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# FINAL REPORT

# SERIOUS INCIDENT

# to
# ATR 42

# EI-CBK

## near

## Dublin

## 8 August 2003

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***Notification of Accidents or Incidents should be made on the***
***24 hour reporting line***
***01-604 1293***
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**FINAL REPORT**

In accordance with Annex 13 to the International Civil Aviation Organisation Convention, Council Directive 94/56/EC, and Statutory Instrument No. 205 of 1997, the sole purpose of these investigations is to prevent aviation accidents. It is not the purpose of any such accident investigation and the associated investigation report to apportion blame or liability.

**FINAL REPORT**

**AAIU Formal Report No: 2005-014**
**AAIU File No: 2003/0043**
**Published: 11 August 2005**

| | |
|---|---|
| **Operator:** | Aer Arann |
| **Manufacturer:** | ATR |
| **Model:** | ATR 42-300 |
| **Nationality:** | Ireland |
| **Registration:** | EI-CBK |
| **Location:** | Near Dublin |
| **Date/Time (UTC):** | 8 August 2003 @ 23.07 hrs |

## SYNOPSIS

The aircraft was in the cruise, routing from Luton Airport (EGGW) in the UK, to Galway (EICM), when the RH engine spooled down and stopped. The crew made a PAN call to Shannon ATC. They initially considered diverting to Dublin (EIDW) or Belfast (EGAA) but these were closed due to fog. They then decided to divert to Shannon (EINN) and landed there safely on one engine. The Investigation subsequently found that the RH engine stopped because the fuel tank feeding this engine was empty. The Investigation makes six Safety Recommendations.

## NOTIFICATION

The Operator's maintenance organisation informed the AAIU Duty Inspector of this event at 08.00 hrs on 9 August 2003. The Inspector proceeded to Shannon to inspect the aircraft. In accordance with the provisions of SI 205 of 1997, the Chief Inspector of Accidents, on 11 August 2003, appointed Mr Graham Liddy, who was the Duty Inspector concerned, as the Investigator-in-Charge to conduct a Formal Investigation into this occurrence.

## 1. FACTUAL INFORMATION

### 1.1 History of the Flight

The aircraft over-nighted at Galway Airport on the night of 7/8 August. It was scheduled to fly four legs on 8 August, which were:

| | | |
|---|---|---|
| Galway | to | Luton |
| Luton | to | Waterford (EIWF) |
| Waterford | to | Luton |
| Luton | to | Galway |

No change of crew was scheduled for these four legs. However, the departure from Galway was delayed for nearly five hours due to fog. This would have resulted in the crew going out of duty time before their final arrival back at Galway. It was therefore decided that the aircraft would fly from Galway to Dublin, where the crew would be changed.

The crew who were later flying the aircraft at the time of the incident were originally scheduled to fly another aircraft with a scheduled departure at 09.55 hrs. Due to the reorganisation of the Operator's schedule caused by fog, they were stood down from this flight while still at home and were re-scheduled to report for duty at 12.30 hrs for the departure of EI-CBK from Dublin to Luton at 13.30 hrs.

On the flight of EI-CBK from Galway to Dublin, while in the cruise, the fuel contents gauge of the LH fuel tank wound back to zero. After landing it registered a fuel content that was considered consistent with the estimated contents. As the aircraft taxied to the stand, the LH gauge was again observed to be reducing to zero. The Galway-Dublin crew were conscious that the passengers were bound for Luton, and were already several hours behind schedule. They reasoned that if the defect were written up in the Aircraft's Technical Log (Tech Log), a further delay would ensue. Furthermore, as an unserviceable (u/s) fuel gauge was allowable under the Minimum Equipment List (MEL), and could be carried for 10 days, the crew believed that the probable action of the technical personnel would be to enter up the defect in the Deferred Defects List (DDL) and to sign out the aircraft as serviceable. Getting technical personnel out to the aircraft at Dublin to perform this procedure would involve even further delay. The inbound Captain therefore decided not to enter the defect in the Tech Log but to brief the new crew on the defect.

The oncoming crew met the aircraft at the stand in Dublin. The passengers and their baggage remained on the aircraft. The hand-over of crew was carried out with the aircraft in Hotel Mode (i.e. with the LH engine stopped and RH engine running at idle with its propeller braked), in order to maintain air conditioning in the cabin, as no Ground Power Unit (GPU) was available.

The previous crew briefed the on-coming crew about the LH gauge problem. During the Dublin stop the aircraft was refuelled and 962 kg of fuel[1] was taken on board. This fuel uplift was not recorded in the aircraft's Tech Log. The decision to take on as much fuel as possible at Dublin was based on major slot time delays, which were in turn caused by the disruption due to the widespread fog. It was reported that there was considerable agitation among the passengers during the Dublin stop. This was due to the lack of air conditioning while the RH engine was subsequently shut down during the refuelling operation, the associated cabin heat levels and the flight delays. While taxiing out for take-off at Dublin, there was a bleed air fault with the LH engine. This was resolved by resetting the temperature selector and the bleed push button. The aircraft departed for Luton at 15.07 hrs UTC, which was 1 hr 37 min later than the re-scheduled departure.

