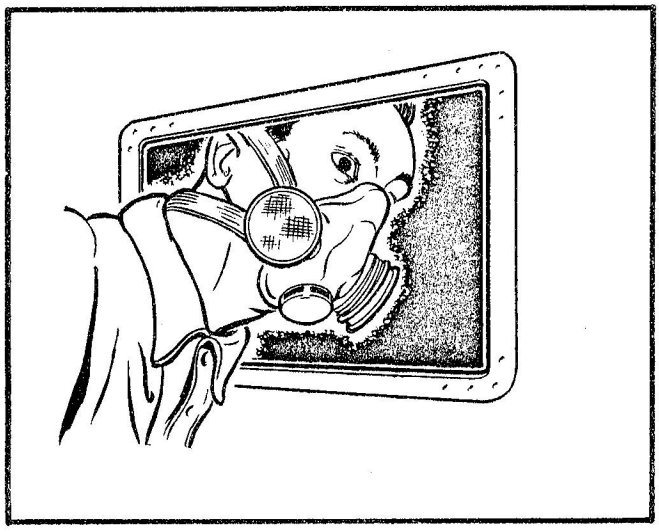

Figure 2 Use of Respirator

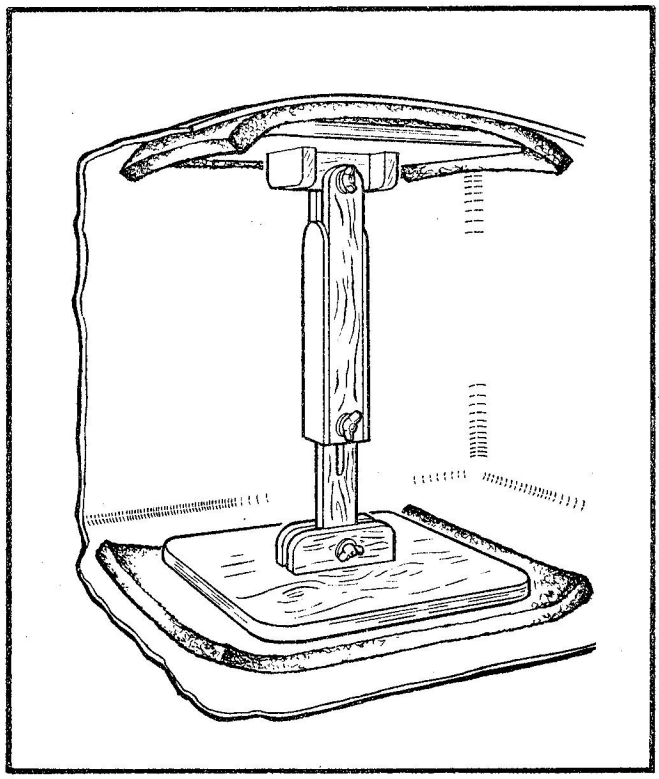

Figure 3 Pedestal for Supporting Cells

(a) Buff the inside of the cell for 2-1/2 inches in all directions from the edge of the injury with clean emery cloth (Item 11) or buffing tool. Buffing must be heavy enough to remove all gloss, leaving the surface covered with closely spaced fine scratches. An air drill may be used as a buffer by inserting a sand or emery wheel in the chuck. When buffing with air drill, do not use excessive pressure. To avoid burning the surface of the material, do not buff in one spot too long. When using power buffer for the first time, practice on a condemned fuel cell before attempting to buff the repair. Occasionally it has been found that buffing by the ordinary power buffer produces a surface that is too smooth for best adhesion. When this condition is found, roughen the buffed surface of the cell or patch with a piece of coarse emery cloth (Item 11).

(b) After buffing, clean the surface lightly with a clean cloth moistened with solvent. Do not soak buffed area but wash lightly until all grit and buffing dust are removed.

(c) Measure the injury and cut a patch of inside repair material (Item 9) large enough to extend two inches in all directions from the edge of the injury. The patch must have a smoothly rounded outline, and the edges must be skived or cut at an angle by tilting the shears instead of cutting at right angles.

(d) Apply the patch with the flat side next to the cell lining and the skived side away from it.

(e) Support the outside of the cell around the injury so that the edges will be lined up properly in their natural position, see Figure 3.

(f) Clean the buffed area on the inside of the cell with solvent (Item 12) immediately before cementing.

(g) When the inner liner is dry, apply a thin coat of cement (Item 10) to this area and

to the inside of the patch. After the first coat is dry, apply another coat of cement to both the cell and the patch. To determine if the cement is dry enough for application of the second coat, test by pressing a knuckle gently against the cemented surface and withdrawing it. If no cement sticks to the knuckle, the surface is ready for the second coat.

(h) Before the patch is applied, the second coat of cement on both the patch and the cell must be slightly tacky. A few threads of cement should stick to the knuckle when it is tested. If the last coat of cement has become dry, tackiness may be increased by wiping it gently with a solvent (Item 12) dampened cloth or by applying another thin coat of cement.

(j) When the last coat of cement has sufficient tackiness, centre the patch over the injury and roll down firmly with a 1/4 inch hand roller. Take care not to apply the patch before the cement has reached the proper stage of tackiness, as air bubbles or blisters may form under the patch in the drying process. If the cement has reached the proper stage before the patch is applied, there will be no skidding or sliding of the patch immediately after application. This can be checked by trying to slide the patch across the surface with the thumb. Sliding should not be evident in any area of the patch.

(k) If blisters or poor adhesion are found in the patch, remove and start the repair over again. A cloth moistened with solvent and rubbed briskly over the cement, before the cement is too dry, will remove it satisfactorily.

OUTSIDE REPAIRS

32 Support the cell around the injury so that the edges of the injury will be lined up properly in their natural position, see Figure 3. Place trestle or other support inside the cell to be repaired. Pad wooden blocks or boards used inside of the cells or cover with cloth to protect liner from damage. Proceed as follows:-

(a) Buff an area on the outside of the cell extending three inches in all directions from the edge of the injury.

(b) Cut a round or oval patch of outside repair fabric (Item 7) large enough to extend 2-1/2 inches beyond the edges of the injury on all sides. Buff one side of this patch.

(c) Clean the buffed surfaces of the cell and the patch with a clean cloth moistened with outside solvent (Item 12).

(d) Apply two coats of cement to each surface, allowing the first coat to dry before applying the second.

(e) While the second coat is still slightly tacky, centre the patch over the injury and roll down, being careful to remove all trapped air.

(f) Apply two coats of Buna Vinylite lacquer (Item 13) on the patch and buffed area, allowing proper drying time between each coat. If Vinylite lacquer is not available, cement (Item 10) may be used.

INJURIES OVER TWO INCHES AND LESS THAN TEN INCHES

33 If the injury is two inches or longer in size, use two patches both inside and outside the cell. Proceed as follows:-

(a) Buff an area of the cell one inch larger all around than the size of the first patch. Buff both sides of the first patch. Make a feather edge on the first patch to facilitate sticking down the second patch.

