CF-105

MAINTENANCE FEATURES OF RUBBER FUEL CELLS

LOG/105/19

January 1956

Prepared by: G. Emmerson
Approved by: J.P. Booth

AVRO AIRCRAFT LIMITED, MALTON, ONTARIO

CONFIDENTIAL

1. INTRODUCTION

This report deals with the maintenance features of Rubber Fuel Cells. Information contained in this report is based on experience with the CF100 rubber fuel cells, and on airline experience with aircraft equipped with rubber fuel cells.

2. FUEL CELL LIFE

(a) Shelf Life

U.S.A.F. - 6 years
Dominion Rubber - 4 - 5 years

For information on storage recommendations refer to page 3 of enclosed Process Standard No. 39.

(b) Aircraft Life

Maximum achieved - 9 years

The aircraft life of a rubber fuel cell depends largely on the preparation of the structure to receive the cell and the method of installing the cell. The number of times the cell is removed and replaced, also has a serious effect on cell life. The nine years mentioned above was achieved with a rubber cell that never had to be removed during that period.

General precautions to consider when installing and removing rubber fuel cells are covered in paragraph 4 and 6 of the enclosed process standard No. 39.

3. CF100 EXPERIENCE

(a) During the early stages of the CF100, considerable trouble was experienced with the bladder type fuel cells because of general inexperience with the installation, resulting in damaged cells. This was usually caused by insufficient covering of projecting nuts, screws, flanged members etc. resulting in torn or chafed cells. Improper torqueing of various pipe clamps also resulted in pinched cells which caused leaks. These problems were gradually overcome however, but the "breaking-in" period extended well over the first year of the flight test program.

(b) On several occasions it was found that the cell became porous and fuel actually sweated through the rubber walls, necessitating the removal and scrapping of the cell.

(c) The use of screwdrivers is a definite hazard as far as the cells are concerned. A small nick by a screwdriver will frequently not show up for some time and usually only after the tank has been subjected to considerable fuel surge.

(d) On the CF100, the refueling nozzle, unless carefully positioned, would scrape the bottom of the wing cells and cause leaks. This, of course, does not apply to the CF105 installation although the general servicing of the fuel system valves, level sensing units, capacitance gauges and piping will demand that the servicing personnel enter the cells. This could conceivably result in some damage to the cells.

4. AIRLINE EXPERIENCE

Based on a report from Eastern Airlines, preference is definitely given to bladder type fuel cells. The report contains information concerning the cost of maintaining the integral and Bladder type fuel tanks.

The following statistics are given to substantiate their preference for bladder type fuel cells:

(a) The cost of maintaining integral tanks on 13 Lockheed 1049 Constellations during the year 1952 averaged $26.00 per aircraft or $93.00 per 1000 hrs.

(b) The cost of maintaining Bladder Type Fuel Cells in 33 Martin 404 Aircraft during the year 1952 averaged out to $.05 per aircraft or $.24 per 1000 hours.

Eastern Airlines Comments on the Merit of Bladder Type fuel cells are as follows:

"There have been no maintenance problems on the bladder type fuel tank to date. Only one cell has been removed and this was due to an accumulation of rivet heads inside of wing chafing a small hole in one cell. This was a result of failure to remove rivets from wing before cells were installed at the factory.

A leak was detected at one spider fitting. This was a fault of installation and needed only tightening.

Personnel concerned with maintaining fuel cells are very favorable toward the bladder type fuel cells."

5. UNITED KINGDOM EXPERIENCE

Gloster

(a) Rubber cells, manufactured by Marston Excelsior Ltd., are used on the Javelin. They have experienced no trouble with the installation and propose that the following care be taken with rubber cell installation:

(1) Space attachment buttons correctly to avoid wrinkling.
(2) Carefully clean bay to prevent rivet mandrels from tearing tanks.
(3) Tape rivets.
(4) Avoid awkward shaped cells.
(5) Place covers over holes in the structure into which the rubber buttons are attached.

(b) Fireproof Tanks Limited

All tanks are guaranteed for two years. At this point they are removed from the aircraft and inspected. They are then re-certified and replaced for another 12 months and so on.

"Depending upon the design of the structure and the restriction of free air flow to a minimum, there is no real limit to the life of the cell."

They have tanks still in service after ten years.

(c) Westland

"If the tanks are properly manhandled, they should last the life of the aircraft.

On the Wyvern, the defect rate per 1000 hours was 3.2 for the quarter ending 31st March 1954.

The total defects were 9 in number and only 2 of these were leaks (subsequently found to be caused by drills).