[1] Aviation fuel is dispensed by fuel suppliers in litres but this is converted to kilograms (kg) when taken on board the aircraft. This is to facilitate weight and balance calculation for the aircraft by the flight crew. The conversion from litres to kg can vary with the specific gravity of the fuel usually within the range of 0.79 to 0.81 kg per litre. Normally the mean valve of 0.80 kg per litre is used. On the ATR 42 the fuel tank gauges are calibrated in kg and the flow rate gauge are calibrated in kg/hr. The operator converts all fuel data into kg and fuel management is conducted in kg. For consistency, all fuel calculations in this report are conducted in kg.

During the flight, the crew found that by cycling the fuel panel circuit breaker they could occasionally get the LH gauge to give a reasonably accurate reading, but after a while this would inevitably reduce to zero. No fuel was taken on at Luton.

The aircraft arrived at Waterford some 6 hours behind the original scheduled arrival. After arrival it was found that, due to the gross disruption of the schedule caused by fog, the baggage loaders at Luton had inadvertently put the baggage for a Luton-Galway flight onto EI-CBK. As a consequence arrangements had to be made for the Galway baggage to be removed from the aircraft at Waterford and then dispatched by road to Galway. There was further delay while this was sorted out. There was another problem when a passenger, who had tablets for epilepsy in their luggage, became concerned as to the whereabouts of the tablets. The passenger was permitted by staff at Waterford to return to the aircraft to double check if the bag was onboard.

The aircraft was refuelled at Waterford. The Captain personally supervised this operation. He found that the auto-refuelling system worked initially, but at some point the input valve to the RH tank closed. This was indicated by the RH valve blue light extinguishing. This light is located in the Electrical Refuelling Control Panel. He then attempted to open the respective RH and LH fuel valves using the electrical switches for manual operation. These switches are located in the Electrical Refuelling Control Panel. He could not get the RH valve to open using the electrical switch. He then opted to refuel the RH tank using the manual toggle ring (sometimes referred to as "manual trigger") that opens the fuel valve to the RH tank. The manual toggle rings for the LH and RH tanks are located in the refuelling point, underneath the leading edge of the starboard wing. He asked the refueller operator to pull the toggle ring, but the operator did not know how to do this. However he volunteered to do it once the Captain had showed him what to do. The Captain observed that a blue light did come on at the Electrical Refuelling Control Panel, but because of his location near the wing refuelling point, he was unable to observe if it was the light for the RH or the LH valve. A total of 600 kg (750 litres) of fuel was taken on. The Captain then dipped both fuel tanks and recorded in the Tech Log that the LH tank contained 750 litres (600 kg) and the RH tank contained 900 litres (720 kg), giving a total of 1,650 litres (1,320 kg). In the course of the drip-stick calculation the Captain found that the lateral inclinometer reading, which is used in the fuel contents calculation, was difficult to determine, as the markings on the inclinometer were indistinct.

The aircraft then flew to Luton, where again the Captain supervised the refuelling. The Captain had estimated that there was approximately 325 kg of fuel in both the port and starboard tank prior to refuelling. He uplifted 1200 litres of fuel, which equates to 960 kg of fuel. Again there were problems with the RH valve in the course of the refuelling operation, in that it remained closed. The Captain requested the refueller operator, who was at the wing refuelling point, to open the manual toggle ring for the RH valve but the operator refused to accept responsibility for this. The Captain then climbed onto the refuelling vehicle's hydraulic platform and pulled the manual toggle ring himself. He observed that a blue light, indicating a valve had opened, had come on in the main refuelling panel. Again because of his location he was unable to observe if the indicating light was that of the LH or the RH valve. He did assume, however, that it was the RH valve. As he did not have access to a set of portable steps, he was unable to reach the dip points under the wing. Consequently no physical dip check on the fuel contents of the individual tanks was made prior to departure. The Captain subsequently stated that this was the first time he had ever personally operated the manual toggle rings. The Captain considered that considerable further delay would result from a search for steps and he decided to proceed with the next leg of the flight.

The First Officer completed the load and balance sheets using the fuel up-lift data provided by the refueller operator (1200 litres). After refuelling, the Captain noted that there was no increase in the fuel contents shown by the RH fuel gauge. The LH gauge was showing zero continuously at this point. The Captain, at this point, believed that the RH gauge was now unreliable.

**The Incident Flight**

The aircraft departed Luton at 21.45 hrs with 47 adult passengers and one infant. The First Officer was the handling pilot for this leg. After take-off rotation, she noted that the aircraft was left wing heavy, but well within control limits. She handed over control briefly to the Captain so he could assess the degree of imbalance. The First Officer noted that the degree of imbalance did not cause problems for the autopilot, but that the overhead panel light, which indicated deployment of the starboard spoiler, occasionally illuminated. This showed that the system was on the margin of requiring starboard spoiler deployment to counteract the imbalance. The Captain handed control back to the First Officer, and it was decided to run the RH engine from the LH fuel tank for 15 minutes. At the nominal planning engine fuel burn rate of 10 kg per minute, this would consume an additional 150 kg of fuel from the LH tank, thereby reducing the imbalance by 150 kg. After 15 minutes the RH engine fuel selector was switched back to the RH tank (its normal setting).

