Part V—Emergency Handling

Chapter 2—Aircraft Systems: Emergency Procedures

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1 Powered flying controls failure

(*a*) *General*

(i) Failure of any PFC unit is indicated by the illumination of its surface red warning light at the top of the engine instruments panel. Speed should be reduced immediately to 0·90M or below and the particular surface unit which has failed can be identified by moving the controls and noting on the CSI which unit remains static.

(ii) In the case of the aileron and elevators the surface part which has failed should become static in the "trail" position. If an elevator control has failed, CSI detection requires fairly large stick deflections. Under certain conditions the surface may go fully down, and may do so at varying rates from very slow to very rapid (see Part I, Chap 10, para 2). If this occurs there will be a nose-down change of trim which may be accompanied by appreciable negative G and a tendency to roll away from the failed surface. Experience has shown that the surface may return to a more neutral position with decreased Mach number. Landings can be carried out in this condition without difficulty provided that a long straight approach is made and the runway threshold speed is 150 knots.

(iii) In the event of the rudder PFC failure warning light becoming illuminated the STANDBY rudder motor must first be stopped until it is established which unit has failed. If the main rudder unit is stopped first a runaway may occur. If the rudder operates normally, having stopped the standby unit, then the standby unit is unserviceable and must remain stopped. If, however, the rudder is inoperative the main unit is unserviceable and it must be stopped and the standby unit restarted.

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(iv) Any PFC unit which has failed must be switched off.

(*b*) *Flight with one aileron or elevator unit failed*

(i) If an aileron or elevator PFC unit fails, speed must be reduced to below 0·90M. Additionally, if an outboard elevator fails, the pitch damper must be switched off.

(ii) *Failure below 0·90M.* At speeds below 0·90M the effect of failure of an aileron or elevator unit is hardly noticeable, both in aircraft response and control forces experienced.

(iii) *Failure above 0·90M.* If an elevator unit fails above 0.90M, the push forces required at higher Mach numbers are reduced, and instability may be encountered.

(*c*) *Landing with one aileron or elevator unit failed*:

(i) *With an aileron unit failed*

Rolling performance is slightly reduced at circuit and approach speeds. Carry out a normal approach and landing, but maintain speed at 150 knots for as long as possible on the approach to avoid a reduction in control performance in the event of another unit failing, and to ensure adequate control until the aircraft is lined up with the runway.

(ii) *With an elevator unit failed*

If an elevator has failed in the "trail" position carry out a normal approach and landing. An increased backward pressure will be necessary for the round-out in landing. Speed should be maintained at 150 knots for as long as possible on the approach for the same reason as in (i) above. Should the elevator fail in the fully down position, a straight approach should be made and the speed maintained at 150 knots until the runway threshold is reached (see (*a*)(ii) above).

(*d*) *Flight with half of the PFC motors inoperative*

The following recommendations and limitations for flight with half PFC motors inoperative are based on flight trials:—

(i) Maximum permitted speed 275 knots or 0·90M.

(ii) Aircraft to be restricted to gentle manœuvres only.

(iii) Relieve elevator and aileron artificial feel to alleviate stick forces which are otherwise increased by the spring struts of the inoperative PFC motors.

(iv) If a landing is to be attempted, reduce weight as much as possible and if possible establish a mid or preferably aft C of G position to ensure maximum possible elevator power for flare-out.

(v) At a safe height reduce speed in the landing configuration to check that adequate elevator control is available for landing. The recommended approach speed at maximum landing weight (125,000 lb) is 10 knots above the minimum elevator control speed or 150 knots, whichever is greater, down to the runway threshold. Because of control inadequacies, lower speeds should not be attempted. Final approach angle should be shallow.

(vi) Select an airfield offering longest into-wind runway and calmest air conditions.

(vii) Augment rate of roll by use of rudder, particularly at low speeds, as on approach, where rate of roll is low.

2 Artificial feel failure

(a) If feel failure occurs it will be shown by the 1st pilot's master warning indicator showing white and the relevant feel indicator at the top of the engine instruments panel also showing white.

(*b*) The consequence of feel failure to the low value is that the aircraft could very easily be over-stressed through over-application of control, and the aircraft speed must be limited to 275 knots. If the aircraft is above this speed at the time of failure, care should be taken that while reducing speed the use of rudder is avoided altogether and elevator application is restrained, constant reference being made to the accelerometer to ensure G limitations are not exceeded. While above 275 knots great care must be taken in applying aileron and only small control deflections must be used

and manoeuvres in roll must be severely restricted. Once below 275 knots the aircraft can still be over-stressed very easily by use of elevator or rudder, since the feel will be equivalent to a speed of 80 knots in the case of the elevator and 140 knots in the case of the rudder. Care should, therefore, be taken to avoid large deflections of these controls. The aileron may be used normally below 275 knots with the artificial feel inoperative.