Initial trouble with Ozone attacking the tanks was cured by the use of nylon net covering."

6. CF105 RUBBER FUEL CELLS

(a) Location

The two rubber fuel cells are of "triple bubble" cross section, and

are located in the fuselage between the engine air intake ducts above the armament bay including the greater part of the dorsal fairing from Sta. 315 to 480.

Access to the tanks is available by removing two dorsal fairings (6 latches each) and by unbolting 2 access panels in the fuselage structure (36 screws each).

(b) Attachment

Running laterally through the fuel cells, are fuselage tie rods, attached at each side of the fuselage to former rings.

The fuel cell sealing arrangement at the fuselage tie rods is shown on the enclosed drawing. This attachment also helps to support the tank.

Conventional attachment buttons similar to those used on the CF100 fasten the cell to the fuselage structure. The cell is attached around the tank access door by sealed screws and anchor nuts.

(c) Equipment Installed Inside the Fuel Cell

The following equipment is installed inside the cells:

Tank Shut off Valves
Air No Fuel Valves
Fuel No Air Valves
Level Sensing Valves
Flow Limiters
Tank Capacitance Units
Piping.

The method of sealing the mounting brackets for this equipment is shown on the enclosed drawing.

(d) Leak Detection

A trough is installed along the structure at the bottom surface of the fuel cells. In the event of a fuel leak, the fuel will run to the trough and will be carried back through piping to the flame trap on the bottom of the fuselage where it will run overboard.

Any sign of fuel at the flame trap will indicate a fuel leak. It will be necessary then, to isolate the leak to one tank by unscrewing a fitting in the line under each tank.

(e) Condensate Drain

A condensate drain fitting is located on the bottom of the fuselage at approximately Sta. 480.0. This fitting is connected by piping to a drain fitting at the bottom of each fuselage cell. By pushing up a spring loaded valve, the condensate may be drained off. This is planned as a daily operation.

