INCIDENT

Aircraft Type and Registration:	Dassault Falcon 20-F5, N757CX
No & Type of Engines:	2 Honeywell TFE-731-SER turbofan engines
Year of Manufacture:	1980
Date & Time (UTC):	9 May 2007 at 2205 hrs
Location:	Descent and approach to London (Stansted) Airport
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - 5
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	7,622 hours (of which 2,053 were on type) Last 90 days - 109 hours Last 28 days - 34 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was descending towards London (Stansted) having flown from Gander, Canada, when a lateral flight control restriction became apparent. Full force by the pilots was applied to both control wheels in an attempt to recover lateral control, but no movement was possible. The aircraft was landed safely at London (Stansted) by means of the elevator and rudder controls. During the investigation, a significant volume of water was discovered below the floor panels in the forward fuselage; the water had frozen in flight and caused a restriction to the movement of the aileron trim actuator.

History of the flight

The flight originated in Little Rock, Arkansas, USA. Both members of the flight crew were commercial pilots who flew the aircraft regularly; one of the passengers was also qualified to fly the aircraft. The two pilots reported for the flight at 1000 hrs (0500 hrs local time).

The first sector was from Little Rock to Teterboro Airport, New Jersey and was uneventful: the aircraft was then on the ground for 41 minutes. The passenger qualified to fly the aircraft was the handling pilot during the second sector, from Teterboro to Gander, Canada. During the approach to Gander, whilst flying manually, he noticed that the lateral flight controls were unusually stiff and commented on this to one of the commercial pilots; this pilot was the aircraft commander during

the subsequent flight to Stansted. He noticed that the aileron trim position indicator was positioned at about 1/8 to 1/4 of maximum deflection. He centred the trim and the handling pilot reported that the lateral control was now better. At this stage, the commercial pilot assumed that the reason for the stiffness was that the ailerons had been mis-trimmed. The aircraft landed uneventfully and was on the ground at Gander for 39 minutes.

The third sector, from Gander to Stansted, was operated by the two commercial pilots; the commander occupied the left hand seat and was the handling pilot. The flight control check before flight was normal. After about two hours at cruise altitude, with the autopilot engaged, the pilots noticed a flickering aileron TRIM caption on the Primary Flying Display (PFD) (see 'Autopilot description'). The commander applied corrective trim, in the required direction, but the caption re-appeared from time to time. The commander disconnected the autopilot and found that the roll control felt stiffer than was normal; he then re-engaged the autopilot and continued the flight. Several times the aircraft started to drift off the required track; the commander used the aileron trim to adjust the tracking. The non-handling pilot consulted the Emergency/Abnormal procedures checklist to see if there was any guidance on a lateral flight control problem. There was no specific procedure available, but under the heading 'ABNORMAL RESISTANCE OF FLIGHT CONTROLS' there was the information:

> *'Do not hesitate to apply extra force in an attempt to overcome abnormal resistance during the movement of a flight control.'*

On the descent towards Stansted, whilst attempting to follow radar vectors, the commander found that the lateral flight control problem had become worse. The autopilot turned the aircraft to the left normally when required but the aircraft was reluctant to return to wings level flight. Then, whilst in a left turn, the bank angle continued to increase, and when it reached around 45º the commander disconnected the autopilot with the intention of flying manually. He found that the roll control was very stiff when rolling to the right and he used the rudder to bring the aircraft to a wings level attitude. Both pilots now applied force to the control wheel but were unable to move it. The control wheel was central but the aileron trim indication was now indicating 2 units (1/2 of maximum deflection) to the right.

The commander was only able to make turns through the gentle use of rudder, accordingly he restricted the bank angle to a maximum of 10º. The pilots advised ATC that they had a jammed flight control and were not able to do turns to the right and were only able to make shallow left turns. ATC responded by asking the pilots if they were declaring an emergency; the reply was "YES SIR". ATC provided vectors requiring left turns only until the aircraft was in a position from which it could intercept the localiser and establish on the ILS approach for Runway 23 (See Figure 1).