NOTE

Feathering is the process of tapering the edge of the patch by buffing, to a considerable greater degree, than can be obtained by merely skiving or bevelling with shears. Extend the taper at least 1/2 inch in from the edge of patch. Failure to feather edge of the first patch will produce an undesirable channel under the second patch. Such channels trap fuel and cause eventual failure of cell.

(b) The second patch must overlap the first by one inch in all directions. Complete all necessary buffing before the cement is applied. Buff an area on the cell 1/2 inch larger in all directions than the second patch.

(c) Apply first patch, refer to paras. 31 or 32, preceding.

(d) Before applying the second patch, ensure that cement (Item 10) under the first is thoroughly dried, otherwise the solvent in the cement may cause the edges of the first patch to become loose.

(e) Apply two coats of cement on patch and buffed area. Allow proper drying time between each coat. Apply second patch. Check repair for loose edges and trapped air.

NOTE

Some injuries, especially on flat surfaces, are simple to repair. Injuries in corners or other awkward places may prove very difficult if not impossible. Where the contour of the cell prevents good adhesion of the patch, it is better to abandon the repair and condemn the cell rather than to make a doubtful repair.

CAUTION

Air-cure repaired fuel cells a minimum of 72 hours prior to installation. Do not, under any circumstances, put a cell in a Vitacap chamber, pot heater, Plexiglas oven or any similar heating chamber. Such action would cause the cell to deteriorate and shrink beyond safe dimensions.

REPAIRING VERY LARGE INJURIES

34 The repair of large hole injuries or long tears exceeding 10 inches is not advisable. In extreme emergencies, however, they may be repaired using the methods outlined in preceding paragraphs but the cells must be replaced as soon as possible.

REPAIRING BLISTERS

35 An inner liner blister is caused by trapped air between the liner and the sealant, and is often mistaken for separation of plies. Ply separation is the loss of adhesion between successive layers. Blisters under one inch in diameter are not injurious and need not be repaired. To repair a blister, proceed as follows:

(a) Buff the surface of a blister and an area extending 2-1/2 inches in all directions from its edges.

(b) Slit the blister from end to end with a knife and buff under side of loose edges, see Figure 4.

(c) Apply two coats of cement (Item 19) to the inside surfaces. Allow proper drying time between coats, refer to para. 31, preceding.

(d) Roll down the blister carefully to remove all trapped air.

(e) After the blister has dried thoroughly, apply a patch extending two inches in all directions from its edges, and complete the repair in the same manner as an inside injury, refer to para. 31, preceding.

REPAIRING LOOSE SEAMS AND PATCHES

36 Repair loose lap seams on the inside of the cell as soon as they are noticed to prevent the separation from spreading to the sealant. Proceed as follows:-

(a) Buff both surfaces inside the separation. Buff an area on top of the loose seam extending 2-1/2 inches in all directions from the edges of the separation, continuing the measurement on the next cell wall when the end of the cell is reached.

(b) Clean the buffed surfaces inside the separation with a cloth moistened with solvent (Item 12). Allow to dry.

(c) Apply two coats of cement (Item 10), allowing proper drying time between coats.

(d) Roll the separation down firmly to remove trapped air and allow to dry.

(e) Cut a patch of inside repair material (Item 9) extending two inches in all directions from the edges of the separation. Round the corners slightly and buff one side. Bevel the edges of the patch with bevelled edge on the outside.

(f) Cleanse the buffed surface of the patch and cell with solvent (Item 12), apply the patch, and complete the repair in the same manner as an inside injury, refer to para. 31, preceding.

(g) Repair loose lap seams on the outside of the cell by the same method as that described in the preceding para. except that outside repair material (Item 7) is used.

(h) Repair loose patches by buffing, washing, cementing the separation and rolling it down, unless it is obviously better to replace the patch with a new one.

BUILT-UP REPAIRS

37 If the injury consists of a hole in the cell with a section of material blown out rather than a slit or cut, it is necessary to replace the material that is missing. This repair is made as follows:-

(a) Mark two circles around injury on outside of cell wall. Draw the inside circle large enough to include all damaged sealant and ragged edges, but not smaller than 3 inches in diameter, and the outer circle on a one inch larger radius. Buff area on retainer extending from outside circle outward for 2-1/2 inches larger radius. Remark outside circle. Using the inside circle as a guide, cut away the cell material with a knife blade held at right angles to cell wall. Bevel the edge of hole, using the larger circle as one guide, and edge of line in hole as other. This results in a bevel of 30° and provides efficient adhesion surface. Cut liner to featheredge, see Figure 5.

(b) Support cell, refer to para. 32.

(c) Cut three patches of sealant (Item 14) one inch larger in diameter than top of the cutout in cell so that they will overlap about 1/2 inch all around when applied. Use cement (Item 10) as layers are applied. Apply each layer of sealant separately, sticking each down thoroughly, see Figure 6.

(d) After repair has dried, carefully trim excess sealant (Item 14) to a line flush with outside of cell. A handy tool for fuel cell work can be made from an ordinary soldering iron. A semi-circular piece of copper, 3/8 inch thick cut on a 1 inch radius, is welded or brazed onto a 3-1/2 inch length of 3/8 inch round copper stock. The head is tapered down so that the tool resembles a rod cutter, see Figure 7. The finished part then is inserted in the soldering iron in place of the regular copper tip. This is known as a hot knife and is adaptable to removing fittings, trimming sealant, etc. When hot, it cuts very readily and care should be taken not to cut too deep. It is advisable to practice on a condemned cell before using the knife for actual repair.

(e) Apply outside patches as outlined in para. 32, preceding, see Figure 8.

(f) Before proceeding with inside patch, permit this much of the repair to cure for several hours to avoid its loosening during the remainder of the operation. Carefully remove inner support from cell and place a support against the outside over the repair area. Apply inside patches, refer to para. 31, preceding. If injury is in an awkward location making it impossible to stock the inner patches the repair should be abandoned and the cell condemned.