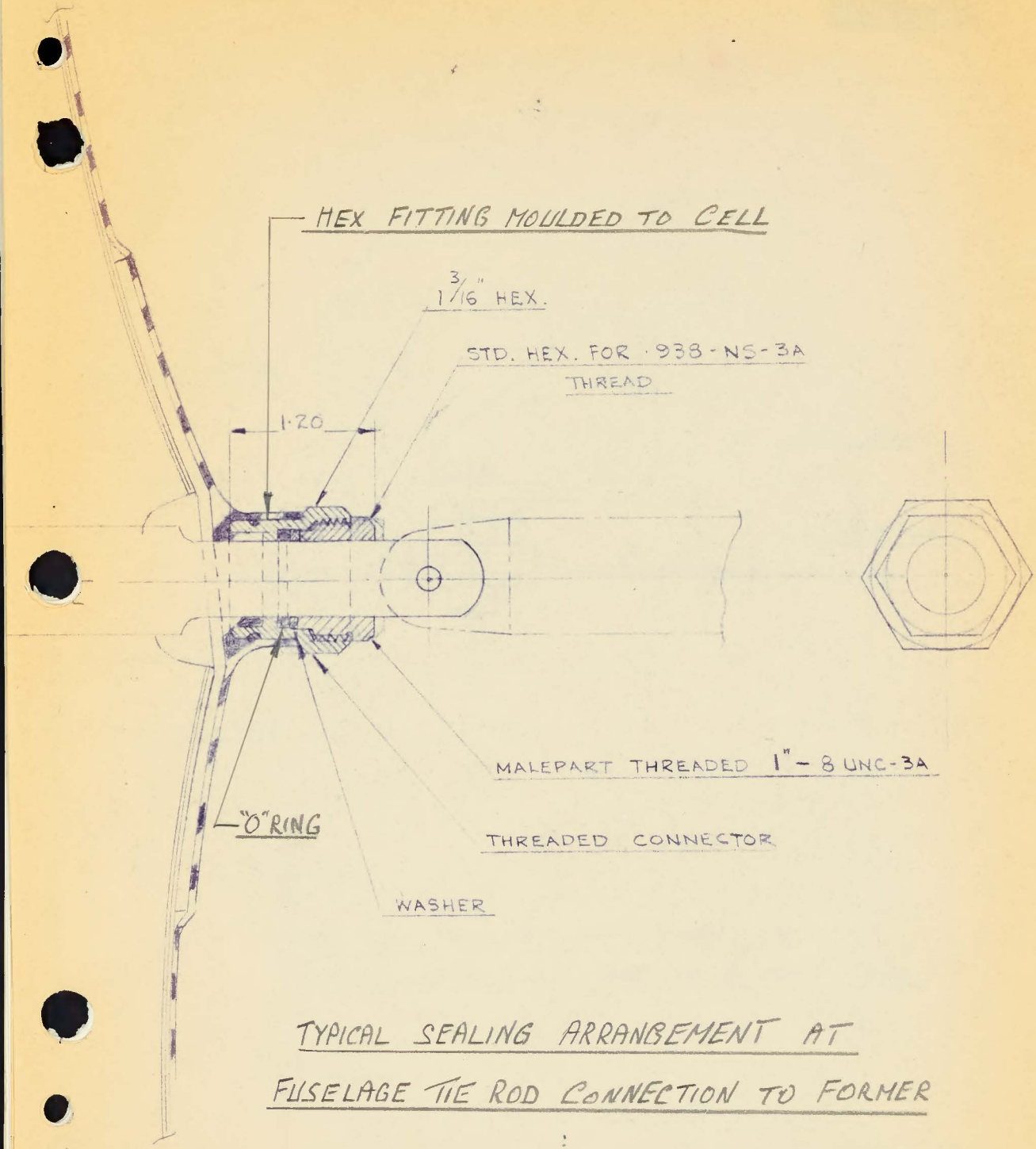
(f) Cell Removal

The procedure for removing the Forward Fuselage Fuel Cell (Cell #1) is outlined. The procedure for removing Cell #2 is similar.

Removal Procedure

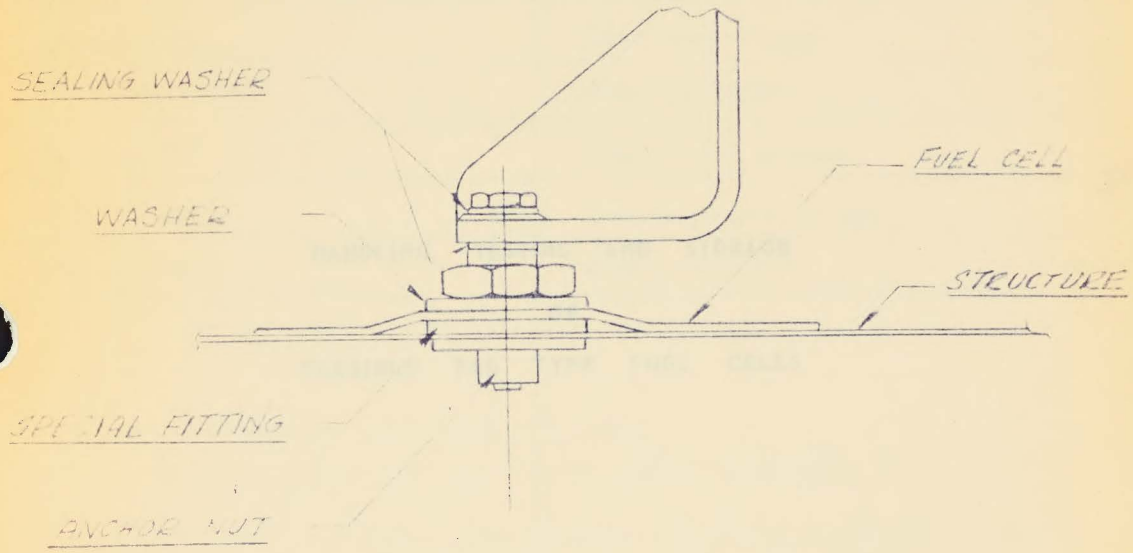
1. Remove dorsal fairing by undoing 6 latches.
2. Remove tank access panel by undoing 36 screws.
3. Remove all fuselage tie rods.
4. Remove Capacitor Units at rear and front of cell.
5. Undo wraplocs on $\frac{1}{4}$ in. lines and remove $\frac{1}{4}$ in. lines by undoing 14 flareless tube fittings.
6. Remove hanger assemblies at Stn. 370, 359 and 348 by undoing 12 bolts.
7. Undo Wig-o-flex coupling on vertical pipe and on left hand line No. 32.
8. Remove pipe #12P.
9. Undo Wig-o-flex coupling at forward Fuel No Air Valve and in line No. 13P.
10. Remove Level Sensing Valve by undoing 2 electrical connectors and 4 bolts.
11. Remove forward Fuel No Air Valve - 4 bolts.
12. Undo Wig-o-flex at top and bottom of vertical pipe and remove pipe.
13. Undo top and bottom Air No Fuel Valve and remove - 8 bolts.
14. Undo and remove aft Fuel No Air Valve and remove - 1 Wig-o-flex coupling and 4 bolts.
15. Undo Shut-off Valve and remove - 1 Wig-o-flex and 4 bolts.
16. Undo Air No Fuel Valve at Sta. 392 and remove - 1 Wig-o-flex coupling and 4 bolts.
17. Remove condensate drain by undoing 2 bolts and 1 connector in Armament Bay.
18. Undo bag slide type hangers - 8 off.
19. Detach rubber cell from tie rod attachment fittings on the formers.
20. Remove cell through access door.

