INCIDENT

Aircraft Type and Registration:	Airbus A340-311, G-VAEL
No & Type of Engines:	4 CFM56-5C2 turbofan engines
Year of Manufacture:	1993
Date & Time (UTC):	30 April 1995 at 0407 hrs
Location:	Over Liège, Belgium
Type of Flight:	Public Transport
Persons on Board:	Crew - Not known Passengers - Not known
Injuries:	Crew - None Passengers - None
Nature of Damage:	Car destroyed, building roof and ceiling damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	14,500 hours (of which 250 hours were on type) Last 90 days - 202 hours Last 28 days - 54 hours
Information Source:	Request by Belgian authorities and inquiries and inspection by the AAIB

Flight History

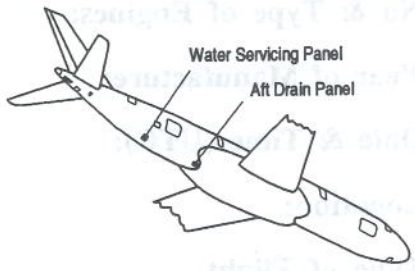
Two substantial blocks of ice fell on Liège, Belgium, reportedly damaging a car and the roof and ceiling of a building. Radar recordings showed that the only aircraft overflying Liège at the time was G-VAEL, en route from Hong Kong to London Heathrow. Records for the aircraft indicated that at the time of the incident there had been no reports of any water leakage; however, a leak from the potable water system in the aft fuselage was subsequently reported in the Technical Log on 1 May 1995. AAIB later investigated the incident at the request of the Belgian Civil Aviation Administration.

Potable Water System

The A340 potable water supply is carried in three 350 ltr capacity cylindrical tanks, located beneath the fuselage main deck floor (Fig 1.1). The two Forward Tanks are situated behind the sidewall lining of

the bulk cargo compartment and are interconnected to effectively form a single functional unit; the Aft Tank is situated approximately 6 metres to the rear in the aft cargo compartment. The tanks are pneumatically pressurised.

The normal filling point for the system is at a port in a Water Servicing Panel (Fig 2) located in the lower rear fuselage. The port comprises a protruding open-ended pipe with an external land formed near its end. The pipeline from the port branches into two and passes to the bottom of each tank, via a Fill/Drain valve in each branch. The Fill/Drain line can also be connected, via a Filling Line Drain Valve, to a drain port in an Aft Drain Panel located in the fuselage undersurface, and additional Drain Valves allow the tanks to be isolated from the system. An Overflow port is also associated with each tank, situated in the Aft Drain Panel in the case of the Forward Tanks and in the Water Servicing Panel in the case of the Aft Tank. Each Overflow Port is connected to the top of the respective tank via an Overflow Valve. Fill/Drain and Overflow pipes are of stainless steel. The external fuselage structure of the aft cargo compartment has no thermal insulation and the water system pipelines and valves are provided with thermal insulation blankets (Fig 3.1) and with external electrical heating elements operated by temperature sensors. Modification to fit an electrical heater cuff on each of the four ports of the Fill/Drain/Overflow Valve operated by a local temperature sensor was carried out on G-VAEL in November 1994. The Fill/Drain and Overflow Ports are also electrically heated.



The design includes a water-tight blanking cap for the Fill/Drain Port, secured by a ring ball mechanism when fitted and retained on a cable lanyard when removed. An elastomeric blanking pad carried on the Water Servicing Panel Door was apparently intended to cover the end of the Overflow Port when the door was closed and to form a debris shield; inspection of sample aircraft indicated that it would not form a watertight seal for the port. A seal is provided between the Servicing Panel Door and the fuselage; the door has a single drain hole near the front. Filling of the system is normally carried out at the Fill/Drain Port at the Water Servicing Panel, with valves operating automatically and shutting off when a preselected water tank quantity has been reached.

The Fill/Drain Valves are ball type valves (Fig 3.2), each consisting of a rotatable bored stainless steel ball contained inside a plastic body provided with two ports. The Fill/Drain and Overflow valves associated with each tank are ganged together and are operated in unison by an electric motorised actuator, via an overload clutch, or manually via a teleflex cable drive from a manual handle. Ball travel is restricted by actuator limit switches, or by mechanical stops when the valve pair is operated manually.

Bilge overboard drains for the rear fuselage consist of 5 mm diameter apertures at approximately 1 to 2 metre spacing, with valves that are automatically closed at altitude by differential pressure loads.

The A330 potable water system is identical to the A340 system.