The flight continued uneventfully until 23.06 hrs when the RH engine (No.2) started to wind down and stopped. At this time the aircraft was at Flight Level 180 (18,000 ft) and about 40 miles west of Dublin. The Captain believed the engine had flamed out. Because both the LH and RH fuel gauge were now reading zero, and both low fuel contents warning lights were on, the Captain was unsure of how much fuel was on the aircraft, and it's distribution between the LH and RH tanks. He decided against attempting to restart No.2 engine. Instead the engine closedown drill was performed. At 23.07 hrs, the crew called Shannon and made a PAN call. Their first proposed course of action was to turn back to Dublin. However, when they received the Dublin weather from Shannon ATC, they decided to divert to Shannon. The aircraft's altitude reduced from FL 180 to FL 123 due to the reduced available engine power, and the cabin was prepared for a precautionary landing. Shannon ATC provided radar vectoring to Runway (RWY) 24. On the approach the crew decided to remain high on the glide-slope during the approach in order to increase gliding distance in the event of the LH engine failing. The aircraft landed safely at 23.34 hrs and taxied to the ramp on one engine.

Due to the non-availability of a GPU and delays with ground services, the LH engine remained running for approximately 30 minutes after the aircraft reached the ramp, in order to retain cabin lighting and air-conditioning. After this delay the passengers disembarked normally, and the aircraft was shut down.

## 1.2 Injuries To Persons

No injuries were reported to the investigation.

| Injuries | Crew | Passengers | Others |
|---|---|---|---|
| Fatal | 0 | 0 | 0 |
| Serious | 0 | 0 | 0 |
| Minor | 0 | 0 | 0 |
| None | 3 | 48 | |

## 1.3 Damage To Aircraft

There was no damage to the aircraft.

## 1.4 Other Damage

There was no other damage.

## 1.5 Personnel Information

### 1.5.1 Captain

| | |
|---|---|
| Personal Details: | Male, aged 55 years |
| Licence: | ATPL (Netherlands) |
| Last Periodic Check: | Licence Proficiency Check (LPC) 1 Dec 2002 |
| | Operating Proficiency Check (OPC) 20 Jun 2003 |
| Medical Certificate: | 9 May 2003 |

Flying Experience:

| | | |
|---|---|---|
| Total all types: | 14,300 | hours |
| Total on type: | 5,200 | hours |
| Last 28 days: | 84 | hours |
| Last 24 hours: | 6.5 | hours |

Duty Time:

| | | |
|---|---|---|
| Duty Time up to incident: | 14 | hours |
| Rest period prior to duty: | 75 | hours |

### 1.5.2 First Officer

| | |
|---|---|
| Personal Details | Female, aged 31 years |
| Licence: | CPL (Ireland) |
| Last Periodic Check: | Licence Proficiency Check (LPC) 17 May 2003 |
| | Operating Proficiency Check (OPC) 17 May 2003 |
| Medical Certificate: | 7 January 2003 |

Flying Experience:

| | | |
|---|---|---|
| Total all types: | 1,500 | hours |
| Total on type: | 1,200 | hours |
| Last 28 days: | 70 | hours |
| Last 24 hours: | 14 | hours |

Duty Time:

| | | |
|---|---|---|
| Duty Time up to incident: | 14 | hours |
| Rest period prior to duty: | 18 | hours |

## 1.6 Aircraft Information

### 1.6.1 Leading Particulars

| | |
|---|---|
| **Aircraft type:** | ATR 42-300 |
| **Manufacturer:** | ATR |

| | |
|---|---|
| **Constructor's number:** | 199 |
| **Year of manufacture:** | 1990 |
| **Certificate of registration:** | 9 Feb 2001 |
| **Certificate of airworthiness:** | Valid to 11 Jan 2004 |
| **Total airframe hours:** | 23,762 Hrs |
| **Total cycles:** | 25108 |
| **Engines:** | 2 x Pratt & Whitney PWC 120 |
| **Maximum authorised take-off weight:** | 16,900kg |

### 1.6.2 General Information

The ATR 42 is a high wing aircraft with two turbo-prop engines.

**1.6.2.2** The aircraft has two fuel tanks, one in each wing. The refuelling point, designed for pressure refuelling, is located outboard of the engine on the RH wing, underneath the wing leading edge. The refuelling point is connected via two valves to the LH and RH fuel tanks. The valve located to the left (port) of the refuelling point feeds the LH fuel tank and the valve on the right (starboard) feeds the RH tank. These valves are usually operated remotely from the Electrical Refuelling Control Panel located behind a panel in the RH main undercarriage fairing.


**Photo 1**

This shows the Electrical Refuelling Control Panel located in the RH Fairing when inspected at Shannon. The blue valve lights can be seen on top of the panel, just to the right of centre. Note the refuelling quantity pre-select at 500 kg in bottom right, and the LH and RH fuel gauges, indicating zero, at bottom right.[2]

[2] This image is a composite of 2 photos. Flash photography was required in one shot to show the readings on the pre-select panel, but this obscured the LED's of the fuel gauges. Consequently another shot was taken without flash and the two images were composed into one for the purpose of clarity.

