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RAPIDE AIRCRAFT TECHNICAL NEWS SHEET

TECHNICAL NEWS SHEET SERIES CT(89) No 17 ISSUE 2

FIRE PRECAUTIONS DURING ENGINE STARTING

- COMPLETELY REVISED -

1. PLANNING INFORMATION

1.1 **Aircraft Affected.**

All de Havilland DH89A Dragon Rapide aircraft.

1.2 **Reason for Issue.**

The purpose of this Technical News Sheet (TNS) CT(89) No 17, Issue 2, is to update and augment fire prevention guidance first given in 1954 by the de Havilland Aircraft Co. Ltd. At that time a number of DH89A aircraft operating under Tropical conditions had burned out after lower wing fabric covering was ignited by engine exhaust flames during hot starts.

Three recent fabric fires above and behind the exhaust outlets have occurred during engine starts in UK summer conditions. In each case prompt action by ground staff extinguished the fire before the aircraft suffered irreparable damage, or its occupants were endangered.

It is therefore now necessary to reiterate the importance of certain DH89A design features and modifications, to explain the factors contributory to fire risk, and to recommend how aircraft handling procedures should take account of the threat of fire at engine start.

2. BACKGROUND

2.1 **General.** The aircraft configuration features two similar engine nacelles with six cylinder exhaust manifolds exiting to the starboard side in each case. Exhaust emerges normally from a venturi section approximately 2 ft (60 cm) below the lower surface of either fabric covered stub wing. The port exhaust discharges between the fuselage and port nacelle and is just visible to the pilot, whereas the starboard exhaust exits on the outboard side of its nacelle, remote from cockpit view. A cabin heater, if fitted, is run off a muff on the port exhaust and displaces the outlet further aft to approximately level with the wing trailing edge. Exceptionally, as a fire prevention measure, the starboard exhaust may be modified with an extension pipe to benefit by the same more rearward outlet position.

The fuel system for each engine is self-contained with a 38 Imperial Gallon (172 litre) tank and Enots sliding plate type fuel on/off cock immediately aft of each firewall.

2.2 **Fuel Priming.** Fuel enrichment for engine starting is obtained by either of two available methods, or a combination of each. Manually flooding the carburettors entails opening the starboard cowling to hold down each 'tickler' button in turn, while simultaneously operating one of the engine driven fuel pump hand priming levers. A cockpit-mounted Kigass priming pump, selectable to either engine, may also be used. This system sprays atomised fuel into the induction system at No. 3 and No. 4 cylinders. Excess priming fuel arising from either method is drained overboard by elbows and pipes connected at multiple positions to the three low points of the various induction manifold passages adjacent to cylinders No. 4, 5 and 6. To avoid the ingress at engine start of an excessively rich mixture, it is vital that all such drains are clear and correctly routed. The two induction manifold drain pipes (and two fuel pump overflow pipes) are directed into the receptacle on the port side of each front trouser fairing. Spillage overboard is then on the opposite side of the engine nacelle to the exhaust outlet.

3. PREVIOUS DESIGN AND MAINTENANCE ACTIONS

3.1 **Modifications.** The DH89A Dragon Rapide airframe and its engines (DH Gipsy Six 1, Gipsy Queen II and Gipsy Queen III) have previously been subject to several modifications to reduce the risk of fire during engine starting or in the air:

a. **Rapide Mod. No. 5 with Gipsy Mod. G.1152.** This combined engine and airframe modification introduced an additional induction manifold drain connection adjacent to No. 4 cylinder. Originally the position was undrained and so likely to retain surplus priming fuel and cause a large exhaust flame in over-rich starts. **UK CAA Airworthiness Directive AD No. 2737 PRE 80 refers**.

b. **Rapide Mod. No. 16.** As an alternative to the standard length DH89A exhausts, exiting beneath the wing, in 1954 de Havilland developed Mod. No. 16 to extend the outlet position beyond the rear edge of the lower trouser fairings, aft of the main area of fabric wing surface. Aircraft already equipped with a cabin heater on the port engine required fitment of Mod. No. 16 only on the starboard side.