The weather conditions at London Stansted featured strong gusting winds from a westerly direction, with a cloudbase at around 2,000 ft. The commander was able to intercept and maintain the ILS course by using the rudder. He was concerned, however, that in the turbulent crosswind conditions he might have some difficulty were the aircraft to roll whilst close to the ground during the landing. The surface wind prior to touchdown was from 240º at 16 kt with a maximum of 25 kt. A successful landing was made at 2222 hrs and the aircraft came to a stop on the runway. The pilots confirmed to ATC that they did not require any assistance and were able to taxi to a parking area.

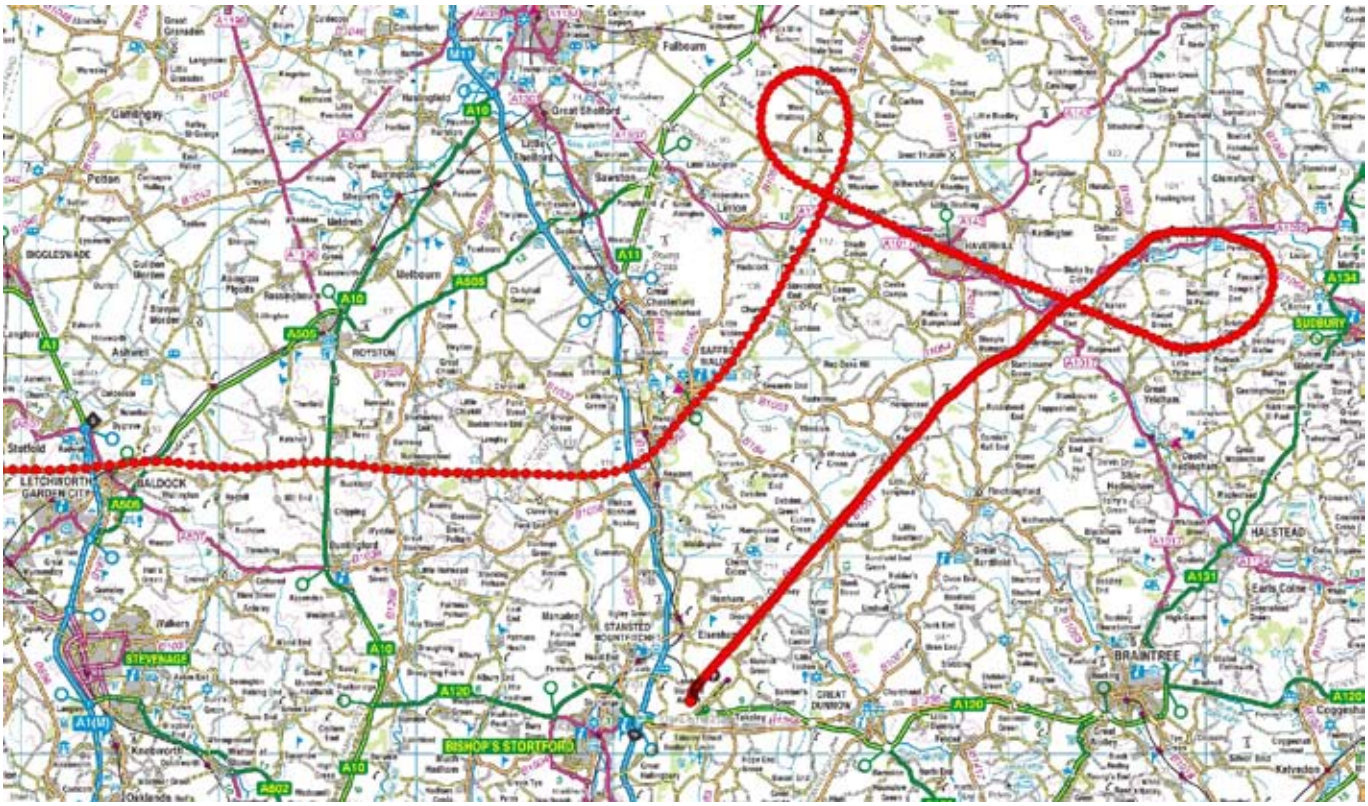

Figure 1

Radar track of N757CX inbound to London Stansted

Some 20 minutes after the aircraft had been shut down the control wheel was still jammed. The non-handling pilot carried out an external inspection of the aircraft and found that he could not move the ailerons either. The pilots left the aircraft parked and retired to their accommodation.