In the event of the refuelling valves failing to open by means of selection at the Electrical Refuelling Control Panel, they can be opened manually by pulling toggle rings, which are located on either side of the refuelling point valves in the RH wing. The toggle rings carry no identification (LH or RH) marks.

The aircraft is equipped with electrical fuel gauges. In the event of gauge failure, the fuel contents of each wing tank can be measured, when the aircraft is on the ground, by the means of manual magnet indicators located at two locations in each tank. These manual indicators are usually referred to as "drip-sticks" and the procedure of using these to measure the tank contents is known as "dipping". In some publications the drip-sticks are referred to Manual Magnetic Indicators (MMI's). To measure the tank contents, the drip-stick is unscrewed from the lower surface of the wing and allowed to free-fall until it engages with a magnet, which is floating on the fuel in the tank. The graduations on the drip-stick are calibrated in centimetres of protrusion. The graduation mark on the free hanging drip-stick, in line with the lower surface of the wing, is noted. The protrusion of the drip-stick under the wing's lower surface is inversely proportional to the tank contents. The graduation mark noted on the drip-stick is then transposed onto a chart to calculate the tank's contents.

**Photo 2**
This shows the LH Inner Drip Stick deployed to read LH Fuel Tank contents at Shannon.


**Photo 3**
This shows the RH Inner Drip Stick indicating a reading of zero as recorded at Shannon after the incident.

To compensate for the possibility of the aircraft being on uneven ground, there are two dip points in each wing, one inboard of the engine and another outboard of the engine. To determine the fuel contents of each wing, it is necessary to record the graduations of both the inner and outer drip-sticks, and then to transpose these readings onto appropriate charts. If either drip-stick shows an extreme value (i.e. zero or maximum, which equates to graduation readings of 0 or 19 cm respectively) due to lateral inclined ground, then the reading of that drip-stick is ignored and the fuel contents are calculated on the protrusion of the other drip-stick on that side of the aircraft, factored by the reading of the lateral inclinometer (see next paragraph). The contents results obtained from the chart are in litres, which must then be converted into kg for weight and balance calculations. The chart for this conversion is contained in the Operator's Minimum Equipment List, and is derived from the aircraft manufacturer's Flight Manual. **Annex A** shows one of three worked examples from the Flight Manual that indicate how the chart is used.

**1.6.2.3** The drip-stick method of determining the fuel tank contents is susceptible to error if the aircraft is not parked on level ground in the lateral sense. Even a slope of 1° will induce a significant error. To overcome this problem, the aircraft is equipped with a lateral inclinometer, which is located behind a panel within the LH main undercarriage fairing. To correct for any lateral slope, the inclinometer reading is applied to the fuel contents chart as a correction factor.

**1.6.2.4** There are low fuel tank contents warning lights beside the respective fuel gauges in the cockpit instrument panel. However these warning lights are not driven independently of the fuel gauges, but merely come on when the indicated fuel contents reduce to a predetermined level. Consequently if the gauge is reading zero due to a fault, the low contents warning light will illuminate, regardless of actual tank contents.

**1.6.2.5** The purpose of the Selected Fuel Quantity unit, located in the bottom LH corner of the Electrical Refuelling Control Panel, is twofold:

Firstly, it determines how much fuel should be added to the aircraft. The operator sets the total fuel quantity required in the aircraft at the end of refuelling. If an aircraft had 250kg of fuel on board initially and the Selected Fuel Quantity was set to 1,000 kg, the system would automatically close the refuelling valves when 750 kg of fuel is added.

Secondly, the system is designed to ensure that at the end of refuelling the quantities in the LH and RH tanks are identical. Thus if initially an aircraft had 150 kg in the LH tank and 100 kg in the RH tank, and the selector was set to 1,000 kg, the LH valve would close when 350 kg was added to the LH tank and the RH valve would close when 400 kg was added to the RH tank.

In the event that a fuel contents indicator was unserviceable and reading zero, the Selected Fuel Quantity system has no way of knowing the initial quantity in the tank and hence the amount of fuel to be added to that tank. In this case the tank's refuelling valve would remain open and the tank would continue to fill until the valve is closed by the high level sensor when the tank is full.

### 1.6.3 Maintenance History

The last maintenance check performed on the aircraft prior to the incident was a C8.1 (1-3A) check, which was accomplished 243 hrs before the incident. At the time of the incident there were no deferred defects entered in the aircraft's Technical Log.

### 1.6.4 Subsequent Inspection of the Aircraft

The aircraft was inspected by the Investigation the day after the event. It was noted that the RH fuel tank was empty. This was measured by a dip check and confirmed by performing a physical drain of the tank. It was also determined that the LH tank contained 480 kg of fuel, by doing a drip check. Inspection of the Electrical Refuelling Control Panel in the fairing showed that the selected fuel quantity was 500 kg.