Incident Examination

In the case of the incident to G-VAEL (Manufacturer's Serial Number (MSN) 0015) records showed that a slight water leak from the aft fuselage bilge drains was reported the day after the ice-fall. This was traced to the connector between the water overflow line from the Aft Tank and the Aft Overflow Valve. Little information was available to enable the cause of the leakage to be established as the valve was replaced and returned to the manufacturer before AAIB involvement and it has not proved possible to obtain a report of a manufacturer's defect investigation. The passage overboard of water leaked into the rear fuselage should have been prevented by bilge drain valves, but it was not possible to establish whether this was in fact the case or whether there may have been other overboard drain paths. It was also possible that if the connector damage had resulted from the effects of freezing (see below), the Fill/Drain and/or Overflow Valves could have been similarly damaged, allowing internal leakage to the ports in the Aft Servicing Panel. The absence of reports of the Panel Door having been found open or missing after the flight suggested that the ice fall had not originated from within the Servicing Panel. Thus the available evidence indicated that the ice-fall had resulted from leakage from the water system, either into the fuselage or into the Servicing panel, that had caused ice formations to build-up on the outside of the fuselage skin and to subsequently detach.

Similar Installation Examination

Two sample A340 aircraft (one of which was G-VAEL) inspected during maintenance checks in September 1995 required replacement of the Aft Fill/Drain/Overflow Valve due to leakage. No Fill/Drain Port cap or lanyard was present at the panel in either case. One of the aircraft required replacement of a Water Servicing Panel door hinge due to its partial separation, the hinge pin having migrated axially and disengaged from both the fuselage and the door brackets at one side (Fig 3.3).

Examination of one of the above rejected valves (MSN 151 from G-VAEL) confirmed that the Overflow Valve leaked when fully closed and revealed that the valve ball was loose in its body and exhibited gross play on the operating spindle. A manufacturer's defect investigation report is awaited. It was also noticeable that there was a relatively small amount of overtravel of the Fill/Drain Valve ball in its body from the point of flow cut-off to the point where the actuator closed limit switch operated, measured at 2.5 mm at the manual operating cable connection point, equivalent to 5° of lever and ball

rotation. This was half the overtravel available at the mechanical stop position. It was anticipated that the amount of overtravel of a normal Overflow Valve would be similar. It was also apparent that valve operation required an appreciable load on the manual operating lever (5.5 to 6.5 kg at the effective moment arm of 25.5 mm at the cable connection point).

Some information suggested that in previous cases ice build-up in the Servicing Panel in-flight due to water leakage past the valves may have inflicted mechanical damage to the door attachments resulting in detachment of the door. However, examination of the failed hinge noted above suggested that partial failure of a hinge in normal service was also a distinct possibility. The 4.93 mm diameter pin normally protruded marginally beyond the fixed bracket, by approximately 0.5 mm, and had been slightly swaged at either end to retain the pin axially (Fig 2). This had produced an end diameter at one end of 5.11 mm, which marginally prevented the end from passing through the bracket holes, but the end which had migrated out had a diameter of only 5.00 mm, allowing it to migrate readily through the brackets. No distress was apparent suggestive of forcible pin migration. Wear markings indicated that the pin may have been in its partially disengaged position for an appreciable period of operation. Further migration of the pin sufficient to disengage it from the other side of the hinge as well would probably be prevented by the surrounding structure but partial disengagement could result in overloading of hinge elements.

Previous Problems

It was apparent from the operator's experience and from reports received by the aircraft manufacturer that a considerable number of problems had been experienced with the A340 potable water system in service. These included cases of burst pipes, leakage from the Fill/Drain/Overflow Valves, excessive wear of the valve actuator and unlatching and/or loss of the Water Servicing Panel Door. The total number of these events was unclear as reports received by the manufacturer were incomplete, in part because in most cases components had been returned directly to the vendor, in some cases by maintenance agencies acting for operators, without information passing to the aircraft manufacturer.

The records of G-VAEL's operator showed that usage of Fill/Drain/Overflow valves had been at a rate of over 3 valves per aircraft in the last year. The rejections were believed to have been due to cases of both external leakage (from the body) and internal leakage (through the valve when closed). Additionally, since service entry in early 1994 of a fleet of 4 aircraft, 5 cases of split pipes had occurred and 3 Servicing Panel Doors had been lost and several defective hinges had been reported.

The split pipe and valve leakage problems had generally been associated with the Aft Tank overflow system. Several modifications to the system have been introduced to resolve the problem and further changes are reportedly intended.