(*c*) Should a feel failure occur which causes the system to stay at the high value, the forces required to manoeuvre will remain high even at low speeds. Normal flight should be continued in this condition but more use of the trimmers will be necessary. To obtain low forces for the circuit and landing the low speed feel condition should be selected by operating the appropriate feel relief button.

(*d*) Post-Mod. 1927. After unlocking the feel, if a failure has occurred, the relevant feel indicator and master warning indicator remain white, the feel should be relieved and speed maintained below 250 knots.

(*e*) Certain electrical faults can occur without any feel indications appearing. If, at any time, the feel system is thought to be faulty, the feel should be relieved and the speed maintained below 250 knots.

3 Pitch damper and yaw damper failures

(*a*) *Failure of the pitch dampers*

May be indicated by oscillation of the aircraft in pitch. The pitch dampers must be switched off immediately. (See Part III, Chap 2, Para 9(*a*).

(*b*) *Failure of the yaw damper*

May be indicated by oscillation of the aircraft in yaw or by a sudden appreciable side-slip. The yaw damper must be switched off immediately and the aircraft must not be retrimmed until this has been done.

4 Failure of auto-mach trimmer

The handling of the aircraft with the auto-mach trimmer inoperative at speed above 0·86M is described in Part III, Chap 2, para. 8(*b*)(i). If the auto-mach trimmer has failed with the servo extended the magnetic indicator will be white ; it may be possible to retract it by inching the actuator with the reset switch, and retrimming. If the servo cannot be retracted, adequate elevator control will still be available.

5 Elevator feel trimmer and auto-mach trimmer " run away "

(*a*) If a " run away " of either the elevator feel trimmer or the auto-mach trimmer occurs, the effect will be similar, namely an unexpected change of attitude or control forces. The immediate corrective action must be to operate the elevator feel trimmer in the opposing direction.

(*b*) If the auto-mach trimmer has " run away," retrimming will reduce the stick forces and prevent the aircraft exceeding the limitation. An attempt should be made to retract the servo (see para 4 above) and whether successful or not the auto-mach trimmer should then be switched off.

(*c*) If the feel trimmer has " run away ", retrimming on the normal control will isolate the normal elevator circuit, indicated by the elevator and aileron TRIM indicator showing white. Elevator trimming can then be done using the emergency trimming control.

NOTE: To safeguard against delayed action on the part of the pilot when the auto-mach trimmer runs away, a contacting accelerometer cuts out the trimmer if the normal acceleration of the aircraft exceeds 1·7G or is less than 0·7G ; however, once acceleration is again between these values the run away condition will recur until the servo has extended fully.

6 Undercarriage emergency operation

If, after normal DOWN selection, three green lights are not obtained, carry out the following procedure: —

(*a*) Check the hydraulic pressure and if normal continue with (*b*).

(*b*) Check control and indicator fuses for serviceability.

(*c*) Where possible, check the undercarriage visually; if no signs of damage:

(i) Re cycle the undercarriage and

(ii) If three greens are not obtained, operate the emergency air system.

If hydraulic pressure is low, see Part I, Chap. 13, para. 6(*b*) and (*c*).

6A Undercarriage failure to lower

(*a*) *General*

(i) If, after using emergency air, only one main leg is lowered, it is recommended that the aircraft is abandoned. In other cases, if a landing is considered feasible, then the general principle is that all crew stay with the aircraft. Techniques for landing are given in (*b*) below.

(ii) Where practicable, the landing should be made at an airfield equipped with foam-laying apparatus. When landing with one main unit unlocked, the foam strip should be laid along the side of the runway that the wingtip is expected to strike. The foam will act as a lubricant and so delay the start of the ground loop, which imposes a heavy strain upon the undercarriage.

(iii) The possibility of major damage will also be reduced if, after touchdown, the unsupported wing or nose is lowered at a controlled rate whilst the flying controls are still effective, rather than be allowed to drop on to the runway.

(*b*) *Landing Techniques*

(i) *Belly landing*

If, after use of emergency air, all units of the undercarriage remain retracted, it is recommended that the aircraft is belly-landed as follows: —

1 Reduce weight as much as is practicable and switch off all unnecessary equipment.

2 Have the nav/radar make the ejection seats safe. The pip-pin for the canopy jettison gun must *not* be removed.

3 Ensure that the bomb doors and the entrance door are closed.

4 Ensure that all crew are strapped in and all loose objects stowed.

5 Make a normal approach.

6 Jettison the canopy while still on the approach.

7 Make a normal landing, keeping the wings level and the rate of descent to a minimum.

8 Close the HP cocks. As soon as possible, operate the fire extinguishers and switch off all electrics.

(ii) *Nosewheel up, both main wheels down*

1 Move C of G as far aft as possible, within permitted limits of the available fuel.

2 Carry out a low overshoot, to check wind conditions.

3 Carry out a normal circuit. Open the entrance door. Jettison canopy on completion of final turn. Switch on landing lights at night.