Inspection of the lateral inclinometer in the LH main undercarriage fairing showed that the graduated marks on the inclinometer were very faded and very difficult to read. This was brought to the attention of the Operator, and the IAA, and a speedy rectification was effected. An external visual inspection of the aircraft did not reveal any indication of a fuel leak.

### 1.6.5 Lateral Balance

The ATR 42 is certified to operate with a maximum lateral imbalance of 550 kg. Lateral imbalance is the result of operating with unequal fuel quantities in the LH and RH fuel tanks.

## 1.7 Meteorological Information

At the time of the engine stoppage the aircraft was flying in clear air. Atmospheric conditions were not a factor in the engine stoppage. Dublin and Belfast airports were closed due to fog when the RH engine shut down west of Dublin. There were no other meteorological aspects to this incident.

## 1.8 Aids to Navigation

Not applicable.

## 1.9 Communications

The aircraft was working Shannon ATC when the RH engine shut down, and continued to work Shannon ATC for the remainder of the flight. There were no other communications aspects to this incident.

## 1.10 Aerodrome Information

Not applicable.

## 1.11 Flight Recorders

### 1.11.1 Cockpit Voice Recorder (CVR)

The aircraft was equipped with a Fairchild A100A CVR, which has a 30-minute recording capability. This was removed from the aircraft the day after the incident. Due to the delay in disembarking the passengers and the unavailability of a GPU, the LH engine was running for more than 20 minutes after the aircraft arrived on stand at Shannon and the aircraft was not closed down until a few minutes later. The flight crew did not pull the CVR circuit breaker during this period. Therefore the CVR remained running until the aircraft was closed down. As this was half an hour after landing, the tape only retained the post-landing recording. Thus the voice data relating to the period of the in-flight engine close-down was over-taped and lost. The tape did contain some post-landing comments by the First Officer, which indicated that she now suspected that the RH fuel tank was empty and that this caused the RH engine to shut down.

### 1.11.2 Flight Data Recorder (FDR)

The FDR did not contain information that was of any significant use to this investigation.

## 1.12 Wreckage and Impact Information

Not applicable.

## 1.13 Medical Information

There were no medical aspects to this occurrence.

## 1.14 Fire

There was no fire.

## 1.15 Survival Aspects

There are no survival aspects to this occurrence.

## 1.16 Tests and Research

None

## 1.17 Organizational and Management Information

At the time of this incident, the Operator's procedure for processing an aircraft fault was as follows. The flight crew would write the defect into the aircraft's Technical Log. They would then communicate the defect to the Operator's maintenance control using whatever means available. On landing, the aircraft was automatically classified as unserviceable, due to the fact that there was a Technical Log defect entry that had not been signed out by technical personnel. The aircraft would then remain unserviceable until it was visited by technical personnel, who would either repair the defect and sign off the repair, or sign off the defect into the aircraft's deferred defect list where such action was permitted under the aircraft's minimum defect list.

On 18 August 2002, the Operator had issued Amendment No 2, Issue 1 of Part A - General: Administration and Operations Policy **(Annex B)**. This document dealt with, in detail, the handling of deferred defects. In particular it stated: *"Prior to flight, commanders should ensure that defects have been either certified as cleared, or are entered as carried forward in the Technical Log"*. It should be noted that it is technical personnel, not the flight crew, who can enter a defect as carried forward (deferred).

This document also lays down the procedures to be followed by flight crews in the event of a deferrable defect being found when the aircraft is at an outstation. The relevant details of this procedure can be seen in **Annex B**.

Two weeks before this incident, the Operator's Flight Operations Manager issued a Flight Crew Information Letter (FCI), reference FCI No ATR 08/03. This noted that aircraft had been flown with open defects in the Technical Log, the implications of such action, the requirement to comply with Operations Manual section 8.1.11.3 (ref **Annex B**) and an instruction that "*in no circumstances should an aircraft be accepted for flight or flown with open entries in the tech log*". The full text of this FCI is shown in **Annex C**.

## 1.18 Additional Information

### 1.18.1 Discussions with Previous Flight Crews

The Investigation was concerned that the problems experienced with the LH fuel tank indication system were not recorded in the aircraft's Technical Log. The indicator had been causing trouble on all the flights conducted on the day in question. This was a total of four legs prior to the incident flight, operated by two different crews, and yet there was no record of any malfunction recorded by either crew. The Investigation contacted other flight crews who had operated the aircraft on the days prior to the incident and was informed that there had been persistent problems on this aircraft with the LH tank fuel gauge. The Captain of the incident flight also informed the Investigation that he had problems with the fuel indication system when he flew the aircraft on 31 July, eight days before the incident. He indicated that he believed that other crews had this problem as far back as June, which would be more than five weeks before the incident. The Investigation noted that none of these problems were recorded in the aircraft's Technical Log.

### 1.18.2 Wing Refuelling Panel

The Investigation could not find, within the Operator's Flight Manuals or any other documentation, any diagrams which detail the location and operation of the manual Toggle Rings, located in the wing refuelling panel, which are used to manually open the refuelling valves. In Chapter 28 of the ATR 42 Maintenance Manual there is a diagram which shows the location of the refuelling point in the wing and also includes a section of the fuelling point and the pull triggers. A copy of this page, with hand written explanation notes, is reproduced in **Annex D**. It should be noted that the Maintenance Manual is not readily available to flight crews.

