Part I

Chapter 3—Flight Refuelling System

List of Contents

Description

1 General

(*a*) A probe and drogue flight refuelling system is fitted. The system is fitted. The system has its own controls and allows fuel to flow into the normal fuel system, whilst the aircraft engines are run on fuel delivered under pump pressure from the fuselage group.

(*b*) Refuelling is controlled from the cockpit by the second pilot. Individual selection of the following groups is possible:

Port and starboard wing tanks
Fuselage tanks
Port and starboard drop tanks
Forward and aft bomb-bay tanks.

(*c*) The probe is positioned between the pilots' escape hatches and extends forward so that the pilot can comfortably see the probe head whilst flying on to the drogue. The fuel delivery pipe runs through the starboard side of the crew compartment until it passes through the pressure bowl behind the navigator's table. The pipe is then divided between the wing and fuselage refuelling lines.

(*d*) A non-return valve is in each of these lines and a third NRV is in the probe line aft of the cabin to prevent flowing back through the probe.

2 Nitrogen purging system

(*a*) This system is provided to empty the refuelling line passing through the cabin after refuelling thereby minimising the fire risk.

(*b*) Two high pressure nitrogen bottles charged to 1,800 PSI provide the supply which is reduced to 10 PSI in the probe line. With the system in operation the nitrogen forces fuel from the probe line to No. 7 tank, starboard, via a float chamber. This float chamber is normally full during initial purging but as the fluid level falls towards the end of purging a float switch operates to indicate that purging may be discontinued.

Controls and Indicators

3 Flight refuelling controls

(*a*) During refuelling the proportioner switches of tank groups being refuelled are set to REFUEL and the wing and fuselage

tanks to be refuelled are selected by seventeen IN USE—NOT IN USE switches on panel AF. Magnetic indicators on panel AAJ give NORM—REFL—BYP indications.

(*b*) The drop tanks and bomb-bay tanks are selected for the refuelling condition by setting their booster pump control switches to REFUEL.

4 Nitrogen purge control and indicator

The PROBE PURGE ON—OFF switch is also on panel AJ and when set to ON, purging takes place. A magnetic indicator shows white when this is taking place. When purging is complete and the float switch in the float chamber between the probe and tank 7(S) operates, the indicator reverts to black. This is an indication to switch off the system.

5 Probe lights

Two lights are mounted on a fairing below and focussed on the probe. A double pole switch on panel AB can be used to select either light and the light intensity is controlled by a dimmer switch on panel AT.

Normal Management of the System

6 CG control and wing fuel asymmetry

(*a*) It has been assumed that pre-flight planning has ensured that the CG will remain within normal limits throughout the flight, including landing with stores and 10,000 lb of fuel. It has also been assumed that fuel quantities to be transferred in flight have been planned to conform with normal loading conditions. The flight plan must be examined to establish the following for reference in the event of action being necessary due to malfunction:

(i) The minimum distance of the CG aft of the forward limit at any time during flight. To be recorded as CG margin forward.

(ii) The minimum distance of the CG forward of the normal aft limit at any time during flight. To be recorded as CG margin aft.

(*b*) The failures allowed for in the drill will, in some cases, cause the CG to move outside the normal limits and/or asymmetrical fuel distribution to occur; in these circumstances the following extended limits are permissible:

(i) Longitudinal CG—6 inches forward to 2 inches aft of the present limits.

(ii) Wing fuel asymmetry may be at the maximum in flight, but must be less than 8,000 lb for landing. When use is made of these extended limits, gentle manoeuvres only are permitted, speed must not exceed 0·85M and the auto-pilot must not be used.

(*c*) (i) The maximum rolling moment is 320,000 lb/ft and this is exceeded when one drop tank is empty and the other is full.

(ii) If the CG or wing fuel asymmetry limits are exceeded they should be regained by selective use of fuel as soon as possible and to reduce wing fuel asymmetry to less than 8,000 lb before landing. Adequate aileron control exists at maximum fuel asymmetry in flight and for landing with asymmetry less than 8,000 lb.

(*d*) To keep the CG within limits in certain cases of failure when full refuelling is intended starting with a minimum of 6,000 lb of fuel in the fuselage group, the following restrictions apply:

(i) If the port wing refuelling cock fails to open, do not refuel the drop tanks and restrict the contents of the rear bomb-bay tank to 4,000 lb.

(ii) If the starboard wing refuelling cock fails to open, do not refuel the drop tanks.

(iii) If No. 1 tank port or starboard fails to receive fuel, the rear bomb-bay tank contents should not exceed 5,500 lb; if both bomb-bay tanks are to be filled, the total contents of the fuselage tanks should not exceed 21,000 lb.