Aircraft information

History of the aircraft

N757CX (serial number 408) was originally built in 1980 with General Electric CF-700 engines and conventional cockpit instrument displays. Later, it was fitted with Honeywell TFE-331 engines and a 'glass' cockpit display. In December 2006 it was flown to a maintenance company for a 'C' check which was followed by a repaint and retrim; this exercise took approximately ten weeks. It had been back in service for about six weeks at the time of the incident, and in that time had flown approximately 20 hours.

The aircraft was normally based at Little Rock Airport, Arkansas, and operated principally on flights within the USA. The flight times recorded on the day of the incident were:

Little Rock to Teterboro	2 hrs 30 mins
Teterboro to Gander	2 hrs 12 mins
Gander to Stansted	4 hrs 42 mins

Description of the roll control circuit

The Falcon 20 aircraft has dual hydraulic systems with manual reversion of the primary flight controls available in the event of a double hydraulic failure (see Figure 2). From the base of the control columns, rods and bellcranks

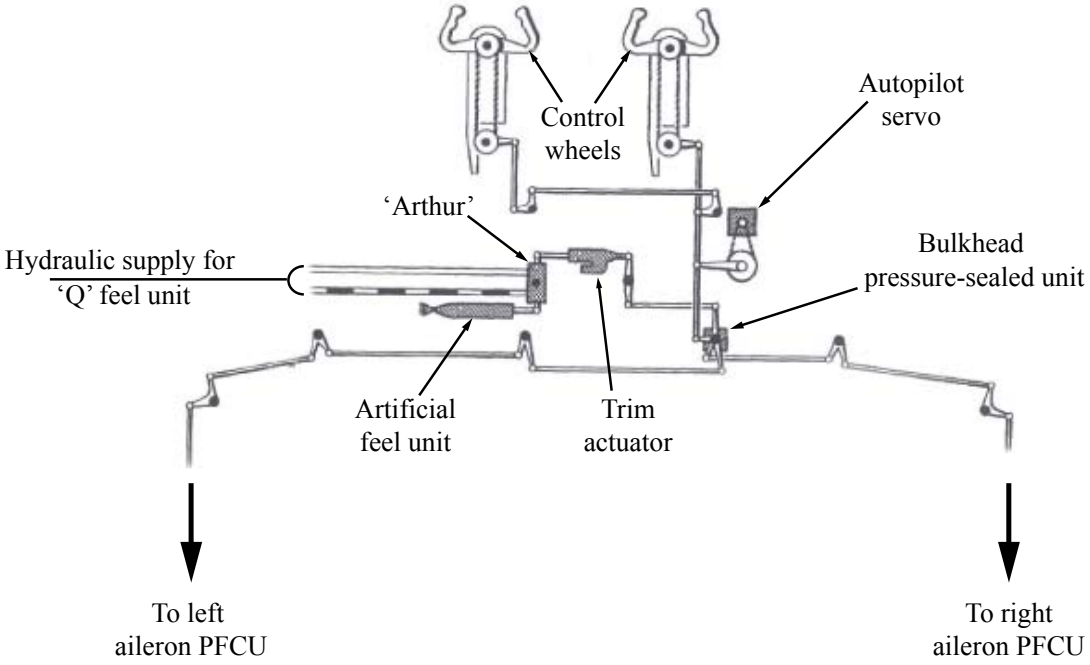

Figure 2

Schematic of Falcon 20 aileron mechanical control system

are used to transmit yoke inputs to the hydraulic servos in the wings. The autopilot actuators for roll and pitch control are situated on the right side of the forward vestibule, above the main floor level, from whence the roll control rod goes down to below floor level. A pressure-sealed bulkhead unit then allows rods to travel outside the pressure hull to the left and right wings. However, a further rod remains in the pressurised area to connect to the electric roll trim actuator, the hydraulic 'Q' feel unit (called 'Arthur' by the manufacturer) and an artificial feel unit, which is a simple spring strut and serves the purpose of centring the control. Thus it can be seen that the aileron trim actuator body moves with pilot or autopilot inputs and that, when trim commands are made, the actuator effectively extends or retracts against the artificial feel unit spring, deflecting the ailerons. It should be noted, therefore, that if movement of the electric trim actuator body, which moves with control inputs, is restricted, then that restriction will be felt by the pilots or the autopilot.