### 1.18.3 Access to Drip-sticks

The Investigation noted that, where steps were not available, it was practice, by both the operator's technical and flight crew personnel, to climb onto the doors of the main undercarriage to access the inner under-wing panel where the inner drip-sticks are located. When the undercarriage is extended, these door panels open into a horizontal position, thereby providing a convenient platform to access the drip-sticks. The Investigation was concerned about this practice and was subsequently informed by the aircraft manufacturer that the doors were not designed for such loads and should not be used for this purpose.

The Investigation also noted that the Operator's aircraft did not carry any steps or small ladder, which could be used by flight crews to access either the outboard or inboard drip sticks or the refuelling panel in the wing. Flight crews stated that this caused particular problems in out-stations, where such steps were frequently not available or where delays would result from searches to find such steps.

**1.18.4** During the last flight the co-pilot became concerned regarding the fuel tank indications and did attempt to calculate the actual fuel remaining on board the aircraft, based on the hours flown, the fuel uplifts, the fuel burn rate and the period of cross-feeding the RH engine from the LH tank**.**

### 1.18.5 Interim Safety Recommendations

Arising from concerns raised in the course of this Investigation, the AAIU issued the following interim Safety Recommendations on 1 Sept 2003:

*Aer Arann should advise all technical personnel and Flight Crews that it is not permissible to stand on the open undercarriage doors for the purpose of taking fuel dip measurements, or for any other purpose.* (**SR 24 of 2003**).

*Aer Arann should consider the provision of a small step ladder on their aircraft, in order to ensure that Flight Crews can dip the fuel tanks when suitable steps are not available at airports. (***SR 25 of 2003***).*

The Operator informed the AAIU on 17 Sept 2003 that they had taken the following action to implement these interim Safety Recommendations:

With regards to SR 24 of 2003:

*a). A quality assurance notice has been issued to advise Maintenance personnel that it is not permissible to stand on the open undercarriage doors to read MFLI's* (Manual Fuel Level Indicators) *or for any other reason.*

*b). An FCI has been issued to advise Flight Crew that it is not permissible stand on the open undercarriage doors to read MFLI's or for any other reason."*

With regards to SR 25 of 2003:

"*Where a defect occurs that requires the use of the MFLI to verify the fuel quantity, then a suitable steps/stand will be placed on board the aircraft for use by the Flight Crew at out stations. This requirement has been included in the above quality assurance notice."*

On 3 Sept 2003, the Investigation made a further interim Safety Recommendation to the Operator and the IAA:

*Aer Arann, in conjunction with the IAA, should devise a system for processing deferrable defects, that will meet the required safety criteria, and will also give Flight Crews the ability to write up such defects in the Technical Log, as they occur, without unwarranted adverse effects on operations.* (**SR 26 of 2003**).

The Operator informed the AAIU on 17 Sept 2003 that they had taken the following action to implement this interim Safety Recommendation:

*"In the interim, an FCI has been issued to remind Flight Crew to comply with the existing procedures. A revised procedure involving an amendment to the MMOE and Operations manual is also being developed in consultation with the IAA."*

The Operator further responded in regard to this interim Safety Recommendation on 23 Oct 2003:

"*With reference to the above recommendation, a revised system for defect deferral at outstations has been discussed and is acceptable in principle to the IAA pending satisfactory evaluation. This system will involve the Captain phoning the (LMC) Line Maintenance Controller/Shift Supervisor to discuss details of the defect. If the defect can be deferred, the LMC/Shift Supervisor will enter the details on an Access database. The database will automatically assign a reference number to each defect. The Captain will enter the details of deferral on the technical log quoting the reference number. On satisfactory completion of this testing and evaluation, the MMOE and Operations manual will be amended with the revised system.*

*The above system will be added to the Operations manual as a temporary revision by means of an FCI until complete re-issue of the manual. Re-issue of the manual is expected before the end of 2003. A complete re-issue of the MMOE is currently taking place and the above system will be included in the re-issued document. This will be completed before end of Nov 03".*

The IAA informed the AAIU on 22 October 2003 that "*The Authority agrees with this recommendation and will ensure that appropriate action is taken by the airline."*

### 1.18.6 Operations Manual

The operator's Operations Manual does specify that the Commander must ensure that fuel checks are carried out during the course of a flight. However there is no reference in the manual with regard to any checks to be made when operating with unreliable or faulty fuel gauges.

### 1.18.7 Subsequent Inspection of the Aircraft

The aircraft was flown to the Operator's maintenance support provider in France after this event. Inspection there found that a plug in the LH system, reference 3qtc, located at the back of the indicator panel, was in poor condition and the plug was then replaced. The RH system was found to be serviceable. The aircraft then returned to service.

### 1.18.8 Electrical Refuelling Control Panel

No problems with the Electrical Refuelling Control Panel on this aircraft, and particularly on the RH refuelling valve, were reported prior to this incident. No defects or problems were found subsequently. In later correspondence the Captain stated that he had probably confused quantity per side with total quantity, and that this was the cause of the problem he encountered. (Ref paragraph 2.1.6 below).