It appears that Mod. No. 16 was little adopted as a Special Order Only (SOO) option, even for its intended tropical use, and manufacturing data is not present in the de Havilland Support Ltd. drawing archive. An associated operational issue would be that the exhaust outlet is brought relatively close to the ground, creating a new potential fire hazard when starting the engines over dry grass surfaces.

c. **Gipsy Mod. G.4030.** Introduction by H+S Aviation Ltd. of Gipsy Mod. G.4030, a JAR-25 compliant fire resistant fuel hose, followed the loss of a DH89A after an in-flight engine fire in 1989. Hot gases from a blown copper-asbestos cylinder head gasket had burned through the earlier standard of fuel hose linking the front and rear carburettors. Improved hose Part No. 86073 is mandated by the UK CAA, **Airworthiness Directive AD No. 007-06-89 refers**.

Additional mitigation may be provided by the use of Gipsy Mod. G.4015 solid copper cylinder head to cylinder barrel gaskets.

d. **Deletion of Fuel Primer.** Excessive use of the Kigass priming pump has been a feature of some start-up fires. Deletion of the in-cockpit fuel priming system

was one of the modifications made by British European Airways to produce its *Islander Class* variant, which was invariably attended for engine start by ground crew. This intended safety measure cannot be recommended because omission of the Kigass system and atomising nozzles is detrimental to prompt engine starting.

3.2 **Wing Lower Surface.** As a fire precaution some 1950s operators in the Middle East are known to have affixed Dural panels to the stub wing lower surfaces in the vicinity of the engine exhausts. In 1954 these innovations were reviewed by the de Havilland Aircraft Company; it was found that they had not prevented several instances of fire during engine start and hence were not proceeded with as a Design Authority modification.

Nonetheless, in the three more recent cases it has appeared that the thermal mass of material in the doped wing surface greatly affects the progress of fire as initiated by a transitory exhaust flame. Single thickness unsupported fabric burns readily while double-covered areas of fabric patches and rib tapes do not always continue to support combustion. Fabric fires often extinguish readily when plywood skinned regions such as wing leading edges are reached. Use locally of a more fire retardant surface finish may also be beneficial.

Noting these facts, some operators have raised modifications to attach plywood or metal skins to the lower wing surfaces above the engine exhausts. An ideal solution appears to be a continuation of the leading edge plywood as far aft as the rear spar, prior to fabric covering and fitment of the normal screwed retaining strips or rib stringing. Details of such modifications should be sought from the operators concerned but may still require additional local approval.

3.3 **Related Inspections.** In addition to applying normal engineering inspection practices and standards, with regard to condition, assembly, functioning and cleanliness, directed inspections have previously been defined as below:

a. **Induction Manifold Drain Elbows.** Gipsy Engine Technical News Sheet G. No. 62 (Reference A) explains the possibility of confusion between the types of induction manifold drain elbow specified for four and six cylinder engines. A one-time inspection was recommended to ensure that the drain elbow beside No. 5 cylinder is Part No. 2005-43/3 with a calibrated hole size of 3.5 mm. The Tee piece adjacent to No. 6 cylinder is fitted with its 2 mm hole to the rear.

b. **Carburettor Needle Valve Assemblies.** Reference B, Gipsy Engine Technical News Sheet G. No. 16 (now cancelled) referred to a fault condition whereby wear of the Hobson carburettor needle valve seat could allow flooding of the carburettor to occur. This condition has implications for throttle response from idle and also fire safety at start, if with fuel selected 'ON' there is a tendency for the carburettors to 'self-prime' under the head of a near full fuel tank.

Reference B was cancelled after the introduction of Gipsy Mod. G.1136 (revised carburettor needle side clearance) and Gipsy Mod. G.1714 (improved needle seat).

However, a simple test described at Reference B may still be informative:

> "*Turn on the fuel and operate the fuel pump priming levers without operating the carburettor tickler. Fuel will issue from the induction manifold drain pipe if wear of the needle seat has occurred*".

4. OPERATIONAL ASPECTS

4.1 **General.** There are a number of operational techniques to mitigate the risk of a fire occurring during engine starting. Avoidance of over-priming is a key precaution and use of an engine shut-down method appropriate to the climatic conditions may be another. It is also essential that ground staff are properly trained in overseeing engine starts, have prearranged signals for two-way communication with the pilot, and that they are provided with suitable extinguishers with which to control a fire in the first instance.

4.2 **Sources of Fire Risk.** The primary concern is to avoid ignition of wing fabric covering by a temporarily over-rich exhaust flame, or by ignition of a fuel vapour-laden atmosphere between the ground and the wing.