NOTE - It is recommended that a rubber mat be laid down on the bottom of the rubber cell during the removal of piping and equipment.



TYPICAL SEALING ARRANGEMENT AT
FUSELAGE TIE ROD CONNECTION TO FORMER

CONFIDENTIAL



TYPICAL BRACKET ATTACHMENT TO
FUSELAGE STRUCTURE THROUGH RUBBER CELL

CONFIDENTIAL

CONFIDENTIAL

AVRO AIRCRAFT LIMITED

PROCESS STANDARD NO. 39

PROCESS STANDARD

HANDLING, TESTING AND STORAGE OF FLEXIBLE BAG TYPE FUEL CELLS

Original signed by:

COMPILED BY _____

TECHNICAL APPRDVAL W. F. Sloan

PRDDUCTION APPROVAL E. Scott

INSPECTIDN APPROVAL W. Parish

ISSUED BY

STANDARDS SECTIDN

DATE June 26, 1953

CONFIDENTIAL

RECORD SHEET

P. S. No. 39

DATE	CHANGES
June 26, 1955	Basic Issue 5 pages
September 1, 1953	Page 1 re-issued
May 30, 1955	Pages 4 & 5 re-issued
July 4, 1955	Complete re-issue 4 pages
July 25, 1955	Page 1 re-issued

CONFIDENTIAL

HANDLING, TESTING AND STORAGE OF FLEXIBLE BAG TYPE FUEL CELLS

1 GENERAL

This Process Standard lays down the procedure to be followed for the testing, installation, inspection, removal and storage of flexible bag or bladder type cells as used in the C100 aircraft.

2 RECEIVING TESTING OF CELL

The fuel cell is received in a container in which it may be stored for an appreciable time under the proper storage conditions, and therefore no receiving test will be necessary and the container is not to be opened until the cell is required for installation in the aircraft.

3 PRE-INSTALLATION TESTING OF CELL

The fuel cell may be tested as follows prior to installation in the aircraft, at the option of Production.

(a) Place the cell on a clean bench and put approximately 1 gallon of kerosene into it.

(b) Plug all air and fuel openings in the cell.

(c) Inflate the cell with compressed air to 1/4 p.s.i. maximum pressure.

(d) Sprinkle powdered chalk onto the cell and dust all over the outer surface. Any dampening of the chalk may indicate porosity or leakage. To verify the leakage, however, the suspect area must be cleaned with a cloth dampened with methyl ethyl ketone and after a lapse of approximately 5 minutes, again tested with chalk. R

NOTE: This cleaning procedure also applies to any area which has been inadvertently wetted with kerosene prior to the chalk test.

(e) After the test is completed, drain the cell and smear the rubber surface on the inside of the cell with light engine oil (SAE10). This will prevent the cell from cracking or drying out due to the removal of plasticizer from the rubber laminations. The cell will remain flexible for approximately 12 hours after having been drained, and may be handled during this time without the oil treatment.

CONFIDENTIAL

4 INSTALLATION OF CELL

The cells must be installed in the following manner:

(a) Inspect fuel cell compartment to ensure that it has been thoroughly cleaned of all filings, trimmings, loose washers, bolts or nuts etc. and that all sharp projections have been filed smooth or protected. Ref. P. S. 36.

(b) Sharp tools such as screw drivers or files must not be used in the installation of flexible fuel cells.

(c) The cell must be rolled into a roll, installed in its compartment and then developed out to its full size and the hanger fittings connected.

It should not remain in the folded or collapsed condition longer than necessary. The cell may most easily be handled at temperatures above 40°F but no danger of cracking exists at temperatures considerably below this figure.

(d) The sealing or compression surfaces must be assembled when absolutely dry. No sealing paste is to be used.

(e) Where torque is to be applied to bolts, nuts and studs used in connection with the fuel cells, it must be applied in the following manner:

A final torque of 35 in. lbs. ± 5 in. lbs. must be applied to all bolts. Where stop nuts are used the nuts must be run on the bolt with the fingers until the locking area is reached. A torque wrench must then be applied and the nut run through the lock and a reading taken. This reading must be added to the final torque value of 35 in. lbs. ± 5 in. lbs. and the nut torqued to this total value. There must be no repetition of torquing after its first application without first backing the nut off completely and following the above procedure again.