### 1.18.9 Flight Logs

The Operator provides pre-printed Flight Logs for each flight. These include the various legs of each flight, reporting points, planned leg time, minimum fuel at each reporting point etc. The crew enter the planned Estimated Time of Arrival (ETA), and Actual Time of Arrival (ATA) and Actual Total Fuel at each reporting point. The Investigation noted the forms for some of the flights were only partially completed with regard to ATA's and fuel contents. The standard fuel data was not entered up during the final flight where the engine stopped.

## 1.19 Useful or Effective Investigation Techniques

None

## 2. ANALYSIS

**2.1** **Annex E** tabulates the available information regarding fuel contents, fuel uplifts, fuel consumption rates etc from the time the aircraft tanks were dipped following refuelling at Waterford. The calculation starts at the bottom of the table with the known tanks contents as measured by dipping at Shannon after the incident (480 kg in LH tank and 0 in RH tank). Based on usage and the understanding that all the fuel uplifted at Luton was pumped into the LH tank, the calculations indicate that there was 618 kg in the LH tank and 689 kg in the RH tank after the Waterford refuelling. This gives a total of 1307 kg of fuel on the aircraft at Waterford.

The Waterford dip indicated that there was 600 kg in the LH tank and 720 kg in the RH tank giving a total of 1320 kg. This agrees very closely to the calculated figure. The marginally larger difference between the calculated contents of the individual tanks and the dipped value is readily explained because of the difficulty in accurately determining the inclinometer reading.

**2.2** The total fuel burn from Waterford to Luton was approximately 814 kg and taken equally from each tank. Thus the contents on arrival at Luton were approximately LH tank 206 kg and RH tank 277 kg.

**2.3** The RH engine flamed out 69 minutes after departure from Luton. For 15 minutes of this flight the RH engine was fed from the LH tank. During the remaining 54 minutes, the RH engine was drawing from the RH tank at an average rate of 5 kg/min. This equates to a drawdown of 270 kg from the RH tank and when added to 7 kg for engine start and taxi, gives a total of 277 kg consumed from the RH tank. This is equal to the RH tank contents on departure from Luton. Thus at the end of a total of 69 minutes flying the RH engine spooled down as there was no fuel in the RH tank.

**2.4** The calculations in **Annex E** are consistent with:

- The entire Luton fuel uplift being put into the LH tank
- The RH tank running dry 69 minutes after take-off from Luton, thereby causing the RH engine to stop due to fuel starvation.

**2.5** It was not possible for the Investigation to determine accurately the fuel situation of the aircraft prior to the dips taken at Waterford. This is due to the faulty LH fuel gauge, the absence of any dip checks on the day prior to that at Waterford, and a lack of accurate information about how long the aircraft was running in Hotel Mode, and holding prior to take off with both engines running during the 1 hr 52 min stopover at Dublin.

**2.6** During the refuelling at Waterford the Captain had selected a quantity of 500 kg on the Electrical Refuelling Control Panel. Normally (both fuel gauges operating correctly) this would have terminated the refuelling automatically when the contents of each tank reached 250 kg. The Captain subsequently stated that it was his intention to add 500 kg to each side but that he had inadvertently selected 500 kg (whereas a setting of 1,000 kg would have filled each tank to 500 kg). This mis-selection was the reason why the RH valve closed when its contents reached 250 kg, and why the Captain had to use the manual triggers in the wing refuelling point to reopen the valve to the RH tank in order to take on additional fuel. Because of these problems at Waterford he opted to go directly to manual operation of the refuelling valves during the subsequent refuelling at Luton.

**2.7** During the refuelling at Luton, the Captain had inadvertently filled all the uplifted fuel into the LH tank. This occurred because he was facing rearwards when standing on the steps and he inadvertently believed that by opening the valve on his right that the fuel would be supplied to the RH tank. In actual fact the valve on his right side was the valve for the LH side of the aircraft and the fuel was fed into the LH tank. He saw a blue valve light on the Electrical Refuelling Control Panel, indicating an open valve, but from his position at the wing refuelling point it was impossible for him to determine that the light was that of the LH valve and not the RH valve. He was unable to detect the mistake because the LH fuel gauge was reading zero, due to the gauging defect.

He further rationalised that the failure of the RH fuel gauge indication to increase by the amount of fuel that he believed had been added to this tank (but in reality diverted to the LH tank), was because there was now a fault in the RH gauge (i.e. it was now beginning to under-read, similar to the real defect in the LH gauge). It should be noted that there are no markings on the valve toggles, which would indicate to which side either valve relates. It is also noteworthy this was the first time that the Captain had ever operated these valves manually.

**2.8** The efforts of the co-pilot, during the final flight, to calculate the aircraft's fuel contents and fuel distribution were not successful due to insufficient data with regard to the distribution of the fuel uplifts between the LH and RH tanks and the doubts arising from the non-entry of the Dublin fuel uplift in the aircraft documentation. However her comments on the CVR after landing at Shannon indicated that she had deduced, at this stage, that the RH fuel tank might be empty.