Discussion

Pipe Splitting

The manufacturer has attributed the cases of Aft Tank Overflow line splitting to the effects of water freezing in the line because of inadequate protection by the pipe heater element as the result of an unsuitable location for the temperature sensor controlling the element. The manufacturer reportedly intends to optimise the protection of the overflow pipe by modifying the sensor locations based on the findings of a programme in November 1995 to record temperatures encountered in service in relevant parts of the system.

Valve Damage

Freezing is also considered to have caused many of the Fill/Drain/Overflow Valve problems; signs of mechanical damage consistent with the effects of freezing, such as bent flanges, have reportedly been found on most of the failed valves. The addition of valve port heater cuffs did not apparently prevent water freezing in the valve in all situations, reportedly because of incorrect location of the temperature sensor controlling the cuff, and further action to modify the sensor location has been carried out. The manufacturer reportedly intends to optimise the protection of the valve by further action to ensure correct sensor location.

Incomplete Valve Closure

It also appears possible that leakage could occur as a result of incomplete closure of the Fill/Drain or Overflow Valves after tank replenishment. The evidence from the reported cases of excessive actuator wear has apparently indicated that the actuator had continued to run for an extended period with the ball valve stalled before the closed limit switch had been reached and with the overload clutch slipping; leakage through the valve would be a distinct possibility in such a case, given the small amount of valve overtravel, as noted above. The evidence suggested that stalling could result from distortion of the valve body under loading applied by the bolts fastening the valve to its mounting bracket, or because of loads applied by the manual operating mechanism following permanent deformation of the bracket, possibly due to the loads applied to the bracket during manual operation. The manufacturer has issued modifications aimed at preventing valve body distortion under mounting bolt loads, providing reinforcement of the valve bracket and requiring rigging of the manual operating mechanism to a specified dimension.

Fill/Drain Port Blanking Cap

As seen from Fig 1.1, any leakage through either Fill/Drain Valve would allow water from the respective tank to flow to the Fill/Drain Ports, up to a quantity of potentially most of the tank contents. Additionally, the fill line between the two Fill/Drain Valves has a low point that holds 4 to 5 ltr of water after filling that flows to the Aft Fill/Drain Port on take-off rotation. Water leaking from the port is likely to be retained within the Water Servicing Panel in appreciable quantities by the door seal, particularly with the aircraft in a nose up pitch attitude. Such leakage would reportedly be prevented by the fitment of the Fill/Drain Port blanking cap and the manufacturer has issued modifications aimed at improving the cap lanyard and providing a placard at the Servicing Panel instructing replacement of the cap after servicing.

Overflow Port Leakage

The quantity of water that could be released into the Water Servicing Panel through a leaking Aft Overflow Valve would appear to depend on the aircraft attitude. On the ground it would be limited to the reported 2 ltr capacity of the overflow line between the Aft Tank and the Overflow Valve; this line could possibly remain partially full after manual tank replenishment, or after normal replenishment should a malfunction allow an overflow to occur before the system automatically shut off the valves. It appeared possible that the potential quantity would be much greater with the aircraft in a nose up attitude, particularly if tanks were fairly full, as the raising of the Forward Tanks relative to the Aft Tank causes water to transfer rearwards through the interconnecting feed line and thence into the aft overflow line (Fig 1.2). Reports suggested that such a transfer would occur during cruise, typically with a 2 to 3° nose up body angle, while tanks were fairly full. The manufacturer considered that the addition of a water-tight blanking cap at the Overflow Port was not possible, because of a need to maintain consistency with the Aft Drain Panel Overflow Port. To prevent possible ice build-up in the Water Servicing Panel in the event of Overflow Valve leakage, a mandatory modification is to be introduced to replace the Overflow Port blanking pad with a drain funnel intended to pass any water leaking from the Overflow Port overboard and to increase the drainage provision in the door.

Water Servicing Panel Door Loss

The evidence indicated that while some of the cases of door loss could have been due to ice build-up in the Water Servicing Panel, this could not have been the situation in at least one case, where the door detached at low level on departure from Hong Kong. The marginal means of hinge pin retention noted above indicated that pin disengagement from the hinge could have been a factor in some cases. The manufacturer is to introduce mandatory modification to alter the door catch arrangement and to replace the swaged hinge pins with longer pins retained by a split pin at either end.

Recommendation 95-43

It is recommended that the DGAC (France) as the authority responsible for the continued airworthiness of the Airbus A340, review with the manufacturer the service history of the potable water system and aim to ensure that adequate measures are taken to prevent the overboard leakage in-flight of water or ice and the detachment of the Water Servicing Panel Door. The JAA should monitor the safety action arising from this recommendation.