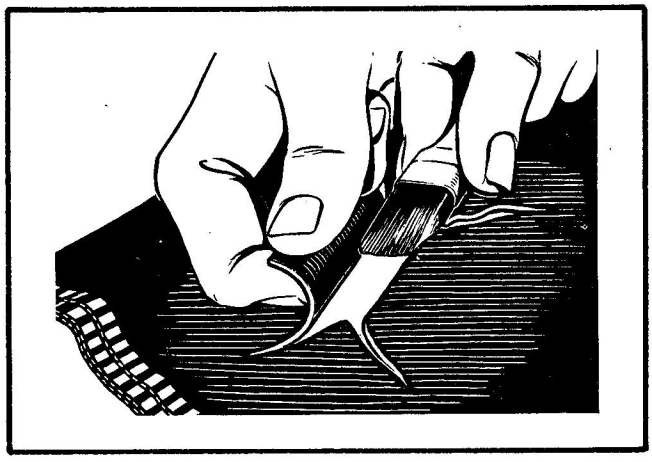

Figure 4 Cementing Blister

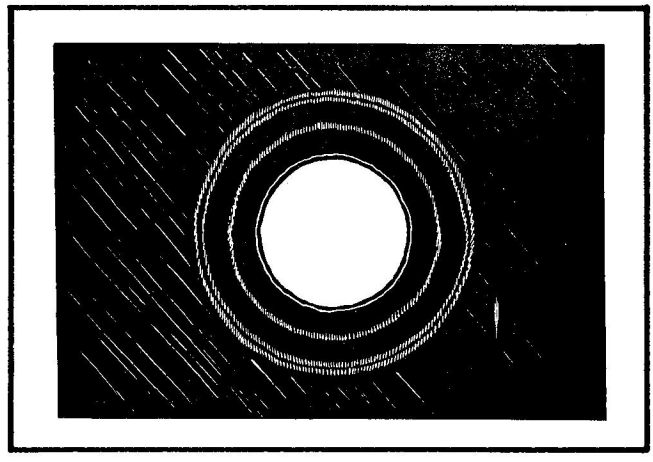

Figure 5 Featheredge Opening

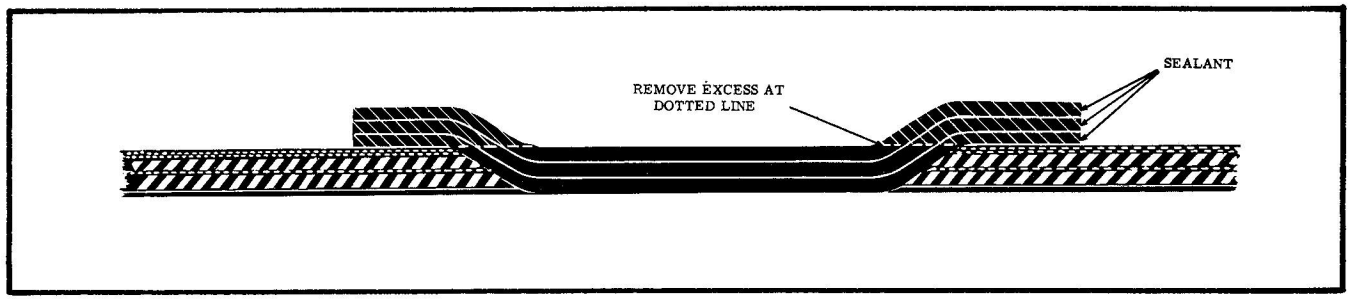

Figure 6 Built-Up Cell

INSIDE CORNER REPAIRS

38 All inside corner repairs require a double (two-layer) patch. To prevent wrinkling or stretching of the repair material, these patches must be cone-shaped and must fit accurately into the corner. Proceed as follows:-

(a) Buff the area around the injury, in the same manner as used in repairing a flat surface, for a distance of 2-1/2 inches in all directions from the edge of the injury.

(b) Cut a patch of inside repair material (Item 9) large enough to extend one inch in all directions from the edge of the injury. Cut a single slit in the patch running from the outside edge to the apex of the corner. At the end of the slit, in the centre of the patch, make a second slit 1/8 inch long at right angles to the first.

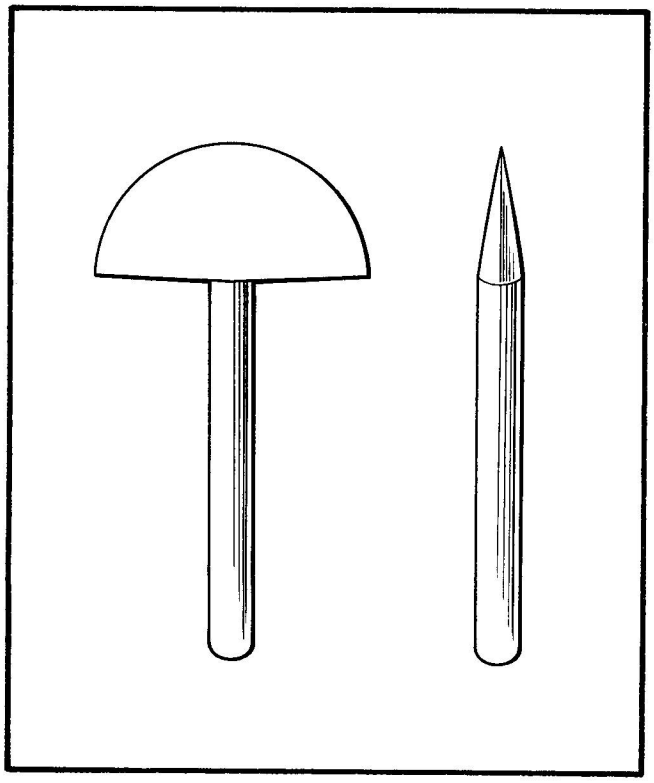

Figure 7 Model of Hot Knife Blade

(c) Before any cement is applied, fit the patch carefully into the corner. Trim to size and place the slit so that the lap formed will be on a flat side as far away from the injury as possible. Scratch the outline of the patch lightly on the cell while the patch is still in the correct position, indicating the location of the slit so that the patch can be returned to the same position after cementing.

(d) Buff patching material on both sides and feather the edge before cementing. In addition, buff, wash and cement (Item 10) the portion of the top side that will be overlapped at the slit.

(e) Apply two coats of cement to the cell and the inside of the patch, with proper drying time allowed between coats. While the second coat is still slightly tacky, line up the patch with the outline previously drawn on the cell and press down a narrow strip, running from the outer edge of the inner end of the slit with the fingers. Place the patch so that it matches its outline accurately and the inner end of the slit falls in the apex of the corner.

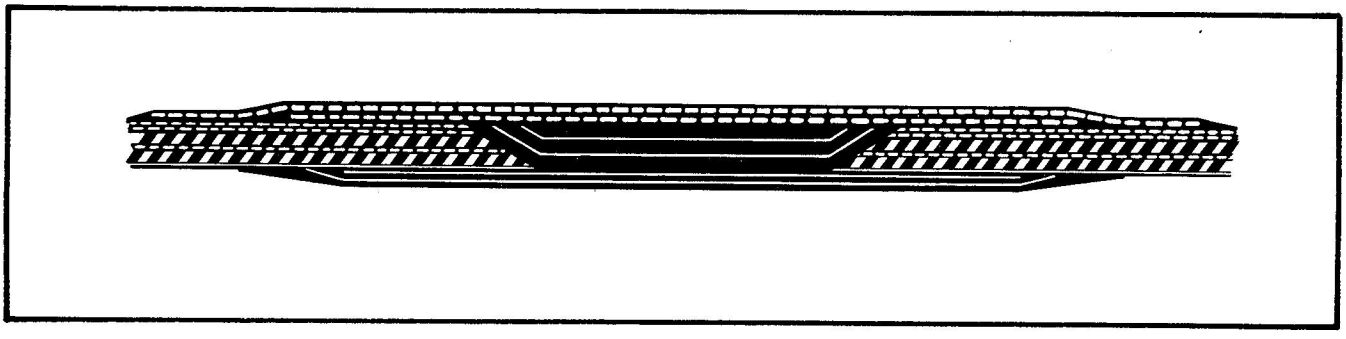

Figure 8 Finished Repair

(f) Work down the patch with a hand roller. Start rolling from the edge of the slit which has already been stuck down and work around the patch to the outer edge of the slit. Avoid any wrinkles or trapped air. If the roller or sticker proves to be too awkward, the patch may be applied with a rolling motion of the finger, see Figure 9.