(iv) If No. 7 tank port or starboard fails to receive fuel, the total contents of the remaining fuselage tanks should not exceed 22,500 lb and the contents of the rear bomb-bay tank should not exceed 2,800 lb; if both bomb-bay tanks are to be filled, the total contents of the fuselage tanks should not exceed 13,000 lb.

(v) If any failure results in the forward bomb-bay tank failing to receive fuel, the rear bomb-bay tank contents should not exceed 2,800 lb.

7 Transfer procedure

(*a*) *General*

The drills for refuelling and malfunctioning procedure are contained in the Flight Reference Cards and must be used at all times. These drills allow for any single failure case. If a double failure occurs, refuelling may still be carried out but care is required.

(*b*) *Before contact*

(i) Before carrying out dry contacts, select the wing or fuselage groups as required, keeping the wing refuelling cocks closed.

(ii) Before carrying out wet contacts switch off the fuel tank pressurisation 15 minutes before contact, check and note the fuel gauge readings and the amount of fuel to be received, ensure that the fuselage group contents are not less than 6,000 lb, fly on the fuselage group with its proportioner at BYPASS and switch off the wing groups.

(iii) Immediately before contact, select all groups that are to receive fuel to REFUEL and, when the drop tanks are to be refuelled, select the drop tank isolation cocks open. The wing refuelling cocks must be closed to ensure that any air in the probe or the fuel lines is passed to the fuselage tanks and not to the engines during the intial transfer of fuel. The wing isolation cocks must be closed before commencing refuelling to prevent high fuel pressures reaching the engines and recuperators.

(iv) If the fuel tank pressurisation gauges indicate a pressure of 2·75 to 5 PSI, refuelling may be carried out. If pressure is above 5 PSI, refuelling must not be carried out.

(*c*) *In contact*

(i) After contact, the fuel gallery pressure gauge starts to register. With the tanker main pump operating and tanks receiving, the pressure should be 5—45 PSI; the fuel flow is approximately 4,000 lb/min., reducing slightly as the tanks fill. If the tanker main pump is not operating, the fuel flow is approximately 1,500 lb/min. Once fuel is seen to be flowing to the fuselage tanks, open the wing refuelling cocks.

(ii) While fuel is being received, ensure that the limits in para. 6 are not exceeded, particularly in cases of wing refuelling cock failure.

(iii) To prevent high fuel pressures rupturing a fuel tank following the failure of two or more high level float switches, tanks are not to be filled completely and the maximum permissible group contents are as follows:

Wing groups
13,700 lb each

Fuselage group
27,000 lb.

If before contact, a tank is more than 400 lb out of proportion, the appropriate maximum permissible group contents must be decreased by the same amount.

(iv) When filling one bomb-bay tank only, stop refuelling it when its contents reach 7,000 lb.

(v) When filling both bomb-bay tanks, stop refuelling the first tank to reach 7,000 lb then, provided that fuel flow ceases, allow the other tank to fill completely. If fuel flow to the first tank does not cease, stop refuelling the other tank at 7,000 lb. If fuel continues to flow to both tanks, break contact immediately.

(vi) When filling the drop tanks, stop refuelling each tank when its contents reach 10,000 lb; refuelling beyond 10,000 lb is safe but results in fuel venting.

(vii) If, at any time, the magnetic indicator of one proportioner cell in any fuel group flickers or shows steady striped, stop

refuelling the appropriate group. If a No. 5 or 6 tank, port or starboard NRV indicator shows striped, close the appropriate wing refuelling cock.

(viii) To stop refuelling, close off sequentially each group receiving fuel starting with the fuselage group, or close the wing refuelling cocks, or break contact. When still in contact with no tanks receiving fuel, the fuel gallery pressure may surge as high as 65 PSI.

(ix) When refuelling the fuselage group only, if the wing refuelling cocks are shut, refuelling must be stopped only by shutting off the tanks individually or by breaking contact.

(x) When refuelling the drop tanks only, refuelling must be stopped by shutting off the tanks one at a time.

(*d*) *After refuelling*

(i) When refuelling is complete, break contact, close the wing refuelling cocks, open the wing isolation cocks, operate the probe nitrogen purge system and then switch the fuel tank pressurisation on. Revert to the normal fuel handling procedure.

(ii) If necessary, use fuel selectively to achieve wing symmetry and transfer fuel internally to satisfy wing relief and CG requirements.

Normal Procedures and Handling

8 Initial approach

WARNING. When a red or green light, or no lights are showing on the hose drum unit, contacts must not be attempted. Contacts are only permissible if amber light(s) are showing. If, when in contact, a red light comes on or all lights go out contact must be broken immediately.

(*a*) The speed range is from 210 knots at AUW's up to 180,000 lb (increasing linearly to 225 knots at 210,000 lb) to 310 knots from sea level to 24,000 feet reducing linearly to 260 knots/0·85M at 40,000 feet. The recommended range is 240 to 270 knots.