4 Touch down normally at the correct speed.

5 When firmly on the main wheels, stream the tail parachute (crosswind permitting) and cut the outboard engines.

6 AEO to switch off Nos. 1 and 4 generators, and all rotary transformers.
7 Hold nose up until speed drops to 80 knots, runway length permitting.
8 While elevator control is still available, lower the nose on to the ground.
9 As soon as the nose touches, cut the remaining engines; co-pilot to switch off all booster-pumps and LP cocks ; AEO to switch OFF all generators and to operate the battery isolating switches.
10 When the nose is firmly on the ground, apply the brakes gently and evenly.
11 When the aircraft stops, pilots leave first, followed by the navigator/radar, navigator/ plotter and AEO in that order.

(iii) *Nosewheel down, one main leg down*

1 Move C of G as far aft and as far away from the failed main wheel as possible.
2 Carry out at least one low overshoot, to check wind conditions.
3 Carry out a normal circuit and jettison the canopy on completion of final turn. Switch on landing lights at night.
4 Touch down normally at the correct speed.
5 On touch-down, cut the outer engines and lower the nosewheel on to the ground.
6 AEO to switch off Nos. 1 and 4 generators and all rotary transformers
7 Hold the wing up, using aileron, rudder and nosewheel steering.
8 Before control effectiveness is lost, lower the wing and cut the remaining engines; hold the aircraft straight for as long as possible. Co-pilot to switch off booster-pumps and LP cocks; AEO to switch off all the generators and operate the battery isolating switches.
9 When the aircraft stops, pilots leave first, followed by navigator/radar, navigator/plotter, and AEO in that order.

(iv) *Nosewheel down, both main legs up*

1 Move C of G as far aft as possible with remaining fuel.
2 Carry out at least one low overshoot, to check wind conditions.
3 Carry out a normal circuit and jettison the canopy on completion of the final turn. Switch on landing lights at night.
4 Switch off all rotary transformers, except as necessary to provide lights at night.
5 Approach with the nose well up, using extreme care to keep the wings level.
6 As soon as the tail touches, cut all engines. AEO to switch off all generators and rotary transformers and to isolate both batteries. Co-pilot to switch OFF all booster-pumps and LP cocks.
7 When the aircraft stops, crew to leave through the entrance door. If the nosewheel has collapsed, crew to leave through the canopy opening in the order, pilots, navigator/radar, navigator/plotter and AEO.

7 Emergency operation of the wheel brakes

If the pressure in the brake accumulator falls to 2,900 PSI, switch the hydraulic power pack to START to recharge the wheel brake accumulators. Check that the pressures rise and that the power pack cuts out when the hydraulic pressure reaches 4,000 PSI. Use the brakes judiciously and avoid, whenever possible, causing the maxaret units to operate. If it is necessary to taxy off the runway for operational reasons, taxy slowly so that only one application of the brakes is required to stop the aircraft.

8 Canopy jettisoning

To jettison the canopy prior to forced landing or ditching, pull back either of the two levers marked CANOPY RELEASE on the port or starboard wall of the cockpit. If possible, pull both levers simultaneously. When abandoning the aircraft the canopy will be automatically jettisoned when an ejection seat firing handle is pulled.

9 Cabin pressurisation failure at altitude

If the cabin pressurisation fails above 40,000 feet, the following emergency drill should be used :

Captain warn crew

Oxygen mask harness . .	Toggle close, check 100% oxygen selected
Throttles	Closed
Airbrakes	HIGH DRAG

Descend at 0·94M/300 knots to 25,000 feet cabin altitude or below.

10 Action in the event of oxygen failure or noxious fumes

(*a*) *Oxygen failure*

(i) 1 If the magnetic indicator of the regulator being used by any crew member ceases to operate, but his *breathing is not impeded,* check that the pressure on the regulator gauge is normal (200-400 PSI) and select 100% OXYGEN (or check it, if Mk. 17D regulator is fitted). If breathing remains unimpeded, only the magnetic indicator is faulty and the sortie can be continued ; a further check of the regulator itself can be made by pressing in the EMERGENCY switch, which should produce increased breathing pressure. If breathing becomes impeded upon selection of 100% OXYGEN, the regulator is failing to deliver oxygen.

2 If *breathing becomes impeded* simultaneously with the magnetic indicator ceasing to operate, check that the mask is connected to the system at the CONNECTOR INLET (WARNING). If correct, the regulator is failing to deliver oxygen.

(ii) Having established that the regulator is faulty, if the cabin altitude is above 10,000 feet, depress the regulator EMERGENCY switch briefly. If this does not clear the fault, operate the emergency oxygen set and disconnect the mask from the main supply at the CONNECTOR INLET (WARNING). If the cabin altitude is less than 10,000 feet, loosen the mask from the face instead of operating the EO set, thus leaving the latter available for use (manually initiated) should the cabin pressure fail later in the flight.