(g) After the patch has been rolled down, apply cement (Item 10) to the surfaces that will form the lap. Be careful to coat the inner end of the slit well and roll down the lap.

(h) Be sure that all edges are rolled down securely. If some of the edges do not stick well, wipe the loose places with a clean, lintless cloth moistened with solvent (Item 12). After they have dried for a short time, reroll. If they still fail to stick apply one more thin coat of cement (Item 10) and roll again after it has dried. If the patch is still loose at any point it should be torn off and scrapped, the cell cleaned of cement, and the repair procedure repeated.

(j) After the first patch has been carefully examined and found to be absolutely smooth and tight, apply a second patch of inside repair material (Item 9), large enough to overlap the first patch at least one inch. Apply the second patch in the same manner as the first, after it has been fitted to the corner by making a slit and overlapping. The location of the overlap on the second patch, however, must be opposite that of the first patch. Be sure to buff both surfaces that form the overlap before cementing.

(k) Roll the second patch in the same way as the first. Take extreme care to remove all trapped air. If there are any wrinkles or air bubbles that cannot be removed, the second patch must be pulled off and started over.

NOTE

Due to the awkwardness of sticking down patches, injuries in a corner of the cell will be found difficult to repair. Often the irregularity of the inner surface will prevent a patch from adhering. In cases where a reasonable effort has been made on a corner repair and the patch refuses to adhere, the repair may be abandoned and the cell condemned at the discretion of engineering authority.

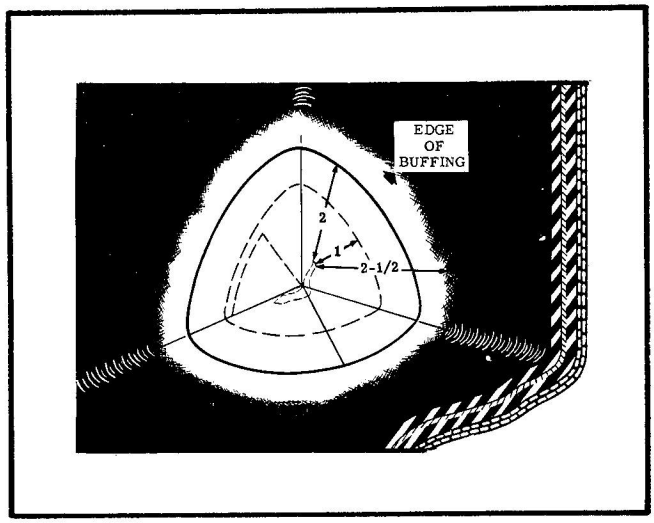

Figure 9 Complete Inside Corner Repair

OUTSIDE CORNER REPAIRS

39 Outside corner repairs are made in the same manner as inside corner repairs, see para. 38, preceding, with a slit cut in each patch so that it will fit the corner. Cut patches from outside repair material (Item 7) and apply by the same method as outside patches for slit injuries on a flat surface, refer to para. 32, preceding. Cover the lap on an outside corner patch by an extra strip of repair fabric extending one inch on each side of the outside edge of the lap from the apex of the corner to the outer edge of the patch.

REINFORCING WRAP FOR TUBULAR FITTINGS

40 The normal procedure for wrapping fittings is as follows:-

(a) Determine the extent to which fitting surface is to be wrapped. Include as much as the tubular portion as possible and, in one-piece fitting, extend the fingers two inches onto the flat surface of the cell proper, see Figure 10.

(b) Wrap the fitting with paper to make an exact template of the stock required. Allow enough stock to overlap 1/4 inch.

(c) Cut a wrap of outside repair stock (Item 7) according to the above template. The template may be saved and used on other fittings of the same manufacturer and stock number.

(d) Remove any partial fabric wrapping which may have been applied previously to the fittings.

(e) Buff the surface of the fitting to be wrapped. This should be done carefully with 40 or 80 grit sandpaper (Item 11). Do not use a power buffer, as fittings are easily damaged and difficult to procure and replace.

(f) Apply two coats of cement (Item 10) to the surface, allowing proper drying time between coats.

(g) Buff and cement fabric wrap in the same manner as in preparing an outside patch, refer to para. 32, preceding.

(h) Apply fabric wrap carefully to the fitting, sticking securely and overlapping 1/4 inch at adjoining surfaces. A mandrel the same size as the inside diameter of the tubular fitting may be inserted in some cases to facilitate sticking.

(j) After one-piece fittings have been wrapped, cover the fingered area with a re-inforcing patch (Item 8). Cut this cover patch so that its inside diameter is the same as the outside diameter of the base of the fitting and the outside diameter extends 1/2 inch beyond the fingers of the wrap.

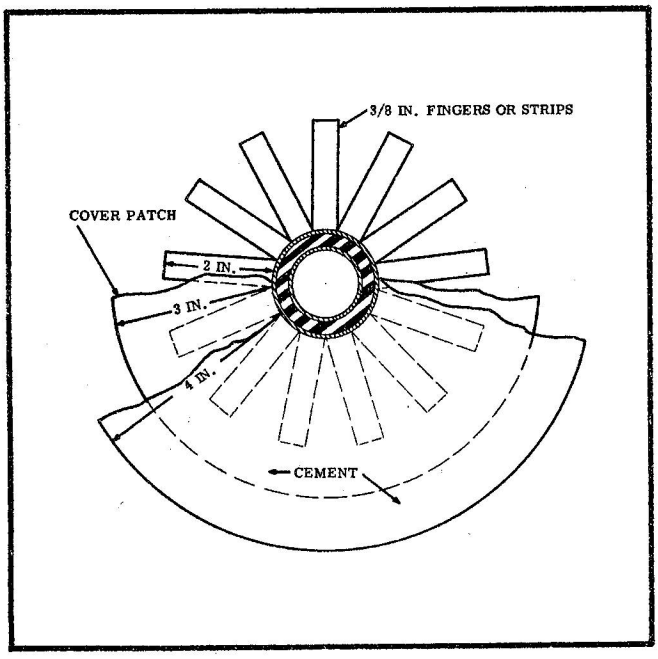

Figure 10 Application of Wrap

CAUTION

Do not wrap a fitting if the weather-cracks penetrate beyond 50 percent of the depth of the stock. Fittings that are weather-cracked to this extent must be replaced. When wrapping a fitting that is weather-cracked less than 50 percent of the depth of the stock, work the cement into the cracks and allow to dry thoroughly.