(*b*) The recommended relative closing speed is 2 to 3 knots (maximum of 5 knots) which should be used approaching from below and dead astern, keeping the signal lights in view at all times.

(*c*) When waiting to commence and approach, the receiver should be positioned behind and to the starboard of the tanker in case the hose becomes detached while being trailed or wound in.

9 Final approach and contact

(*a*) Make the final approach from dead astern and below the drogue, so that the pilot is looking along the line of the hose. Set power to maintain the correct closing speed and, from about 40 feet, adjust speed by visual judgment rather than by reference to the ASI. Accurate and steady flying is required and over-controlling must be avoided. To this end it is important that the seat is adjusted to a comfortable position so that the pilot does not have to lean forward to get an adequate view of the probe. When about 5 to 10 feet short of the drogue a moderate buffet is felt, accompanied by a slight nose-up change of trim as the tail unit of the aircraft enters the tanker's slipstream. At this point a small increase of power may be needed to maintain the closing speed. As the probe enters the drogue, mild buffeting is experienced, accompanied by considerable noise.

(*b*) Once contact has been made and the probe is positively coupled to the drogue, fly the aircraft gradually up the line of the hose until the refuelling position is reached; keep the curve of the hose concave to the receiver. A slight reduction of power is then needed to maintain the refuelling position.

(*c*) The recommended refuelling position is achieved when the forward edge of a 10 feet long yellow band on the hose is just entering the serving carriage of the HDU. Seven feet of the hose must be wound in before the tanker fuel valve opens. When the valve is open, the tanker lights change from amber to green and the fuel gallery pressure gauge on the 2nd pilot's instrument panel starts to indicate. Continue the approach until the recommended position is reached.

(*d*) Due to the line of trail of the hose it is difficult to see the yellow band unless it has been freshly painted; the correct refuelling position is reached when the hose is wound in until the serving

carriage of the HDU is one-third of its travel in from the right-hand side.

10 In contact

Once in contact, make small control movements to hold the correct station, dead astern of the tanker, with the yellow hose markings showing and the signal lights visible and guard against any tendency to over-correct. Avoid carrying the hose excessively downwards or sideways or probe damage may occur; carrying the hose higher than the normal line of trail may induce a sharp nose-up change of trim. It is difficult to achieve a permanent in-trim condition. Coarse throttle movement may be necessary to hold station but, normally, make small movements only. With the throttle friction damper fully off, throttle movement is comfortable.

11 Breaking contact

(*a*) *Normal procedure*

(i) To break contact, reduce power slightly and allow the aircraft to fall astern gradually. Hose unwinding should be controlled at a slow rate by throttle movement. When the last seven feet of the hose is coming off the drum, the signal lights change to amber if the tanker valve has not already been closed. Aim to break contact with the drogue in its natural position so that it can be watched as it draws away. If contact is broken in any other position the drogue will oscillate over a wide area about its normal position.

(ii) If contact is broken with the receiver aircraft riding high, it is possible that the drogue may strike the feel intake. To reduce this possibility and to avoid the danger of being struck by an oscillating drogue, when the last few feet of the hose which are marked with red and white stripes are being unwound, close the throttles to the idling gate. This ensures a swift deceleration once contact has been broken, but, providing that it is not done too soon, should not cause the hose drum brake unit to operate.

(iii) If the red and white stripes are difficult to see, it should be noted that the serving carriage of the HDU is at the left-hand end of its travel when the last few feet of the hose are being unwound.

(*b*) *Emergency procedure*

If a red light comes on, or if all lights go out, or if it is necessary to break contact quickly for any other reason, close the throttles fully and select airbrakes out to ensure that the deceleration rate is sufficient for the hose to reach a speed of 5 ft/sec when its brake is automatically applied, and contact is broken. This method should only be used in emergency conditions or for training purposes as it throws a heavy load on the hose drum unit.

(*c*) *Clearing the tanker*

When contact is broken some fuel splash occurs. This causes no embarrassment to the pilots, since it passes above the line of vision, striking the fuselage at a point above the pilot's head.

12 Incorrect contact

(*a*) If the probe misses the drogue, close the throttles and withdraw to a safe distance along the approach path as the aircraft decelerates.

(*b*) If the probe hits the outer rim of the drogue, the hose may wind in. If this occurs, withdraw behind and to starboard of the tanker while the hose is retrailed.

(*c*) If the probe penetrates the canopy or spokes of the drogue, withdraw along the approach path to break contact with the drogue in the natural posittion; if necessary, wait for the hose to be retrailed.

(*d*) If the probe appears to enter the drogue but fuel does not flow, a soft contact may have occurred due to the closing speed being too low in the final stages of the approach; the hose may wind in. Withdraw and, if necessary, wait for the hose to be retrailed.