POTABLE WATER SYSTEM SCHEMATIC

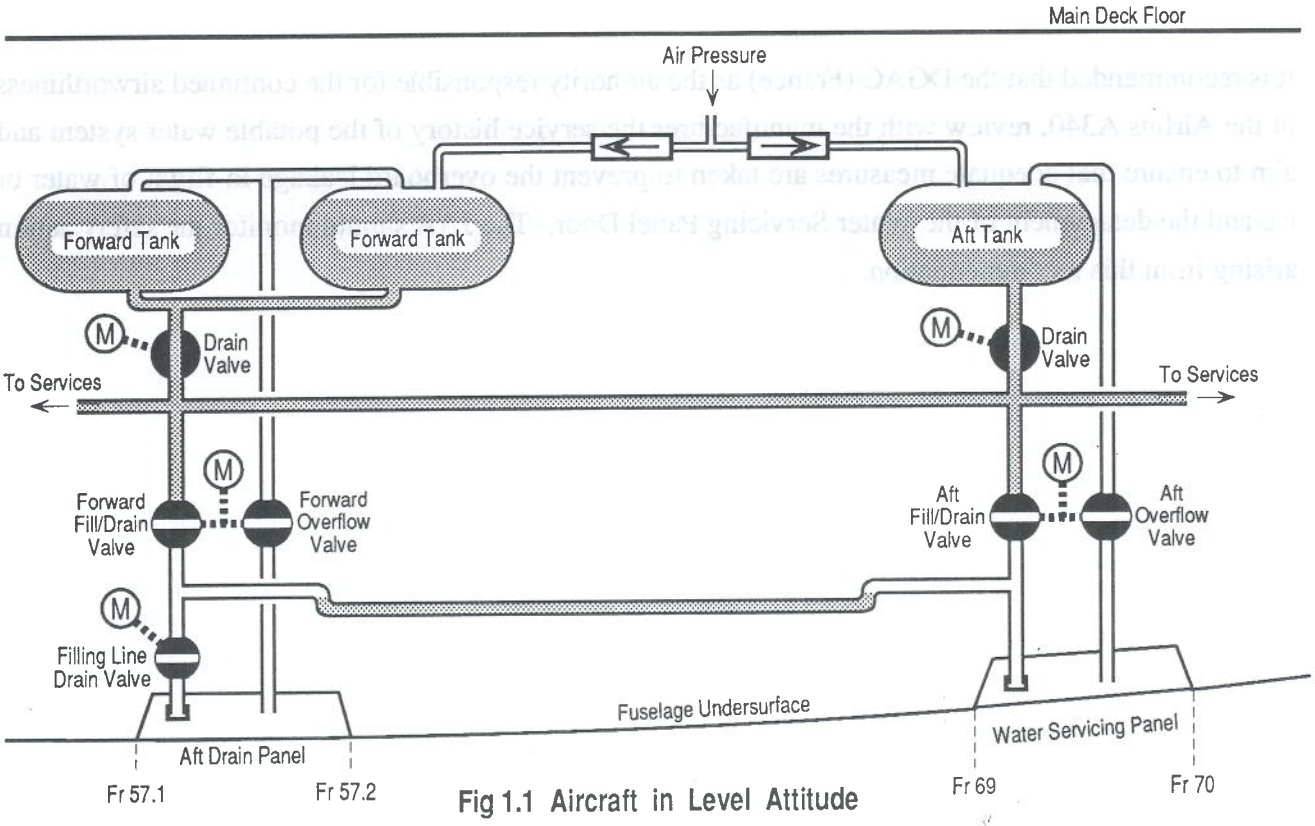