REPLACING FITTINGS

41 When cell fittings are damaged or deteriorated, remove the cell from the aircraft as soon as possible and replace the fitting or install another cell. Fitting replacement is not a difficult operation although it is a lengthy one. Take infinite care to achieve accuracy. The materials and tools used are the same as those used for other repairs. To replace the fitting, proceed as follows:-

(a) Locate the old fitting accurately by measuring from selected points of the cell, so that the new fitting can be centred in exactly the same position. If this is not done, the new fitting may not align properly when the cell is re-installed. Use a fine marking pencil when locating fittings as above. Marks from crayon or chalk are generally too wide for the required accuracy.

(b) When replacing one-piece fittings with those of the two-piece type, it may be necessary to relocate the fitting opening in the cell, due to the fact that the tubular part of the two-piece fittings is sometimes different to that of one-piece fittings. Whenever possible, use replacement fittings of the same type as the fitting that is removed from the cell. Relocation of fitting openings should not be attempted unless no alternate is possible.

(c) If there is a finishing collar covering the fitting flange on the outside of the cell, strip off the collar with a pair of pliers, see Figure 11. Loosen the cement under the collar by the use of solvent (Item 12).

(d) Strip the outside flange from its edge back to the centre of the fitting, taking care to avoid injury to the outside ply of the cell material.

(e) After the outside flange has been stripped back, cut off the fitting and flange flush with the outside surface of the cell. Cut out the core of the fitting to the edge of the cell wall. Be careful to avoid cutting the cell or enlarging the original opening, see Figure 12.

INSTALLING NEW FITTINGS

42 To install new fittings proceed as follows:-

(a) Using a sand wheel or emery buffer, remove enough of the inside flange of the old fitting and the covering ply to reduce the thickness of the cell wall so that it will fit between the flanges of the new fitting.

(b) Buff the inside and outside surfaces of the cell where flanges of the new fitting are to be placed. This buffing must cover an area extending 2-1/2 inches beyond the edge of the flanges when the new fitting is set in place.

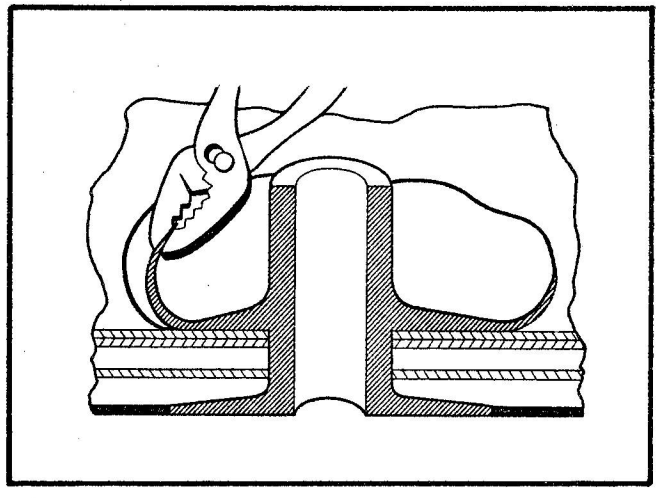

Figure 11 Removing Injured Fitting Flange

(c) If the new fitting has not been buffed, buff the surfaces inside and outside both flanges with 80 grit emery cloth or wire buffer. Avoid deep cuts in the material with the wire wheel, especially if an old wheel is being used.

(d) If the cell wall does not have sufficient thickness to fill the space between the flanges of the new fitting, apply a patch of inside repair material to the inside of the cell in the same manner as in applying an inside patch, refer to para. 31, preceding. This patch must be large enough to extend 1/2 inch beyond the area to be covered by the fitting flange, and the centre must be cut out to match the throat of the fitting. Before the patch is applied, buff the outside surface and feather the edge. Before inserting the fitting

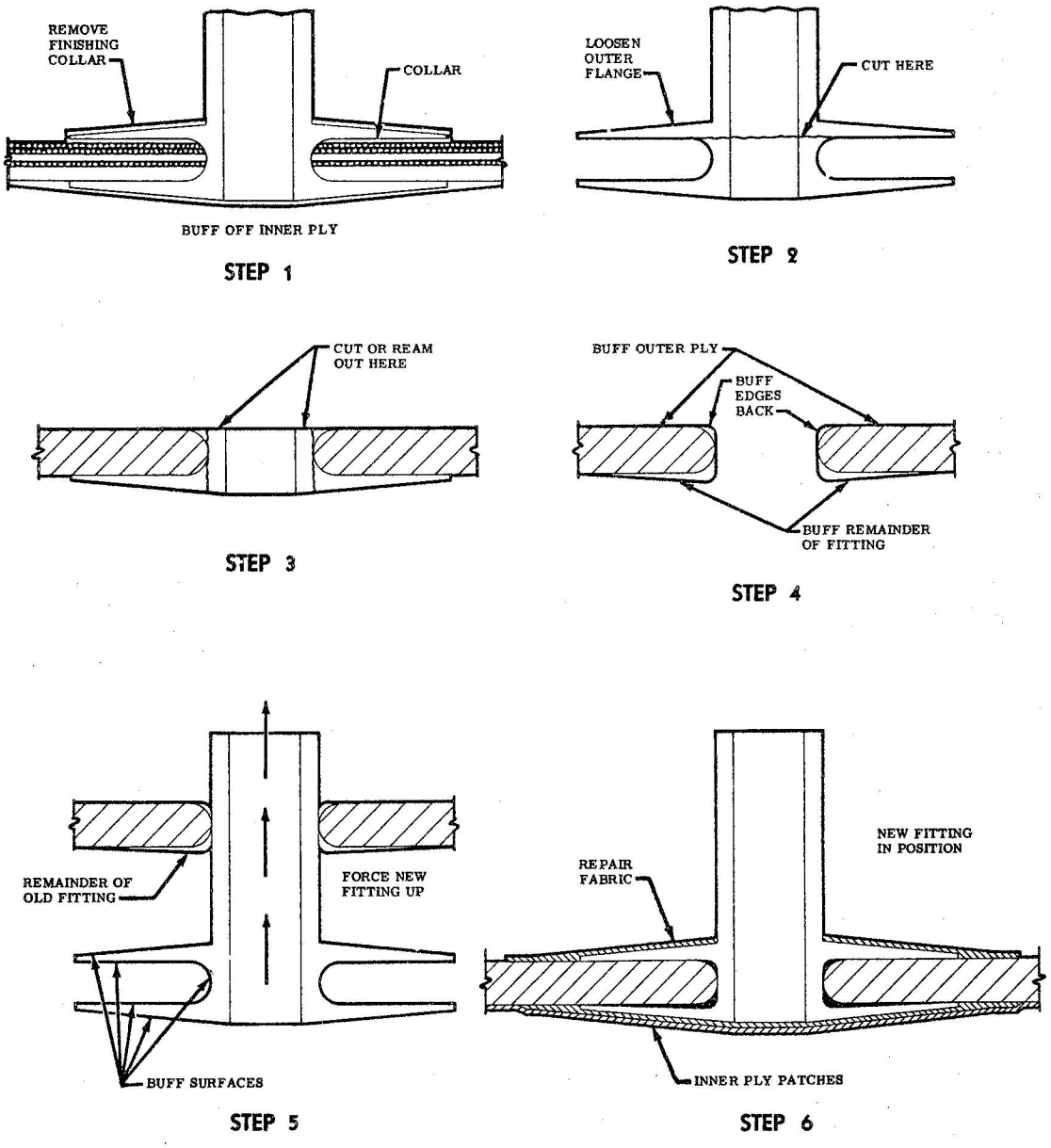

Figure 12 Fuel Cell Fitting Replacement

through the opening, check the size and shape carefully, using a pair of calipers. Make cutout opening to conform exactly with the size and shape of the throat of the fitting. When making replacement of the same fitting, a plug or template can be used to advantage.