Moreover, the roll trim actuator is situated low down at the rear of the forward fuselage (Figure 3) and it can be seen that the underside of the actuator body is only a few centimetres above the lowest point of the belly skins.

Autopilot system

The autopilot controls the ailerons through a servo motor which is connected to the control wheel linkage; there is an engage/disengage clutch mechanism which can be manually overridden by the pilots in case of a failure of the clutch to disengage. The autopilot has a similar arrangement for pitch control. If the aileron trim requirement changes, the autopilot holds the load until it becomes excessive, at which point an aileron mis-trim warning is generated. This warning is displayed on the PFDs: a yellow 'A' indicates a moderate aileron mis-trim (around 3.7 lb) and a flashing red 'A' indicates a significant aileron mis-trim (around 7.4 lb). A left or right pointing arrow is displayed below the warning; there is no additional indication. To correct the mis-trim

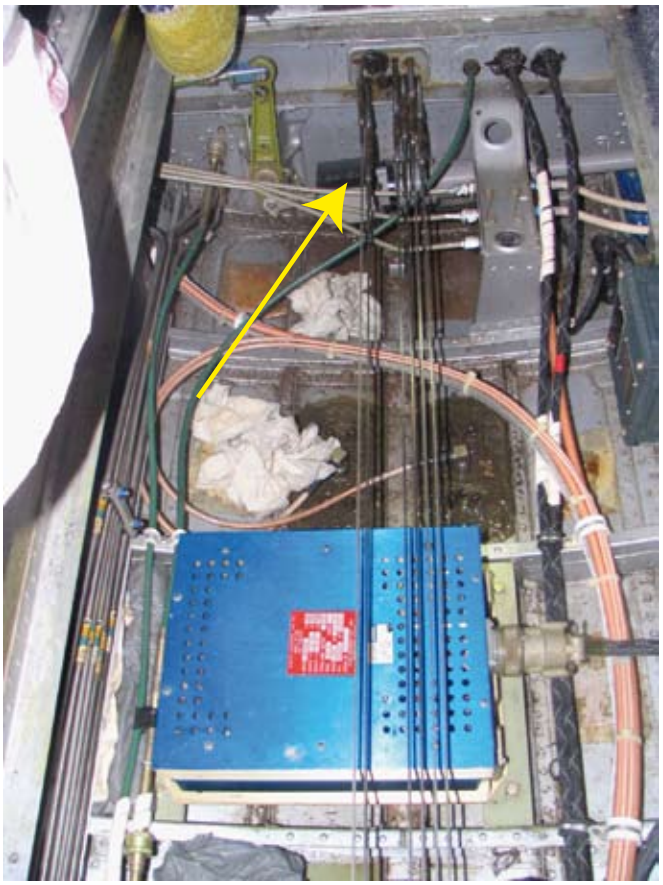

Figure 3

View of lower fuselage skin of N757CX with floor panels removed. Note the location of aileron trim actuator (arrowed)

the pilot applies trim in the appropriate sense, by means of a pair of electric trim switches located on the centre pedestal, until the warning disappears. The aileron trim gauge is marked as a percentage of full aileron deflection (which is +/-15º); the maximum position indicated on the trim gauge is 40%, which equates to +/-6º of aileron deflection, therefore, 2 dots, or half scale, represents 3º of aileron deflection. Normally, when an away-from-neutral trim setting exists, the control wheel will also be displaced from the neutral position, but for small trim commands the amount of deflection is minimal. The autopilot will not disconnect when the load becomes excessive because, were it to do so from a severe out-of-trim condition, the aircraft would roll rapidly.

Fuselage drains

The aircraft is fitted with seven underbelly drains in the forward fuselage of a type which the manufacturer calls 'manual (semi-automatic)'. Most of the drains are located towards the nose but one drain is located just forward of the wing front spar.

The Airplane Flight Manual pre-flight checklist, carried on-board the aircraft, did not contain any reference to the fuselage drains. The drain outlets are flush with the underside of the fuselage and should be marked with a black or coloured circle. This aircraft had recently been repainted and there were no such markings associated with the drains.

Examination of the aircraft

The aircraft was examined about 36 hours after landing. In addition to the AAIB Inspectors, present at the examination were the flight crew, two representatives from the company that had completed the major maintenance and, later, a representative of the aircraft's manufacturer.