Fig 1.1 Aircraft in Level Attitude

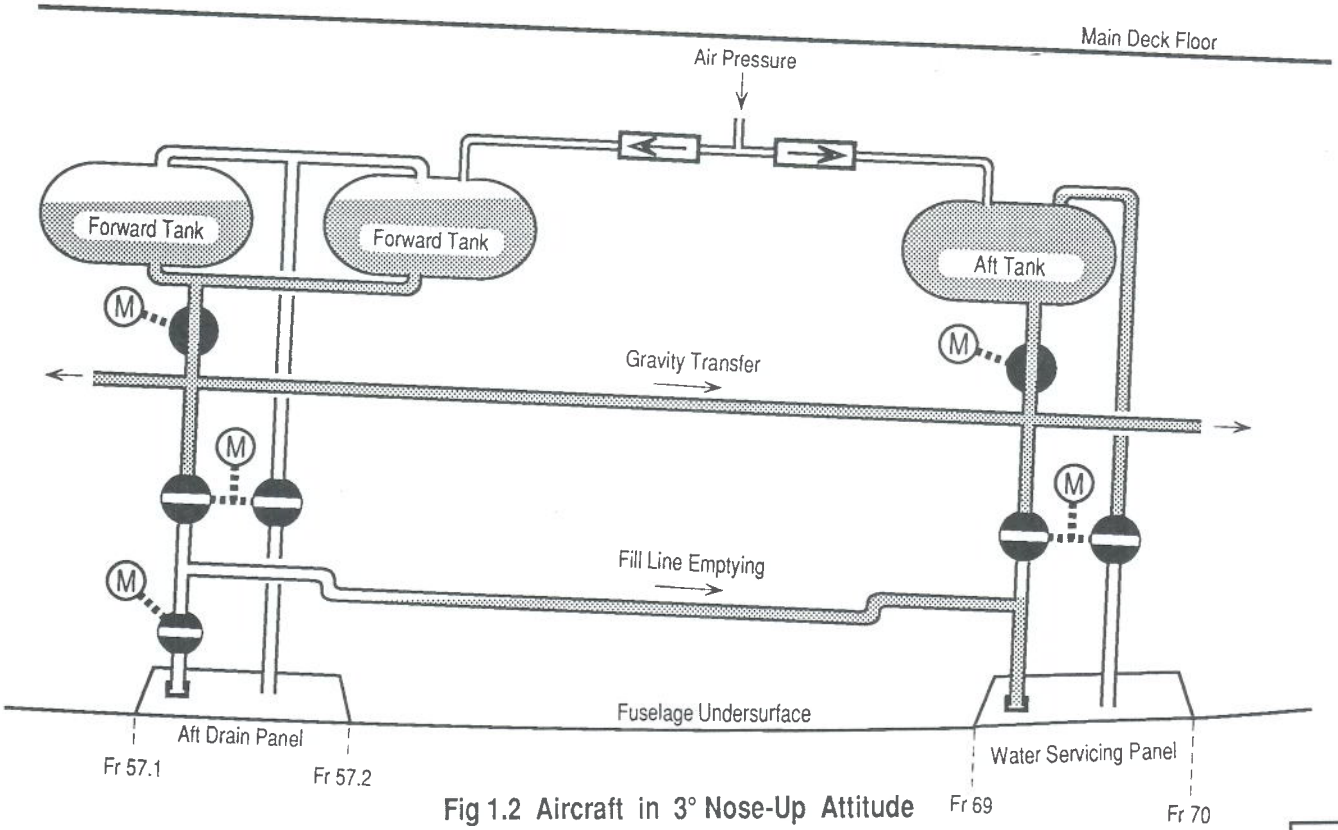