(e) Moisten the surfaces of the fitting with solvent and force the fitting through the opening of the cell, pulling the top flange through from the inside of the cell. Check the fit of the new fitting in the cell opening. If the opening is too small, buff until the new fitting fits satisfactorily. If the opening is too large, fill the excess area with sufficient sealant (Item 10) to assure a perfect fit. After making sure the fit is satisfactory, remove the fitting from the cell.

(f) Apply two coats of cement (Item 10) to the inside of the fitting flanges and the buffed area of the cell wall, allowing each coat to dry thoroughly.

(g) Insert the fitting in the opening of the fuel cell, pulling the top flange through hole from inside the cell. Line up the fitting carefully so that its location is exactly the same as that of the old fitting, refer to para. 41, preceding. Re-activate the cement on the inside fitting flange with solvent (Item 12), using a lintless piece of material, preferably sponge. Stick the flange to the cell wall. Let inside flange dry approximately thirty minutes before working the outside flange. Use the same procedure on the outside flange as outlined above for the inside flange, ensuring that the cement on the throat of the fitting is re-activated.

APPLICATION OF COVER PATCHES

43 Apply cover patches over fitting flanges as follows:-

(a) Apply two patches over each inside flange after the cement holding the fitting has dried thoroughly, (approximately 45 minutes). Cut the first patch one inch larger in all directions than the fitting flange, buff the cured surface, and feather the edge. Cut an opening in the centre of the same shape as the opening in the fitting but 1/8 inch larger in all directions.

(b) Cut the second patch one inch larger in all directions than the first patch. The opening in this patch is cut 1/4 inch larger than the opening in the fitting. Cut and buff all patches at one time.

(c) Cement and apply patches, refer to para. 31, preceding. Centre the opening carefully so that two steps of equal width are formed. After the patches have cured approximately two hours. use a power buffer to blend the edge of the patches so there will be no irregularity of surface which would be attacked by fuel.

(d) Use only one patch on the outside of the fitting. Cut this patch two inches larger in all directions than the fitting flange. Cut the centre to the proper size and shape to accommodate the fitting. A patch applied to a protruding or barrel-type fitting must fit snugly around the base of the fitting barrel. A patch applied to a metal insert fitting may have an opening 1/2 inch larger in all directions than the gasket or compression surface of the fitting.

(e) The fitting replacement procedure described above may not be practical with all replacements. In some cases it may be more convenient to insert the fitting from the outside of the cell. Some installations can be made easier if the patches are cemented to one flange before the fitting is inserted. The following points must be observed:-

(1) Cement must have proper tackiness by knuckle test. (Knuckle will tend to stick to cemented surface, but will not raise any strings when withdrawn.)

(2) Use at least two cover patches on the inside and one on the outside flange.

(3) Outside patch on metal insert fittings must not interfere with gasket or compression surface.

(4) Feather the edge of first patch on inside.

(5) Fill in any void between cutout opening of cell and fitting throat with strips of sealant.

(6) Make sure fitting is in proper position before sticking and applying patches.

(f) Wrap fittings, refer to para. 40, preceding.

REPAIRING NON-METALLIC CELLS

44 A non-metallic tank is a combination fuel cell and rigid tank in one single unit. Whereas most fuel cells are enclosed in a metal shell when placed in the aircraft, non-metallic tanks are complete in themselves.

45 Damage to the non-metallic portion of the tank under 10 square inches in area need not be repaired if the strength of the unit is not impaired, but the inner liner of the self-sealing fuel cell must be repaired and a patch placed over the damaged portion of the non-metallic tanks to prevent gasoline from attacking the injury.

46 If the damaged area is over 10 square inches but under 25 square inches, repair as in para. 33, preceding. If some of the material has been blown away or otherwise displaced, pack the opening with sealant before the patches are applied. Because of the hardness of the non-metallic portion of the cell, do not try cutting the hole to a smooth contour. The sealant material can be applied in small sections if necessary. Fill the entire opening, making sure there are no air pockets which would expand at high altitudes. The hot knife will be found very useful to remove and smooth the sealant. Apply cover patches inside and out as described in para. 33, preceding.

47 Fittings for the different non-metallic cells are interchangeable to a limited extent. Fittings may be interchanged in cells having similar construction and equipped with fittings that have the same distance between flanges.

REPAIR OF SELF-SEALING OIL CELLS

48 Self-sealing oil cells are repaired in the same manner as fuel cells but greater care must be taken in cleaning the cells in preparation for repair work. Repair as follows:-

(a) Allow the oil cell to drain. Remove oil from the inside and outside by washing, refer to para. 22, preceding. Take special care to remove all oil in and around injuries. Hold edge of injuries apart and wash all surfaces with a clean petroleum solvent until all oil is removed. Wash lightly, as the injury must not be soaked with solvent.

(b) Dry the oil cell thoroughly before beginning repair work.

(c) When repairing oil cells, use cement (Item 10).

REPAIR OF FULLY MOULDED FITTINGS

49 Repair of checked, cracked or broken places in the rubber coating of the metal attachment fittings on self-sealing fuel and oil cells are made as follows:-

(a) Carefully buff or sand the surface of the damaged fitting with aloxite cloth (Item 19) and clean so that the damage is removed and only sound material is exposed in the area to be repaired. This would include cleaning and sanding of the metal fitting plate, if exposed. Final step in cleaning should include washing with naphtha (Item 20). Repairs are limited to 15% of surface area for each repair.

(b) Insert special short screw pins or shortened bolts of an appropriate size into the screw holes to keep stock from flowing into them.

(c) If any metal has been exposed in the preparation of the area for vulcanization, apply one coat of metal primer (Item 17) and allow to dry for 30 minutes before proceeding.

(d) Apply two or more coats of Buna-N fast curing cement (Item 10) as necessary, allowing sufficient time for each coat to dry before applying the next coat. When the last coat is dry, add sufficient uncured Buna-N stock (Item 14) to the injured area to bring the thickness of this area up to that of the rest of the fitting area after curing has been accomplished.