(iii) After initiating the emergency set (or loosening the mask) a number of courses are possible. The emergency oxygen set will only provide about 10 minutes supply, enough to arrange more permanent provision for the remainder of the flight. The alternatives are:

1 Raise the cabin pressure from COMBAT to CRUISE, at which cabin altitude oxygen is not required. This would be risky if subsequent battle damage is a likely eventuality, or

2 Connect the crew member concerned to one of the vacant regulators by means of the extension tube; or (less desirable) use the dual connector and extension tube so that he shares the regulator of another crew member (in which case erratic " blinker " operation can be expected and the two crew should not physically exert themselves actively), or

3 Descend until cabin altitude is 10,000 feet.

(*b*) *Noxious fumes*

If the cabin becomes contaminated with noxious fumes, check/set 100% OXYGEN and deflect the EMERGENCY switch to one side. This will prevent inward leaks to the mask.

11 Emergency operation of the entrance door

(*a*) To open the entrance door in flight, depressurise the cabin, then pull the door-opening lever to the EMERGENCY position.

(*b*) If it subsequently becomes necessary to close the door again, the door seal may not re-seat properly and, in this case, full pressurisation may not be obtained.

(*c*) The door may be opened during depressurisation by operation of the door-opening switch at the navigator's station. Manual effort on the door handle must be exerted to ensure that the handle is gated at EMERGENCY.

12 Flight with the entrance door open

(*a*) The entrance door may be safely opened in flight at speeds up to 220 knots. Above this speed there is a danger of the forward bulkhead collapsing. Below 220 knots the handling qualities are not materially affected. There will be a slight nose-up change of trim.

(*b*) The noise level is very high at all speeds and inter-communication between crew members is very difficult; therefore, it is advisable that the captain's orders and intentions are made clear before the door is opened.

13 Generator, bus-bar or battery failure

NOTE: Generators are cleared for a maximum loading of 150 amps continuous operation. Any overloading of a generator is to be reported on landing in order that inspection of the generator(s) can take place before the next flight.

(*a*) *Considerations*

(i) *Load shedding*

It is imperative that load shedding is completed as quickly as possible by all crew members concerned.

(ii) *Airbrakes*

Except in the case where an immediate descent is vital to flight safety, the airbrakes should not be used until load shedding is completed.

(iii) *Resetting of generators*

If, on checking, the generator voltage reads zero, then resetting action is required. Only in the case of a four-generator failure may this be attempted without reducing engine RPM. In all other cases the RPM should be reduced to below 40%. It is appreciated that this may not be possible with Mk. 104 engines and, depending on the state of emergency, the Captain must decide whether the engine is to be flamed-out or not to achieve resetting.

(*b*) *Index to generator failure tables*

Case 1 No. 1 or No. 2 Generator Failure
Case 2 No. 3 or No. 4 Generator Failure
Case 3 Open Circuit No. 1 or No. 2 Generator
Case 4 No. 1 and No. 2 Generator Failure
Case 5 Port Bus-bar Failure
Case 6 No. 3 and No. 4 Generator Failure
Case 7 No. 1 or No. 2 and No. 3 or No. 4 Generator Failure
Case 8 Failure of any Three Generators
Case 9 Total Generator Failure
Over-volting Generators

(*c*) In the event of generator, bus-bar or battery failure the following actions must be carried out. In all cases the AEO must warn the crew.

CASE 1—Failure of No. 1 *or* No. 2 generator

Indication	AEO's *Actions*	*Load shedding*
No. 1 generator red light on *or* No. 2 generator red light on	1. Warn crew 2. Check busbar voltage for signs of over-volting generator on line 3. If busbar voltage is normal check the failed generator voltage 4. *Post-Mod.* 874 If voltage is 109-115 volts, ENGAGE generator and check busbar voltage and load ammeters 5. *Pre-Mod.* 874 (a) If normal decontrolled voltage, select OFF & TRIM and recheck voltage	Prior to use of airbrakes: 1. Inverter EMERGENCY SELECTOR to 1; No. 1 inverter OFF 2. No. 1 rotary transformer OFF

Indication	AEO's *Actions*	*Load shedding*
	(b) If voltage now 109-115 volts, select ON and press the appropriate ENGAGE button. Check busbar voltage and load ammeters 6. If unable to engage generator, set to OFF & TRIM 7. If after action 3 the *generator voltage is zero, leave the generator switch ON.* Only attempt reset action if further generator failures occur, after reducing appropriate engine speed to below 40% RPM	

CASE 2—Failure of No. 3 *or* No. 4 generator

Indication	AEO's *Actions*	*Load shedding*
No. 3 *or* 4 generator red and one amber lights on	1. Warn crew 2. Check loads transferred to port busbar (automatic paralleling) 3. Check the failed generator voltage 4. If voltage is between 109-115 volts, press appropriate ENGAGE button. Check amber light goes out and ammeter is showing load. If generator remains off line, set generator switch to OFF & TRIM 5. If after action 3 *the generator voltage is zero leave the generator switch ON.* Only attempt reset action if further generator failures occur, after reducing appropriate engine speed to below 40% RPM	Prior to use of air-brakes: 1. Inverter EMERGENCY SELECTOR to 1; No. 1 inverter OFF 2. No. 1 rotary transformer OFF