Empirical evidence suggests that this condition is most likely when an engine is restarted a short time after being stopped purely by turning off the ignition. It appears that the fuel content of the carburettor float chambers, already full and within the very hot engine bay, experiences expansion or boil-off which effectively self-primes the engine. This can be seen as a small overflow from the drains at the port side of each front trouser fairing. An engine start occurring prior to the dissipation of this unwanted 'prime' is prone to be over rich and with a consequent yellow exhaust flame. For this reason Reference C advised that carburetted Gipsy engines should be allowed to idle for a few minutes to cool, before turning off the fuel to run the carburettor entirely dry prior to switching off the magnetos in hot climatic conditions. [Similar advice is repeated as a standard end of flight procedure at Chapter III of the de Havilland Dragon Rapide Care and Maintenance Manual]

A secondary risk is that of igniting an explosive air/fuel mixture within the rear engine cowlings, due to spillage during refuelling or venting of a full tank when the fuel expands with temperature. Accumulated dry grass cuttings add obvious potential for combustion.

Intake fires are unlikely on the DH89A. At the low part-throttle position used for engine starting, the flame-trap is in operation and the external air intake is isolated.

4.3 **Safety Considerations.** The worst case eventuality is of a start-up fire arising inboard of the port engine and spreading under the fuselage, or through the depth of the stub wing to ignite fabric immediately forward of the walkway tread. Operators should review this scenario and the necessity for timely fire extinguisher coverage of the cabin exit route. External assistance to open the cabin door, position any entry steps, aid the infirm and manage rapid evacuation to an upwind position are all considerations for prior thought.

Fire hazard during repetitive pleasure flights could be largely eliminated by adopting a policy of controlled 'running changes' when an immediate turn round is planned, as was standard practice when the DH89A was in widespread use. In this case passengers should be constrained to approach or depart the aircraft strictly from the port rear quarter and never to move ahead of the port wing tip or beneath the wing trailing edge.

5. PRE-START PREPARATION

5.1 **Daily Inspection.** Mitigation of fire risk can commence even before bringing an aircraft out to fly. Include the following points in the daily inspection:

- Examine the cylinder barrel to cylinder head joint areas for any obvious sign of blowing or heat damage to the surroundings.
- Examine around the edges of all exhaust gaskets for signs of blowing. Check for loose or missing exhaust studs and nuts and rectify before any further flight.
- Confirm that all four magneto switches are OFF and both throttles are closed.
- Check that the fuel cock On/Off controls are operative. Select ON each side.
- Ensure alignment of the induction manifold drain pipes with the receptacles set into the port side of each front trouser fairing.
- Place a drip tray beneath the external drain outlet to the port side of each main wheel.
- Operate the hand priming lever on the port fuel pump of each engine. If ineffective due to cam position, rotate the propeller backwards 180° and retry. Stop when the pumping action ceases. *[This will prove operation of the port side fuel pumps on both engines while filling the float chambers of all carburettors with fuel]*
- On each engine in turn, depress the 'tickler' button on the **front** carburettor while operating the hand priming lever on the starboard fuel pump. Listen for the sound of fuel spilling into the induction manifold, and cease pumping immediately this is heard.

  Watch to the port of each main wheel to see that fuel is dripping steadily from the overboard drain. *[This will prove that two bores of the Tee piece, adjacent to No. 6 cylinder, are clear of obstruction]*
- Only when fuel drips from the above have ceased, on each engine in turn, depress the 'tickler' button on the **rear** carburettor while operating the hand priming lever on the starboard fuel pump. Listen for the sound of fuel spilling into the induction manifold, and cease pumping immediately this is heard.

  Watch to the port of each main wheel to see that fuel is dripping steadily from the overboard drain. *[This will prove that the bore of the drain elbow beside No. 5 cylinder, and the remaining bore of the Tee piece, are both clear of obstruction]*

Note: The induction manifold drain connection adjacent to No. 4 cylinder is unlikely to collect fuel from the rear carburettor when in ground attitude. It exists primarily to drain surplus Kigass pump output. In any case, a flow from this drain cannot be distinguished externally from fuel draining also from No.5 cylinder. Thus the No. 4 cylinder drain can be checked for clear passage only by applying air pressure at its open end, which is not reasonably practicable except during maintenance.