(e) Place a special heat transfer and pressure fixture on the fitting undergoing repair. The fixture consists of an internal and an external pressure plate, which conform to the contours of the fitting, and a bolt which applies pressure between the plates. Torque to 15 inch-pounds.

(f) Apply a flat type heater to the outer face of the pressure plate fixture and heat the whole assembly to a temperature of 280°F by conduction for a period recommended by the supplier of the uncured Buna-N material (Item 14).

(g) Remove the heater and allow the plate fixture to cool. If necessary, buff, clean and smooth the new surface of the fitting. Apply a coat of Buna-Vinylite lacquer (Item 13) to the fitting area.

(h) Various moulded fittings incorporate locating pins or studs which are required to properly align attaching fittings to the tank. If replacement of the pin is necessary, accomplish as follows:-

(1) Buff the rubber on outside of fitting down to the insert and pin.

(2) On the inside, cut the rubber from around the pin or stud.

(3) If necessary, center punch the pin on outside of cell and remove head with countersink drill. Threaded studs may be screwed out.

(4) Remove remaining portion of pin with drift punch.

NOTE

Do not remove entire pin by drilling.

(5) Install a new pin and with a center punch stake in three places.

(6) Complete repair of fitting as outlined in paras. 49(c) through 49(g).

REPAIR OF BLADDER TYPE CELLS (NON SELF-SEALING)

GENERAL

50 Repairs to bladder type, non self-sealing cells are similar to repairs to self-sealing cells.

FUEL CELLS

51 These cells are of lightweight construction, composed of one or two layers of square woven rubberized fabric outside, nylon film barrier and one layer of Buna-N synthetic rubber inside. Repairs of the inner liner and outside fabric will be the same as for self-sealing fuel cells, disregarding sealant layers and with the exception of buffing. When buffing, exercise care due to the lightweight construction of this type of cell.

OIL CELLS

52 These cells are of lightweight construction, composed of one layer of rubberized fabric outside and one layer of Buna-N synthetic rubber inside, with no nylon barriers. Repairs are the same as for self-sealing oil cells.

WATER-ALCOHOL CELLS

53 Make repairs to water-alcohol cells in the same manner as fuel cells, since the construction of the cell is the same.

REPLACEMENT OF FITTINGS

54 Replacement of fittings on bladder type cells is not satisfactory and will not normally be attempted.

INSPECTION

55 Inspect visually to determine extent of repairs in accordance with para. 11 preceding, needed after removal from the container or aircraft cavity. Inspect for leaks by the use of air pressure, not to exceed 1/4 psi. Apply soap suds on the outside of cell with a small paint brush. Under a manometer to determine any loss of pressure. Air pressure must be used with caution to prevent damage to cell.

HANDLING AND PACKAGING

56 Bladder-type cells are more delicate than self-sealing fuel cells and require more careful handling. They will abrade easily if dragged over a rough surface and will rip if snagged on a protruding sharp point. Bladder-type cells exposed to cold temperatures should be warmed to room temperatures before being unfolded or handled excessively.

57 Prior to packaging, treat cell interior with a light oil (Item 3), refer to para. 10, preceding. Cover all openings with masking tape or similar adhesive material. Fold as smoothly and lightly as possible, with the least number of folds. Do not compress excessively. Wrap in moisture-proof paper and wadding before packaging. Select a box that will fit the folded cell and not permit shifting. If it is necessary to use a larger box in emergency, fill the unused space with crumpled or shredded paper. Packaging is unnecessary if cell is to be installed immediately.

REPAIR OF GOODYEAR NYLON (PLIOCEL) FUEL CELLS

GENERAL

58 Pliocel fuel cells differ in construction and material from Buna rubber fuel cells. This type cell can be identified by the trade name Pliocel stencilled on the cell. Their repair must be accomplished by entirely different methods and with different material. Pliocel construction consists of two layers of nylon woven fabric laminated with three layers of transparent nylon film. Cement (Item 10) and Buna rubber must not be used for this repair.

REPAIRS

59 Repair tears, holes and cuts of less than two inches by the application of a patch on the interior of the cell as follows:-

(a) Clean the repair area with a cloth moistened with methyl ethyl ketone (Item 12) or acetone (Item 22). Either of these solvents will remove any residual matter left by the fuel.

(b) Using scissors or knife, trim the damaged area to remove rough edges or irregularities. Round the corners.

(c) Cut a patch of repair material (Item 23) to sufficient size and shape to cover the damaged area and extend 3/4 inch beyond in all directions.

(d) To prepare the surface, use a cloth moistened in ethyl alcohol (Item 24) and wipe the mating surfaces of the patch and damaged area. Squeeze all excess alcohol from the cloth before wiping the material.

(e) Place the damaged area on a suitably shaped smooth maple block.

(f) Position the patch on the damaged area and cover temporarily with cellophane (Item 25). The cellophane protects the nylon construction from sticking to the iron and, at the same time, permits visibility.

(g) Check temperature of sealing iron as described in para. 64 following. Apply heat to approximately two square inches of the repair patch until the cellophane is slightly browned. Heavy browning is unnecessary and may cause excessive porosity of the repair area. Do not press down on the sealing iron. Hold gently and apply a guiding movement rather than pressure. Do not permit the sealing iron to roll beyond the edge of the patch. Heat applied to the single layer of material will induce porosity. Small blisters will probably appear as the material heats, but these blisters are not harmful. When the area is properly heated, roll down immediately with cold roller and repeat operation until entire patch is completed. Do not attempt to heat more than two square inches at a time, as a greater area would cool before it could be rolled down properly with the cold roller. Finished patch must be bonded securely around its entire edge, see Figures 13 and 14.

(h) Wet cellophane with a lintless cloth moistened in clear water. Permit the wet cloth to remain on cellophane for several minutes and the cellophane will peel off easily. Wipe repaired area with a dry, clean cloth.

(j) Wipe again with a cloth moistened in ethyl alcohol (Item 24). Prepare nylon paint as explained in para. 65, following. Paint three coats of liquid nylon on the entire repaired area. The first and third coats are to be blue nylon (Item 26) and the second coat of yellow nylon (Item 27). Allow twenty minutes drying time between coats.