CASE 3—Open circuit No. 1 *or* No. 2 generator

Indication	AEO's *Actions*	*Load shedding*
No warning lights. Bus-bar voltage 100 volts or less. Zero load on ammeter of faulty generator	1. Warn crew 2. Ensure busbar voltage is above 80 volts; switch faulty generator to OFF & TRIM 3. Check faulty generator warning light now on and that busbar voltage rises to normal 4. Check that voltage of faulty generator reads zero NOTE 1: This fault may bring the sound generator off line. This can be identified by its warning light being on. Positively identify the faulty generator, ensure that bus-bar voltage is above 80 volts, and switch to OFF & TRIM before attempting to engage sound generator. NOTE 2: Similar faults could occur with Nos. 3 and 4 generators *in parallel working only.*	Prior to use of air-brakes: 1. Inverter EMERGENCY SELECTOR to 1; No. 1 inverter OFF 2. No. 1 rotary transformer OFF

CASE 4—Failure of No. 1 *and* No. 2 generators

Indication	AEO's *Actions*	*Load shedding*
No. 1 *and* No. 2 generator red lights on. Battery discharge red warning light probably on	1. Warn crew and pilot of possible loss of outer PFC's and the main rudder PFC 2. Check busbar voltage is above 80 volts and battery discharge is not above 150 amps. (*If above 150 amps see under port busbar failure (Case 5)*) 3. Press No. 1 and No. 2 generators ENGAGE buttons (a) If one or both generators are successfully engaged, check busbar voltage 109-115 volts and generator ammeter(s) showing load	1st PILOT 1. Auto-pilot 2. ILS 3. UHF or VHF CO-PILOT 1. All fuel pumps, except one per group 2. Windscreen demisting NAV/PLOTTER 1. Nos. 4 and 5 inverters 2. Radio and radar altimeters 3. Radio compass 4. Port sextant heater

CASE 4—*continued*

Indication	AEO's *Actions*	*Load shedding*
	(b) If only one generator is successfully engaged, take actions as for No. 1 or No. 2 generator failure (Case 1) (c) If No. 1 or No. 2 generator cannot be engaged: 1. Press in BATTERY BUS-amber light on), No. 1 rotary transformer and No. 1 inverter off line 2. Check load shedding complete 3. Ensure that busbar voltage is above 80 volts and battery discharge below 150 amps; parallel No. 3 generator and check busbar voltage. If 109-115 volts, parallel No. 4 generator and recheck voltage 4. Check voltage of failed generators and attempt to reset/re-engage one generator as for No. 1 or No. 2 generator failure (Case 1) 5. If one generator is successfully engaged, pull out the BATTERY BUSBAR ISOLATION button (amber light out) and return the No. 3 and No. 4 PARALLELING SWITCHES to NORMAL (amber lights out). Check the busbar voltage 109-115 volts and generator ammeter loaded	NAV/RADAR 1. Scanner rotation and stabilisation 2. NBC and H2S 3. Starboard sextant heater AEO 1. No. 1 rotary transformer 2. Window dispensers 3. Ration heaters

CASE 4—*continued*

Indication	AEO's *Actions*	*Load shedding*
	6. Attempt to re-engage the remaining generator as for No. 1 or No. 2 generator failure (Case 1) and recheck busbar voltage and load ammeters NOTE: *Do not attempt paralleling of Nos. 1 and 2 generators under no load conditions.*	

CASE 5—Port bus-bar failure

Indication	AEO's *Actions*	*Load shedding*
Battery discharge warning red light on Battery ammeter load above 150 amps	1. Warn crew and pilot of possible loss of outer PFC's and the main rudder PFC 2. Press in the BATTERY BUSBAR ISOLATION button (amber light on) 3. *If the battery discharge is under* 150 *amps* the fault is on the No. 1 and No. 2 generator busbar (a) If Nos. 1 and 2 generators are off line, leave the generator switches ON. If the generators are still on line switch to OFF & TRIM (b) Ensure that busbar voltage is above 80 volts, parallel No. 3 generator and check the busbar voltage. If 109-115 volts, parallel No. 4 generator and recheck voltage 4. *If the battery discharge is above* 150 *amps,* switch off the 96-volt battery isolating switch	1st PILOT 1. All outer PFC's 2. Main rudder PFC CO-PILOT 1. All port fuel pumps 2. Port transfer pumps 3. Windscreen demisting 4. Port engine deicing NAV/PLOTTER Nos. 4 and 5 inverters