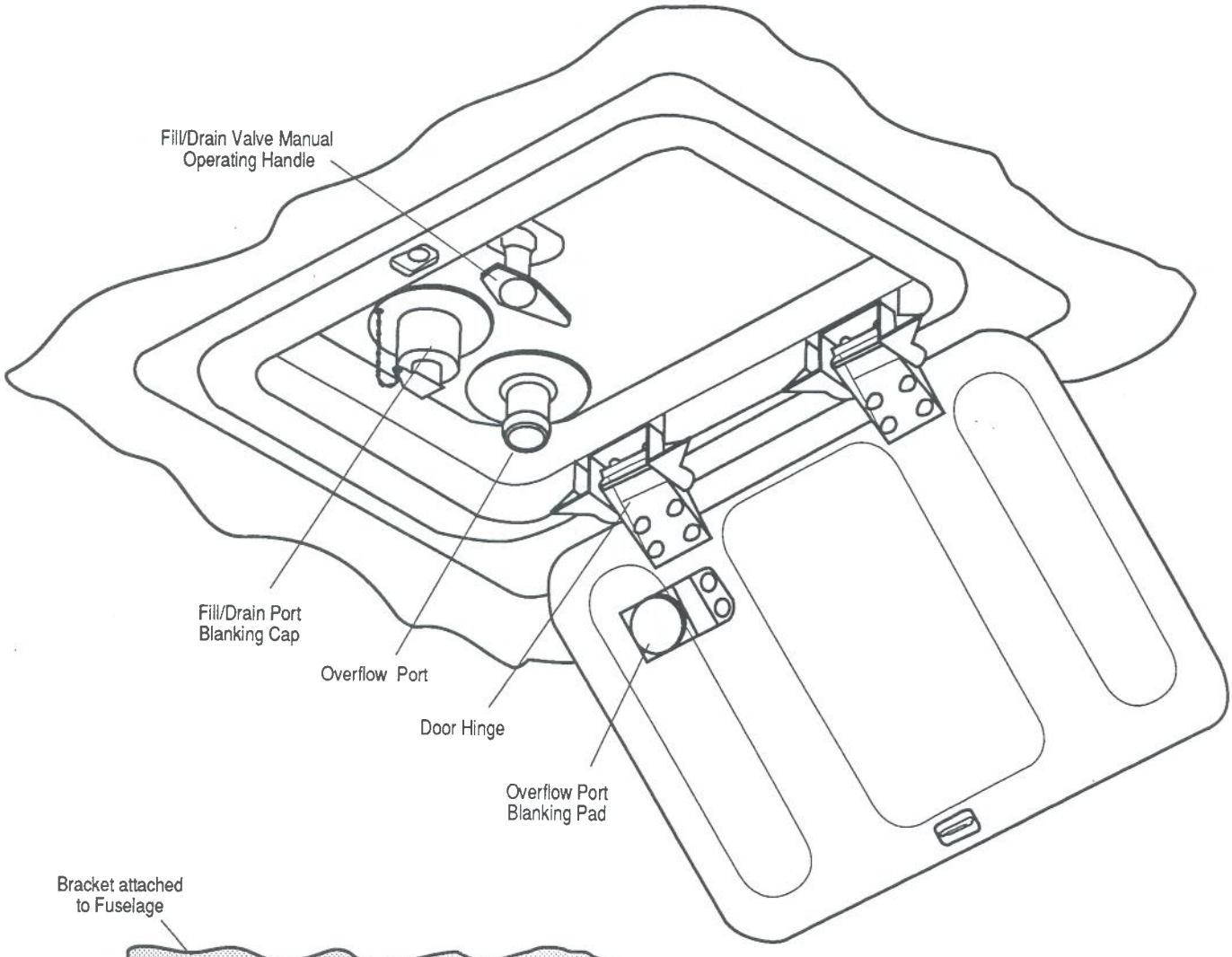
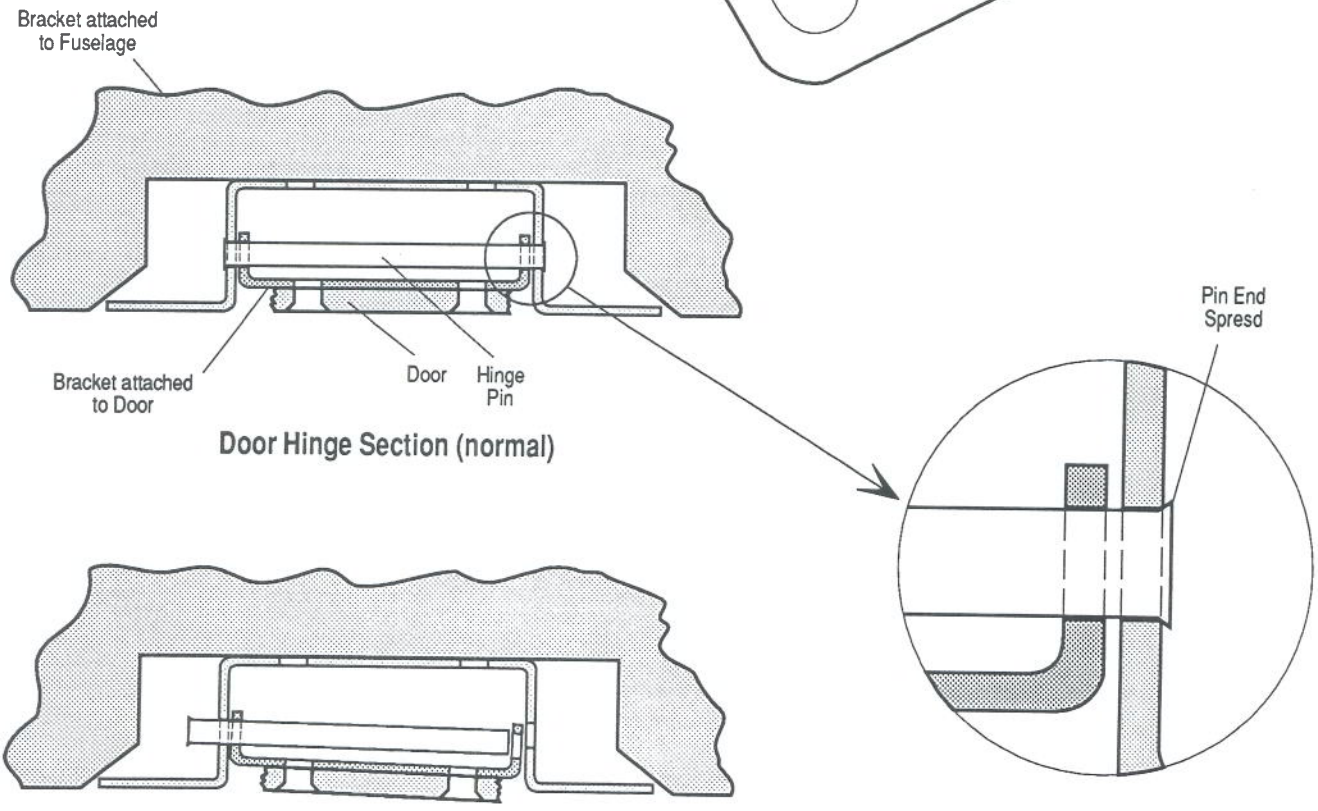