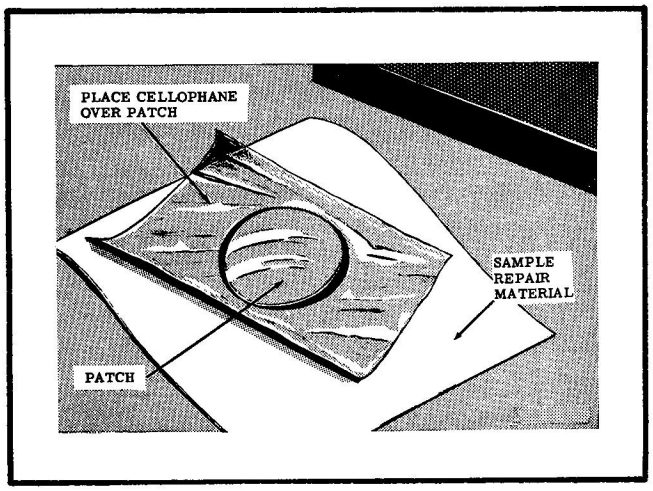

Figure 13 Simulated Repair

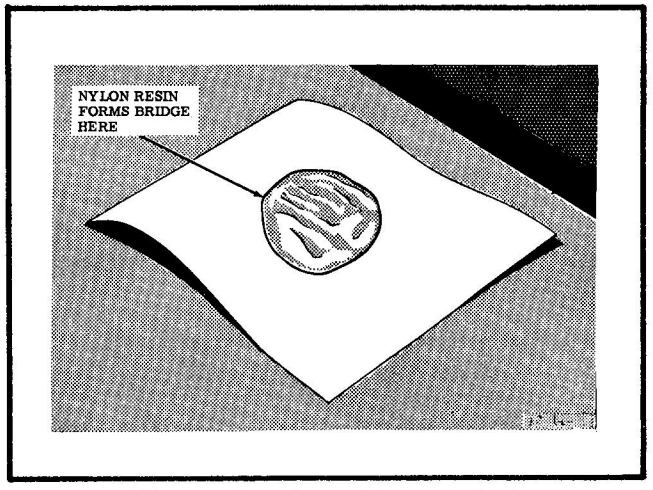

Figure 14 After Removal of Cellophane

60 Repair injuries of two inches or over in the same manner and, in addition, apply a patch on the outside of the cell. The outside patch follows the same pattern as the inside patch but is 1/2 inch larger in all directions and is applied after the inside patch. Before beginning outside repair remove the black outer lacquer with solvent (Items 12 or 22). Paint the finished patch with one coat of synthetic rubber cement (Item 28) over the normal three coats of nylon. Mix the cement (Item 28) at a ratio of one fluid ounce of 1408C to 32 fluid ounces of 5070C to make 5071C. Mix only the amount which can be used in one day. Do not use any paint which has been left over from the day before.

61 Make fitting repairs basically the same as any other repair. Replacement fitting assemblies as found on self-sealing cells are not required. Occasionally it will be simpler to replace a small section of cell rather than attempt repair. A good illustration of this is a tunnel end or corner. The replacement section could be cut from a condemned cell if new part is not available.

62 Fabric fitting collars which are damaged by installation must be torn out to the fitting opening. To repair, remove the fabric collars by working a small amount of ethyl alcohol (Item 24) under the edge, lifting the collar until it is removed. Repair tear in cell ply by overlapping and heat sealing a narrow strip of nylon fabric (Item 23). Apply collars to cell and cut holes, using holes in cell fabric as a guide.

63 If a Pliocel cell is to remain without fuel for a period exceeding seven days, fog the inside of the cell with a solution of equal parts of water and glycerine (Item 29). If spray equipment is not convenient, make the application with a lintless cloth moistened in the solution. Prior to installation of the Pliocel cell in the aircraft or before any repair, remove the residual solution with a cloth well moistened with water.

METHOD OF CHECKING TEMPERATURE OF SEALING IRON

64 To check temperature of sealing iron, proceed as follows:-

(a) Simulate the repair with pieces of scrap repair fabric (Item 23) and cellophane (Item 25).

(b) Apply heat to approximately two square inches until cellophane is slightly browned.

(c) Roll down with cold roller.

(d) Dampen and remove cellophane.

(e) Pull the sealed pieces apart and note their appearance. If all the nylon film has adhered to one piece of material and the remaining piece has bared fabric, the iron temperature is correct and the seal is satisfactory. If, when applying the iron to fabric, it blisters immediately or turns dark brown, the iron is too hot. Pull plug and cool for a few minutes before applying the iron again.

PREPARATION OF NYLON PAINT

65 To prepare nylon paint, heat liquid nylon (Items 26 and 27) in a small double boiler or glue pot to 150° to 160°F. (Minimum temperature 130°F.) Maintain this temperature range during the working period. Heat only the amount of nylon to be used each day.

66 Between applications keep the brush either in the liquid nylon or in a container of ethyl alcohol (Item 24). Do not allow nylon to dry on the brush. Clean thoroughly at the end of each working period in ethyl alcohol (Item 24). Use brushes on one material only unless cleaned thoroughly with the proper solvent.

HANDLING AND PACKAGING

67 Prior to packaging, treat cell interior with water-glycerine solution. For further instructions, refer to paras. 56 and 57, preceding.

MATERIAL SPECIFICATIONS

68 For table showing item numbers, materials, specifications and manufacturer, see Figure 15.

Item No.	Material	RCAF Ref	Specification	Manufacturer
1	Oil, Engine, Grade 100	34A/17	3-GP-100A	
2	Cleaner	33C/182	3-GP-8	
3	Oil, Engine SAE 10W	33C/35	3-GP-45	
4	Talc	33C/11	MAT-2-1	
5	Clay, Bentonite			
6	Soap, Paste	33CM/25	2-GP-4A	
7	Rubber, Synthetic, Buna-N .038"-.062"	32C/		
8	Rubber, Synthetic, Buna-N .020"	32C/		
9	Rubber, Synthetic, Buna-N .045"	32C/		
10	Cement, Synthetic Base, Aromatic Fuel Resistant	33G/116	MIL-P-9117	
11	Cloth, Emery, 40 to 80 grit	29/1833 to 1840		
12	Solvent, Cement, Methyl Ethyl Ketone	33C/520	TT-M-261	
13	Lacquer, Buna Vinylite	33A/	SPEC 1727	Dominion Rubber Montreal PQ.
14	Sheet, Sealant, Fuel cell, Self-sealing .110 gauge	32C/		
15	Cement, Sealing, Synthetic Rubber No. 4006	33G/116	MIL-C-9117A	B.B. Chemical Co. of Canada Box 1447 Montreal
16				
17	Primer, Ty-Ply, BN	33A/462	MIL-P-6889A	
18	Compound, Bubble-soap (dilute 1 to 10)			B.W. Deane & Co. 3620 Namur Montreal
19	Cloth, Aloxite			
20	Naphtha	33C/653	TT-N-95	

Figure 15 (Sheet 1 of 2) Table of Material Specifications

Item No.	Material	RCAF Ref	Specification	Manufacturer
21	Methyl Isobutyl Ketone			Technical Grade
22	Acetone	33C/417	15-GP-50	
23	Fabric, Pliocel Repair Material, FT 45			
24	Alcohol, Ethyl	34A/214	3-GP-525	
25	Cellophane, Water-permeable, 6" wide			Commercial Grade
26	Nylon, Liquid blue 5073C			
27	Nylon, Liquid yellow 5074C			
28	Cement, Chemigum coating 5071C (consists of 5070C and 1408C)			
29	Glycerine	14B/43		
30	Detergent	33C/667		

Figure 15 (Sheet 2 of 2) Table of Material Specifications