It was immediately apparent that the ailerons were free to move without hydraulic power and felt normal when exercised throughout their full range using the control yokes; with hydraulic power applied the control check was also normal. Inspection of the control runs in the wings and above the floor showed no anomalies and the pressure-sealed bulkhead unit, inspected from outside, also appeared normal. The autopilot actuator functioned correctly, with no tendency for the clutch to remain engaged.

It was then decided to lift the central floor panels to gain access to the roll trim actuator and the associated mechanisms underneath. It became immediately apparent that there was a large quantity of water

contained in the belly of the forward fuselage of the aircraft, but, as a hand was dipped into the water in the area of the manual drain, the drain opened and water started to pour out onto the ground at a considerable rate. Unfortunately, there was no container available to catch such an unexpectedly large amount to measure its quantity, and only a sample could be taken: it was also not possible to close the drain until a suitable container could be found.

However, the water continued to flow at a high rate for in excess of ten minutes and it is estimated that at least 20 litres of water was drained from the aircraft. After drying out the area and discarding soaked insulation, the interior was reassembled and the aircraft conducted a lengthy test flight at altitude to ascertain whether the problem had been resolved. There was no recurrence of the lateral flight control symptoms and the aircraft later departed with passengers for its base in the United States. During these legs, and subsequently, there have been no further reports of control restrictions.

The manufacturer has received notification of three previous events similar in nature to that experienced on this flight. These were reported to the European Aviation Safety Agency by means of a 'Significant Event Report' following the incident involving N757CX.

Information from the flight crew

The pilots were interviewed on the day after the flight and the history of flight is largely compiled from their account. Both pilots were experienced on the aircraft type and had flown this particular aircraft frequently. They were also aware that it had recently returned from a scheduled maintenance check. The pilots said that an occasional aileron trim caption was not an unusual event during a flight. They advised that there had been no notable turbulence en-route and the weather was clear throughout all the sectors until the descent in UK airspace. They also reported that the fuel had remained in balance throughout the flight and that the aircraft had about 1,400 lbs of fuel on board during the approach to Stansted.

After the water had been discovered in the fuselage and the keel drain had been found to have been stuck, the crew were asked about their use of fuselage drains. They commented that they routinely checked that the galley drain was working after a flight but that checking of the keel drain was a maintenance function which would have been done before the aircraft was released for flight. The commander believed that he had seen the galley drain working after arrival at Gander.

Recorded flight information

Flight recorders

The aircraft was not required, under the applicable regulations, to be fitted with either a Flight Data Recorder or Cockpit Voice Recorder (CVR). However, a CVR was fitted which recorded the last 30 minutes of flight crew speech and cockpit area microphone sounds before electrical power was removed from the aircraft.

The CVR recordings started just as the crew were given clearance to land, with the aircraft six miles from Stansted. Once the aircraft was on the ground the crew discussed how the "AILERONS WERE COMPLETELY FROZEN – WE HAD NO AILERONS", which prompted the (qualified) passenger to remark "THAT'S WHAT HAPPENED TO US GOING INTO GANDER", referring to the previous sector when he had experienced similar problems whilst manually flying the aircraft during the approach to Gander.

Radar recordings

Radar data for the flight, detected by the Stansted primary radar and secondary surveillance radar, was recorded by the London Area Control Centre.

The recorded data started at 21:50:00 with N757CX overhead Royal Leamington Spa on a south-westerly track whilst descending through Flight level 204. A left turn was then made, as the aircraft passed over Brackley, onto an easterly track. Figure 1 depicts the aircraft on this easterly track overhead Letchworth (21:58:53) at Flight Level 117 (still descending) and ends with the landing and subsequent taxiing at London Stansted (22:26:14). The figure shows several 270° turns to the left, followed by minor heading corrections to the right as the aircraft was positioned to intercept the localiser on the ILS approach to Runway 23.

Analysis

There appears little doubt that the large quantity of water drained from the belly of the forward fuselage was responsible for the initial 'heavy' feel, and subsequent freezing, of the lateral flight controls. Even if the water level did not actually touch the trim actuator with the aircraft on the ground (bearing in mind that the precise quantity was not established before it drained away), the typical cruise attitude of about 4° nose-up would allow the water to migrate and increase the level around the actuator. Restricted movement of the actuator body would then result in corresponding restriction of the ailerons: entrapment by ice would also explain why the (literally) frozen aileron condition which persisted after landing was not replicated when inspected by the AAIB when mild temperatures had allowed the ice to melt over a period of some 36 hours.