CASE 5—*continued*

Indication	AEO's *Actions*	*Load shedding*
	(a) If the battery discharge disappears, the fault is on the battery busbar (b) If discharge remains, the fault is on the 96-volt battery 5. Inform pilot *to switch off outer* PFC's *and main rudder* PFC 6. *If battery busbar fault*: (a) Ensure *all* battery busbar loads are switched off (see load shedding) (b) Switch ON 96-volt battery isolating switch and check battery ammeter. If a heavy discharge is indicated, switch OFF and inform crew of services permanently lost. (c) If nominal discharge and Nos. 1 and 2 generators are off line, carry out reset action as per No. 1 and No. 2 generator failure (Case 4) (d) Pull out battery busbar isolation button (amber light out) and check busbar voltage 109-115 volts (e) Re-start elevator PFC's, maintaining careful check of 96-volt battery ammeter—see NOTE below (f) Remaining loads may be started at Captain's discretion NOTE: If, when an equipment is switched ON a fault is indicated, this equipment must be switched OFF immediately and no further attempt at restarting it is to be made.	
	7. *If 96-volt battery fault*: (a) Leave 96-volt battery isolating switch OFF (b) Confirm outer PFC's and main rudder PFC have stopped (c) Carry out the reset action for Nos. 1 and 2 generators as under No. 1 and 2 generator failure (Case 4). If one or both generators are successfully brought back on to main busbar, pull out the battery busbar isolation button, and re-start the switched-off PFC's (d) If Nos. 1 or 2 generators cannot be brought on line, leave the battery busbar isolation button in, parallel No. 3 generator and check the busbar voltage (e) If 109-115 volts, parallel No. 4 generator and re-check voltage. Restart outer PFC's and main rudder PFC	

CASE 6—Failure of No. 3 *and* No. 4 generators

Indication	AEO's *Actions*	*Load shedding*
No. 3 *and* No. 4 generator red lights on plus two amber lights on	1. Warn crew and load shed 2. Check the failed generator voltages: (a) If 109-115 volts, engage generators, check amber light(s) out and ammeter(s) loaded. If unable to re-engage, switch to OFF & TRIM	1st PILOT 1. Auto-pilot 2. ILS 3. UHF or VHF CO-PILOT 1. All fuel pumps except one per group 2. Windscreen de-misting

CASE 6—*continued*

Indication	AEO's *Actions*	*Load shedding*
	(b) If both generator voltages are zero, no attempt at reset action is to be made until appropriate engine speed is reduced below 40% RPM	NAV/PLOTTER 1. Nos. 4 and 5 inverters 2. Radar and radio altimeters 3. Radio compass 4. Port sextant heater NAV/RADAR 1. Scanner rotation and stabilisation 2. NBC and H2S 3. Starboard sextant heater AEO 1. No. 1 rotary transformer 2. Window dispensers 3. Ration heaters

CASE 7—Failure of No. 1 *or* No. 2 and No. 3 *or* No. 4

No. 1 *or* No. 2 generator red light on plus No. 3 *or* No. 4 red light on plus one amber light on	1. Warn crew and load shed 2. Check load shedding completed 3. Check failed generator voltages: (a) If 109-115 volts, engage generators; if unable to re-engage, select OFF & TRIM (b) If generator voltages are zero, no attempt at the reset action is to be made until appropriate engine speed is reduced below 40% RPM	

CASE 8—Failure of any three generators

Indication	*Actions*	*Load shedding*
Three generator red lights on. Battery discharge red light on plus 1 or 2 amber lights on	AEO'S ACTIONS 1. Warn crew and load shed 2. Switch IFF to EMERGENCY 3. Press the generator ENGAGE buttons in order 4 to 1	1st PILOT 1. Standby rudder PFC 2. Inboard aileron PFC's 3. Auto-pilot 4. ILS 5. VHF or UHF

CASE 8—*continued*

Indication	*Actions*	*Load shedding*
	AEO'S ACTIONS—*cont.* 4. If unable to re-engage No. 1 or No. 2 generators: (a) Check that the busbar voltage is above 80 volts, battery discharge below 125 amps (b) Press in battery busbar isolate button (amber light on) (c) Parallel sound generator(s) 5. Check failed generator voltages: (a) If 109-115 volts, press ENGAGE buttons; if unable to re-engage, select OFF & TRIM (b) If generator voltages are zero, do not attempt reset action until appropriate engine speed below 40% RPM 1ST PILOT'S ACTIONS 1. Check with the AEO and extend airbrakes, if required 2. Load shed CO-PILOT'S ACTIONS 1. Load shed 2. Transmit appropriate emergency message NAV/PLOTTER Load shed NAV/RADAR Load shed	CO-PILOT 1. All fuel pumps, except one per group 2. De-icing 3. Windscreen de-misting NAV/PLOTTER 1. Nos. 1, 2, 4 and 5 inverters 2. Radar and radio altimeters 3. Radio compass 4. Port sextant heater NAV/RADAR 1. Scanner rotation and stabilisation 2. NBC and H2S 3. AMU 4. Bomb bay heating 5. Starboard sextant heater AEO 1. Nos. 1 and 2 rotary transformers 2. UHF/HF, if not required 3. Ration heaters 4. All ECM