- If fuel does not flow overboard after briefly flooding the carburettors, investigate the drain system for blockage. *[Viscous oil can constrict the drain pipes in cold conditions, but may clear once diluted by fuel for several minutes. Otherwise, access may have to be gained to blow the pipes clear by applying compressed air from the lower end]*

- **DO NOT PROCEED TO ENGINE START UNTIL THE DRAINS ARE CLEAR.**

5.2 **Hand Turning Engines.** With the cockpit occupied, wheel brakes ON, all four magneto switches set to OFF, both throttles closed and a fire extinguisher at hand, hand turn each propeller through at least six compressions – in the direction of rotation – to ensure that no hydraulic lock has developed. *[Investigate any unduly low compression, which may indicate a defective cylinder head gasket or cracked cylinder head, and associated fire risks]*

6. COLD-STARTING TECHNIQUE

Having prepared as at Paras 5.1 and 5.2, proceed as follows:

- Avoid if possible starting the engines over a surface of long dry grass or cut hay. *[To avoid the risk of a ground fire]*

- Position the aircraft either facing into wind or up to 45º to the left of the oncoming airflow. *[This will help to clear any fuel vapour or flame to the rear, and may slow the progress of a port engine fire towards the fuselage]*

- Place a suitable fire extinguisher in position for the port engine.

- Brief passengers on exit routes and cabin door operation.

- Brief ground crew: port engine to start first; ensure line of sight to exhaust outlets and wing under surfaces during the starts; agree hand signals to be used in the event of fire.

- Select Kigass priming pump to port engine. Pump full strokes until the priming lines are full, as judged by a sudden increase in resistance to movement of the plunger. Then pump two more full strokes only, or less if the carburettor flooding at Para 5.1 was completed within 30 minutes. *[Or as indicated by experience and temperature]*

- Select Kigass priming pump to starboard engine. Pump full strokes until the priming lines are full, as judged by a sudden increase in resistance to movement of the plunger. Then pump two more full strokes only, or less if the carburettor flooding at Para 5.1 was completed within 30 minutes. *[Or as indicated by experience and temperature]*

- First screw down the Kigass priming pump then set the changeover cock to OFF.

- Ground crew to monitor external drain outlets to the port side of each main wheel and to confirm to the pilot that fuel is draining. Also to advise 'Clear to Start' when fuel drips cease. *[Push aircraft backward if drained fuel extends to exhaust side of the tyre]*

- Set up radio and headset for immediate turn-on, to call ATC for assistance if required.
- Check brakes ON, battery master switch ON, safety covers lifted on starter buttons, all four magneto switches set to ON, both throttles set for starting.
- Pilot to self-brief that cranking may be best continued even if a 'pop' is heard from an exhaust. *[This can indicate ignition of fuel vapour, most quickly dispersed by a successful start]*
- Start port engine first. *[With the starboard propeller still stationary, unimpeded access is available to the port exhaust area in the event of fire]*
- Start starboard engine when cleared by ground crew.
- No further fire cover is needed as soon as both engines are running normally.

7. ENGINE STOPPING TECHNIQUE

The most appropriate engine stopping technique will depend on the operational circumstances and climate:

a. **No Further Running Intended on the Day.**

- Run engines at 1,000 r.p.m. or less for several minutes to facilitate their gradual cool down. Check all magnetos in turn.
- Select the port and then the starboard fuel cocks to OFF. When the running first becomes irregular, turn OFF the port magneto switches and advance the port throttle steadily to wide open as the propeller comes to rest.
  [This throttle technique will minimise the risk of a back-fire]
- Repeat for the starboard engine after the port engine has stopped.
- Close both throttle levers.

b. **Start Intended Later When Cooled Down.**

- Park aircraft facing into wind or up to 45º to the left of the oncoming airflow.
- Run engines at 1,000 r.p.m or less for several minutes to facilitate their gradual cool down. Check all magnetos in turn.
- Turn OFF the port magneto switches and advance the port throttle steadily to wide open as the propeller comes to rest.
- Turn OFF the starboard magneto switches and advance the starboard throttle steadily to wide open as the propeller comes to rest.
- Close both throttle levers.

c. **Hot Restart Intended.**

- Park aircraft facing into wind or up to 45º to the left of the oncoming airflow.
- Run engines at 1,000 r.p.m or less for several minutes to facilitate their gradual cool down. Check all magnetos in turn.
- Select the port and then the starboard fuel cocks to OFF. Approximately 30 seconds later but before the running becomes irregular, turn OFF the port magneto switches and advance the port throttle steadily to wide open as the propeller comes to rest.