The aircraft normally carried out internal flights in the USA; this particular flight was fairly unusual in that it was over a long distance and consisted of a series of sectors with short turnaround times. The effect of the time at altitude would have been to expose any water trapped in the fuselage to cold temperatures. The flight sectors were broken by only short periods of warmer temperatures when the aircraft was at low level or on the ground. During the approach into Gander some degree of freezing of the fuselage water seems to have occurred which restricted the trim actuator movement.

After the departure from Gander the already cold water would have again been exposed to very cold temperatures and progressively froze. The transatlantic flight would have involved few changes in direction so the trim actuator body would have remained largely undisturbed, except when the pilots applied trim. Eventually the trim actuator body would have become completely frozen and trapped, so that later on even the pilots' combined efforts on the control wheel could not move it.

Once the trim actuator body had started to freeze, the autopilot would have had difficulty in moving the ailerons. Therefore, the roll control was, in effect, being achieved through the pilot's use of the electric trim. The amount of roll control available through this means is limited. As the aircraft speed reduced during the descent and approach the aileron control deflection required to maintain or change the heading would have become greater. Thus, the inability of the aircraft to respond and achieve the demanded heading would have become more noticeable. Ultimately the aircraft continued to roll to the left until the commander intervened and disconnected the autopilot. He was unable to roll the aircraft to wings level and had to use the rudder to assist. Both pilots then applied their full combined force to their control wheels but were unable to move them because, by this time, the trim actuator body was trapped. Thereafter, by necessity, all the turns were made using the rudder.

The commander reported that the control wheel had jammed in a wings level position with the aileron trim indicating 2 units. However, since trim position is derived from extension of the trim actuator, the indication could have been misleading – if the actuator body had been firmly trapped by ice in the neutral position, trim commands would simply compress or extend the artificial feel spring without physically moving the control surfaces although indicating some deflection on the trim position indicator.

The source of the water is problematic. The sample appeared relatively clear, fresh and without odour, so is highly unlikely that it originated before, or during, the major inspection which the aircraft had recently undergone. There are no potable or other water supplies in the related area; the only possible source was a drain from the icebox, which is normally replenished before each flight. This drain closes under pressurisation but opens on the ground to allow water from the melted ice to drain away. Not only was this drain found to work normally, but there were no leaks identified in the tubing between it and the icebox.

Water in aircraft bilges can come from a variety of sources: leaking plumbing, condensation and leaking door seals are the most common. The amount of water found would seem to preclude condensation as the capacity of the ice drawer was not sufficient for the water to have accumulated during the course of one or two flights. Therefore, it seems likely that the water must have built up in the fuselage over a period of time. Forensic analysis of the water sample concluded that it was most probably rainwater, rather than condensate or tap water, which would imply that either the aircraft had a leaking door seal on the ground, or that the door had been left open during rain. The quantity would seem to suggest either a long exposure time, or torrential rain, or both. However, the manufacturer believes that a more likely source of the water in question was minor leaks in the area of the icebox drain occurring over an extended period of time; this concurs with the views of the operating crew.

Safety action

In the days following the incident, the aircraft manufacturer issued a communication to operators which included the information:

> *'OPERATOR COMMUNIQUÉ - URGENT - No. 050721-1 Subject: Jammed aileron control during descent'*
>
> *Dassault reminds Operators that drains must be checked during the aircraft daily inspection as described in the Operating Manual daily servicing in the "DRAINING OF CONDENSATION WATER" sub-chapter. This check is also part of the Basic Inspection every 7 days and part of the A inspection. The content of the "DRAINING OF CONDENSATION WATER" section of the daily servicing and Basic Inspection is under consideration in order to see if it can be improved. In the meantime, as a precaution, Dassault recommends that Operators check both manual (also called semi-automatic) drains and automatic drains during the above referenced maintenance operations.'*

The Communication also reminded operators that the drains must be marked by a coloured circle.

It is considered that the action taken by the manufacturer should be sufficient to prevent a re-occurrence. Therefore, no safety recommendations have been made as a result of this investigation.