Fig 1.2 Aircraft in 3° Nose-Up Attitude

Fig 1

POTABLE WATER SERVICING PANEL

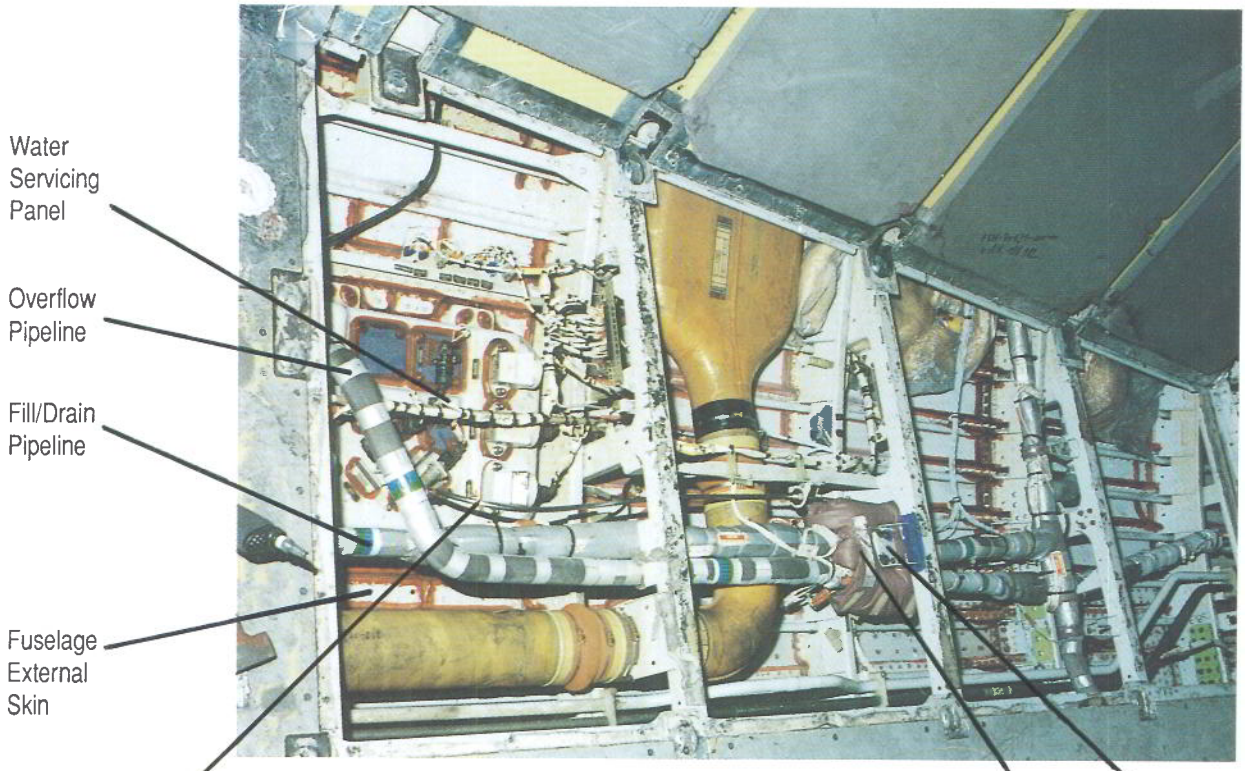




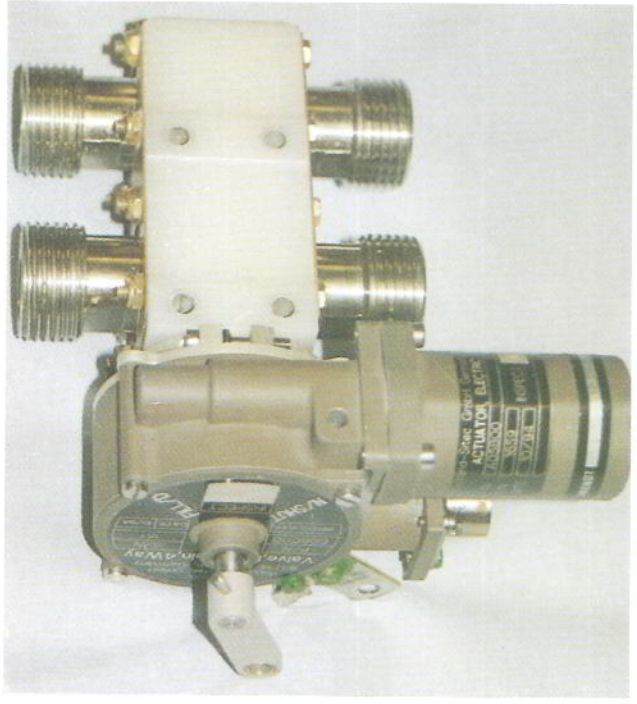
Door Hinge Section (normal)