CASE 9—All four generators failure

Indication	*Actions*	*Load shedding*
All four red lights on plus two amber lights on. 1st Pilot's warning light on	AEO'S ACTIONS 1. Warn crew and load shed 2. Clamp oxygen mask and check that 100% oxygen is selected 3. Set IFF to EMERGENCY 4. Press generator ENGAGE buttons in order 4, 3, 2, 1 5. If generators remain off line and time permits, try resetting 6. Call out the busbar voltage and, when the voltage has dropped to 80 volts, warn Captain and prepare to abandon aircraft 1st PILOT'S ACTIONS 1. Extend airbrakes, as required, informing crew 2. Load shed 3. Clamp oxygen mask and check 100% oxygen selected 4. Order 'Combat' or 'No pressure' to be selected as required 5. Prepare to abandon aircraft CO-PILOT'S ACTIONS 1. Load shed 2. Clamp oxygen mask and check 100% oxygen selected 3. Transmit distress call 4. Select 'Combat' or 'No pressure' as ordered 5. Prepare to abandon aircraft	1st PILOT 1. Standby rudder PFC 2. Inboard aileron PFC's 3. Auto-pilot 4. ILS 5. VHF or UHF CO-PILOT 1. All fuel pumps, except one per group 2. De-icing 3. Windscreen demisting NAV/PLOTTER 1. Nos. 1, 2, 4 and 5 inverters 2. Radar and radio altimeters 3. Radio compass 4. Port sextant heater NAV/RADAR 1. Scanner rotation and stabilisation 2. NBC and H2S 3. AMU 4. Bomb bay heating 5. Starboard sextant heater

CASE 9—*continued*

Indication	*Actions*	*Load shedding*
	NAV/PLOTTER'S ACTIONS 1. Load shed 2. Clamp oxygen mask and check 100% oxygen selected 3. Prepare to abandon aircraft NAV/RADAR 1. Load shed 2. Clamp oxygen mask and check 100% oxygen selected 3. Prepare to abandon aircraft	AEO 1. All rotary transformers 2. UHF/HF, if not required 3. Ration heaters 4. All ECM

Over-volting generators

Indication	*Failure*	*Action*
No. 2 generator red light on. Nos. 2 and 3 rotary transformers red lights on. Busbar voltage high	No. 1 generator over-volting	In all cases—switch to OFF & TRIM the over-volting generator and re-engage the 'failed' generator and rotary transformers
No. 1 generator red light on. Nos. 2 and 3 rotary transformers red lights on. Busbar voltage high	No. 2 generator over-volting	
Nos. 1 and 3 rotary transformers red lights on. No. 3 generator voltage high	No. 3 generator over-volting	

Over-volting generators—*continued*

Indication	*Failure*	*Action*
Nos. 1 and 2 rotary transformers red lights on. No. 4 generator voltage high	No. 4 generator over-volting	

14 Considerations in the event of total generator failure

(*a*) *Introduction*

Ground tests under simulated flight conditions of total generator failure indicate that when the 112-volt busbar voltage has fallen to 70 volts the PFC motors start to run down and the voltage thereafter drops very rapidly. In flight, provided that all non-essential electrical services are switched off immediately the failure occurs, it is estimated that the 112-volt busbar voltage will fall to 70 volts in approximately 4 to 6 minutes. When Type K batteries (Saft) are fitted by modification, it is estimated that this period will be a maximum of 13 minutes. A constant check on the 112-volt busbar voltage following the failure of four generators is therefore essential. If by the time the voltage has dropped to 80 volts all attempts to bring one or more generators back on line has failed, the aircraft should be abandoned.

NOTE: The estimated times are given as a guide. Action must be taken on the battery busbar voltage indication only.

(*b*) *Handling*

When total generator failure occurs the captain must take the appropriate preparatory actions to enable the crew to abandon the aircraft safely and quickly should the need arise.

In the event of having to abandon the aircraft, the following factors must be considered:

(i) *Speed.* Speed must be reduced as much as possible before abandoning the aircraft. As the airbrakes impose a heavy drain on the battery they should, if needed, be operated immediately after the shedding of non-essential services. If not used at this stage no attempt should be made to extend them later. If used, they must not be retracted.

(ii) *Altitude.* The descent should be started immediately complete generator failure occurs, to reduce the time aircrew may have to spend at low temperatures should they have to abandon the aircraft.

(iii) *Attitude.* The aircraft attitude should be kept reasonably level to avoid imposing G-loads which might hinder or prevent aircrew escape.

(iv) *Cabin pressure.* As the entrance door cannot be opened until the cabin pressure has dropped to $\frac{1}{2}$ PSI, the captain must anticipate the time required to de-pressurise, depending on the altitude and circumstances.