  [This action is intended to lower the fuel level in the carburettor float chambers but not to empty them completely, which would compromise restarting. The aim is to reduce 'self-priming' by the carburettors when they are subject to high engine bay temperatures. Multiple short duration flights may require an increased frequency of inspection for serviceability of the Enots fuel cocks and Arens fuel cock controls]
- Repeat for the starboard engine after the port engine has stopped.
- Close both throttle levers.
- Leave fuel cocks at OFF until restart.

8. HOT-STARTING TECHNIQUE.

Most DH89A start-up fires have occurred in high air temperatures and when restarting already hot engines. Conditions of heat and nil wind are particularly hazardous because fuel vapour is then quick to form but slow to disperse. Moreover, a fire emanating from the exhaust will not be blown safely rearward unless the engine start is successful.

The original de Havilland advice at Reference C – to drain the carburettor entirely when stopping Gipsy engines in hot climatic conditions – has been moderated at Para 7.c. to obviate having to refill the float chamber for the subsequent start.

If routine hot starting cannot feasibly be avoided by 'running changes' of passengers then it must be accepted that an added degree of fire risk is inseparable from such a style of DH89A operations. This risk can be mitigated as follows:

- Avoid if at all possible restarting the engines over long dry grass or cut hay. *[To eliminate the risk of a ground fire]*
- Position the aircraft either facing into wind or up to 45º to the left of the oncoming air flow. *[This will help to clear any fuel vapour or flame to the rear, and may slow the progress of a port engine fire towards the fuselage]*
- Place a suitable fire extinguisher in position for the port engine.
- Brief passengers on exit routes and cabin door operation.
- Brief ground crew: port engine to start first; ensure line of sight to exhaust outlet and wing under surface during the start; agree hand signals to be used in the event of fire.
- Set up radio and headset for immediate turn-on, to call ATC for assistance if required.
- Turn both fuel cocks ON.

- **Do not employ the Kigass priming pump during hot starts, unless the engine has already fired but failed to pick up and continue running. In this case, limit use to one Kigass stroke per engine, after first filling the priming lines.**
- Ground crew to monitor external drain outlets to the port of each main wheel and to confirm to the pilot that no fuel is draining. Advise 'Clear to Start' only if no fuel drips are seen. *[Push aircraft backward if drained fuel extends to exhaust side of the tyre]*
- Check brakes ON, battery master switch ON, safety covers lifted on starter buttons, all four magneto switches set to ON, both throttles set for starting.
- Pilot to self-brief that cranking may best be continued even if a 'pop' is heard from an exhaust. *[This may indicate ignition of fuel vapour, most quickly dispersed by a successful start]*
- Start port engine first. *[With the starboard propeller still stationary, unimpeded access is available to the port exhaust area in the event of fire]*
- Start starboard engine when cleared by ground crew.
- No further fire cover is needed as soon as both engines are running normally.

9. COMPLIANCE

The guidance given in this TNS CT(89) No. 17, Issue 2, dated 1 July 2014 should form part of all DH89A operator engineering and pilot training programmes, and be reflected in Operations Manuals. [Individual aircraft may differ from standard or have unique characteristics which require equivalent precautions and procedures to be developed]

Relevant comments from practical DH89A operating experience are welcome and should be submitted to de Havilland Support Ltd. for possible inclusion in future editions of this TNS.

10. REFERENCES

A. TNS G. No. 62, Induction Manifold Drain Elbows, Early Type Gipsy Engines, Rolls-Royce Ltd, Small Engine Division, dated 28 March 1949.

B. TNS G. No. 16, Carburettor Flooding, de Havilland Engine Service, dated 8 April 1954. [Note: this TNS has been cancelled]

C. TNS G. No. 7, Operating Data, (Stopping Procedure), de Havilland Engine Service, dated 24 February 1947. [Note: this TNS has been cancelled]

11. APPROVAL

The technical content of this Technical News Sheet is approved under the authority of UK CAA Approval Reference AD/1819/00.

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