Door Hinge Section (Pin disengaged)

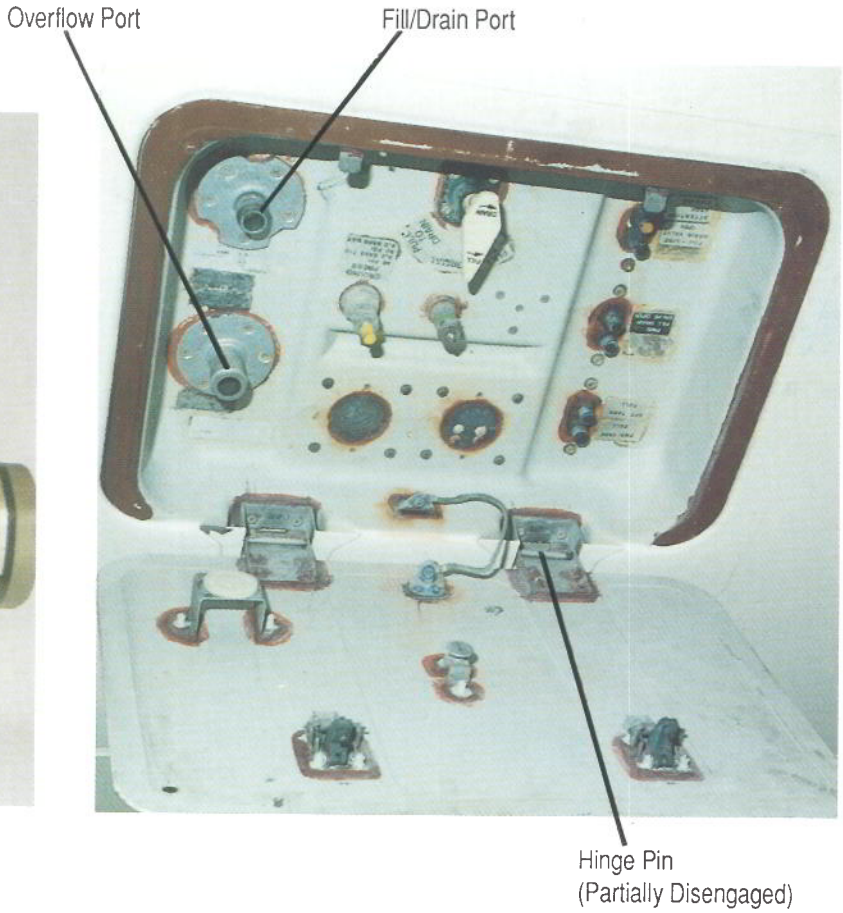
Fig 2



3.1 Fuselage Undersurface in Aft Cargo Compartment



3.2 Fill/Drain/Overflow Valve



3.3 Water Servicing Panel

Fig 3