15 Fuel system failures

(*a*) *General*

(i) Fuel system failures fall into the following two categories:

1 Fuel is not being lost overboard but is being incorrectly distributed. In this case, corresponding group contents gauges will continue to read the same.

2 Fuel is being lost overboard and the group contents gauge of the leaking group will read less than the others.

(ii) It has been assumed in this paragraph that corresponding tanks and groups have been fuelled to the same level. If this is not the case, suitable allowances must be made.

(iii) Typical fuel failures and the corrective actions are listed below.

(*b*) *Corresponding group contents gauges read the same*

(i) *Symptom*

One tank reads higher and the other tanks in the same group read lower than the corresponding tanks on the other side.

Fault

Booster-pump failure and/or the non-return valve stuck open in the highest reading tank.

Action

Select MANUAL in the group concerned and switch off all pumps in the group except that of the highest reading tank. If, after a delay of up to two minutes, the fuel pressure magnetic indicator turns white, the booster-pump has failed and should be switched off. Switch on all booster-pumps in the group and maintain the C of G by selective use of the pumps. If necessary, and preferably at low altitude, the fuel from the tank with the unserviceable pump may be used, by switching off all pumps in the group except that of the affected tank and gravity feeding the engine. It should not be forgotten that fuel in Nos. 1 or 7 tank can be transferred to the other tank if its pump becomes unserviceable and so be used. If, in the check above, the magnetic indicator does not turn white, the non-return valve should be suspected ; maintain the C of G manually, taking care not to switch off the tank with a suspect non-return valve.

(iii) *Symptoms*

One tank in each group on one side of the aircraft reading lower, and all other tanks on the same side reading higher than the corresponding tanks on the other side.

Fault

Sequence-timer failure.

Action

Switch both affected groups to MANUAL and maintain the C of G by selective use of the pumps.

(iii) *Symptoms*

One tank of one group reads lower and all other tanks of the same group read higher than the corresponding tanks on the other side of the aircraft.

Fault

Pump running continuously at full speed.

Action

Switch affected group to MANUAL and maintain an even fuel distribution by selective use of the booster-pumps.

(*c*) *One group contents gauge reads less than the corresponding group contents gauge*

(i) *Symptom*

One tank in affected group reads less than corresponding tank on the other side.

Fault

Tank leak.

Action

From the affected tank feed as many engines as can be supported without loss of thrust, up to a maximum of three, with the object of emptying it as soon as possible. (A limit of three engines is made in the interest of safety). When the tank is nearly empty (approx. 400 lb.) revert to normal in the unaffected groups and cycle the affected group manually, cross-feeding as necessary. During the operation, a close watch should be kept on the C of G. The periscope should be used to confirm the suspected leak and to watch for fire.

(ii) *Symptom*

All tanks in the affected group read less than the corresponding tanks on the opposite side.

Fault

Engine fuel system leak or pipe-line leak.

Action

Check on the flowmeter the consumption of the engine supplied by the affected group and, if excessive, stop the engine and turn off the LP cock. If the consumption is normal, a pipe-line leak must be suspected. Feed up to three engines from the affected group by opening cross-feed cocks as necessary and switching off the booster-pumps which are not being used, with the object of emptying the leaking group as soon as possible. Care will be necessary during this operation, as it may be found that the leaking group will be unable to support the leak and the demands of the extra engines. A close watch must be kept on the lateral trim at this time and also for the remainder of the flight. When the leaking group is nearly empty, return the other engines to normal feeding from their own groups and close the cross-feed cocks, otherwise fuel may be pumped overboard from the serviceable groups through the leaking group. For this reason, it will not be possible to keep the engine of the leaking group running after its fuel is exhausted and lateral trimming may be difficult. If the flowmeter is unserviceable, it is not possible to decide quickly whether the leak is in the pipelines or the engine fuel system, therefore the engine should be shut down and the procedure for a pipe-line leak should be followed. As always with fuel leaks, confirmation should be sought by using the periscope and the fire hazard must be borne in mind.

(*d*) *Stores hang-up*

Correct any out of balance condition, caused by stores hang-up, by selective use of fuel or by transferring fuel in the appropriate direction between Nos. 1 and 7 tanks.

(*e*) *Low fuel state*

When the contents of any tank in a group falls to 400 lb, switch the AUTO/MANUAL switch for the group to MANUAL. When the fuel level falls to 150 lb, switch off the tank booster-pump.

16 Fire in the cabin

The majority of fires in the cabin are likely to be of electrical origin and can usually be controlled by switching off all electrical equipment in the vicinity. If the fire persists after the electrical equipment has been isolated, the water/glycol fire extinguishers may be used. In extreme cases, the fire may be starved of oxygen by depressurising the cabin. Oxygen regulators should be checked at 100% oxygen. The water/glycol fire extinguishers must not be used on inflammable liquids. When Mod. 1560 is embodied, the BCF extinguishers may be used without restriction.