Should over torquing occur, all the attachment bolts in the fitting must be re-torqued as well as the over torqued bolt itself.

Wittek type finger screw clamps, where used on the fuel cell interconnecting pipes, must be tightened finger tight and then given a quarter turn using pliers.

NOTE: The torque value given supersedes all previous torque values as indicated by decals affixed to the cells etc.

(f) To aid in the fitting of the fuel cell interconnectors on assembly to the aircraft, soap solution, simonize, or No. 10 engine oil may be used as a lubricant.

(g) Care must be exercised when fastening or unfastening the snap fasteners that the fastener is tilted slightly to one side before snapping or unsnapping.

(h) Ensure that hanger end protectors are removed before final closure of the cell compartment.

5 INSPECTION

The following inspection procedure is necessary when inspecting the fuel cell prior to final closure of the cell bay

(a) Inspect the cell for final fit within its compartment, making certain that the cell is extended out to the structure and that no corners are folded in.

(b) Inspect the cell for cleanliness prior to fitting accessories.

(c) Inspect all accessories for cleanliness immediately before assembly to the fuel cells and ensure that no foreign matter enters the cells during accessory installation.

(d) Finally, on completion of all installations and pressure tests, cells must be inspected, as far as possible, from the filler cap aperture as an extra check against foreign matter being left in the cell.

6 REMOVAL OF CELL

If it is necessary to remove the cell from the cavity or to deform it inside the cavity, the operation must be performed within 12 hours of the cells having been completely drained. If, however, a little kerosene is left in the cell it will keep it pliable for several days. If the cell is in a completely drained condition, and has been left longer than the 12 hour period, it must be rubbed, flushed or sprayed with light engine oil (SAE10) and left for 24 hours before handling.

(a) Disconnect all fittings, hangers, snap fasteners etc., and fit the hanger ends with protective rubber hose 1½ in. long by ½ in dia. before collapsing the cell.

(b) Collapse cell to as near the completely collapsed condition as possible and roll into a roll before removal from its compartment.

(c) Care must be exercised when removing the cell from its compartment that it does not drag over any sharp edge or projection.

(d) After removal the cell must be placed on a clean, smooth surface and extended out flat to its full size.

7 STORAGE

7.1 The two most commonly used conditions of storage are listed below, together with the necessary precautions which must be taken.

7.1.1 In a wing which has been completed ready for installation on an aircraft, with fuel cells which have been fully installed and tested with air. In this case no preparation of the fuel cell for storage will be necessary. The cell wall may possibly harden due to leaching out of the plasticizer by high temperatures, but the plasticity will be restored when the cell is filled with fuel, and as no further handling of the cell will be required, no difficulties should be experienced.

7.1.2 In the container in which the cell is shipped. To avoid leaching out of the plasticizer in this case, the following precautions must be observed:

(a) Do not remove cell from its shipping container until needed for installation in the aircraft.

(b) Do not store fuel cells near heat or in extremes of humidity, whether high or low.

(c) Do not allow fuel cells to remain longer than necessary in any strong light.

(d) Fuel cells must not be stored directly beneath forced air type electric motor driven heaters, as "ozone" from arcing electric motors causes deterioration of the fuel cell walls.

(e) Store cells in such a manner that their shipping containers are placed level and, when necessary to stack more than one high, ensure that the containers are placed squarely on each other so as to preclude any danger of slipping and of the sharp edge of one container perforating another.

7.2 Fuel cells which have contained fuel and are completely drained for repair or storage must not be handled after 12 hours from the time of being drained, or left for more than 10 days without first applying light engine oil to the inner liner, otherwise cracking of the inner liner will occur.

7.3 Fuel cells removed from aircraft for storage must be inhibited by applying No. 10 engine oil to the inner liner and the cell tagged with a warning tag stating that the hanger end protectors are fitted and must be removed before closure of the cell compartment during installation. The cell must then be stored under the conditions described in 7.1.2 in an approved type container.

7.4 Should shrinkage of the fuel cell occur, when stored for long periods, it may be restored to normal size by immersion in water at room temperature ($70^{o}F$) for 24 hours.

8 GENERAL PRECAUTIONS

(a) Do not work inside fuel cells with tools or sharp projections on person or with shoes on.

(b) When working inside the cell do not allow hot light bulbs to come in contact with the cell outer or inner surfaces.