**2.9** The crew undoubtedly had a long and difficult day. While their duty time had not exceeded 11 hours at the time of the incident, they had arisen at home for a departure that was significantly earlier than the re-scheduled departure. The operator's entire schedule was severely disrupted by fog, which also caused ATC delays. The flight crew had endeavoured, throughout the day, to maintain the revised schedule, but they were frustrated by the further delayed departure from Dublin, the loading of the incorrect baggage at Luton and the subsequent resolution of this problem at Waterford, the episode of the passenger's pills and the difficulties encountered in refuelling at both Waterford and Luton. They were also somewhat concerned by the lateral imbalance of the aircraft in flight and their inability to definitely resolve the cause, aggravated by the unserviceable LH wing tank fuel gauge and their own loss of confidence in the veracity of the reading of the RH tank fuel gauge.

**2.10** The operational support available to the flight crew of a smaller regional airline, such as that of the Operator, at outstations, particularly smaller regional airports, is invariably limited and consequently the resolution of problems with regards to mis-loaded baggage, refuelling problems and even passenger liaison, tends to fall on the crew, as happened in this case.

**2.11** The on-site technical resources available to the Operator's flight crews are limited or non-existent at out-stations. This meant that the flight crew had to sort out any difficulties with regard to refuelling in the case of this event. It also meant that obtaining a simple set of steps to access the drip-sticks to check the fuel contents was a time consuming and delay-inducing process.

**2.12** At another level, the lack of technical resources at out-stations meant that the flight crew was faced with considerable difficulties in resolving technical problems with the aircraft. When a deferrable defect arose, the procedure laid down in the operator's Operations Manual (as per **Annex B**), required that the Captain find an available fax machine facility, fax the Tech Log page to the maintenance shift supervisor in Dublin and await a reply by fax from the supervisor. This could result in a lengthy delay before the aircraft could continue. With a re-occurring intermittent defect, such as the LH fuel gauge in this case, frequent delays, and consequent frustration, would result. Because the Operator's aircraft operated several sectors each day, there would be a cumulative effect resulting from such delays. This in turn generates customer displeasure, which could be passed on to the flight crew because of the scale of the operation.

**2.13** There was an apparent practice, among the Operator's flight crews, of not recording the defect of the LH fuel gauge. The Captain was aware of this. Therefore he had reasonable grounds to suspect that there may have been problems with the RH gauge that were not recorded in the Tech Log. This facilitated his incorrect diagnosis as to why the indicated contents of the RH tank failed to increase by the expected amount during refuelling at Luton.

**2.14** The practice of not recording defects in the Tech Log was an underlying cause of this incident. It resulted in an ongoing tolerance of a defect over an extended period. It also meant that the Operator's maintenance system was not informed of the defect by the standard methodology. It appears that the FCI ATR 08/03 had the unforeseen effect of causing some crews not to enter defects in the Tech Log, particularly where defects were found at outstations.

**2.15** Common sense, prudence and good airmanship would indicate that the fuel tanks should have been dipped prior to each take off when there was any concern that the gauges were faulty or inaccurate, but particularly after any refuelling and most especially when difficulties were encountered during the refuelling or when standard method of refuelling could not be performed. Such precautions were not taken on the day in question, except on the occasion of the refuelling at Waterford. If the tanks had been dipped after the Luton refuelling this serious incident would undoubtedly have been avoided. The absence of a procedure within the Operations Manual dealing with faulty gauges was therefore a contributory factor in this incident.

**2.16** When the aircraft took off from Luton on the last flight the difference between the contents of the LH and RH tanks was 889 kg. This is 339 kg above the maximum permissible lateral imbalance limit of 550 kg. The crew only became aware of a lateral imbalance in the course of this flight when they observed that right wheel input was required to maintain level flight. At the point of the engine stoppage, the lateral imbalance was approximately 754 kg. On landing at Shannon, the imbalance was just below the limit. Thus the aircraft was operated outside the permissible lateral imbalance limits for most of the final sector.

**2.17** The fact that the inclinometer graduations were in poor condition and difficult to read may have caused the Captain to doubt the usefulness of dipping the tanks during refuelling stops. The fact that three worked examples are included in the Manual indicates that the calculation of fuel contents by this method is not entirely straightforward.

**2.18** The use of litres rather than kilograms in the dip calculations in the aircraft manufacturer's Flight Manual may appear to be an additional and unwarranted complication in the determination of fuel contents by this method. However because the drip stick method measures fuel volume, rather than weight, because of the variations in specific density of fuel and the associated effect of temperature variation, the drip stick graphs can only produce a result in litres.

**2.19** The fact that the fuel tank low contents warning light is driven by the actual gauging system, and not by independent derived data, means that this warning is useless in the event of a gauge failure. This suggests that the certification requirement should be reviewed.

**2.20** The Flight Log fuel data was not accurately maintained throughout the day's operation. It was not possible to complete the Log without reliable fuel gauges or, alternatively, accurate knowledge of the fuel tank contents obtained by dipping the tanks contents before each flight.

**2.21** The Operator's Minimum Equipment List (MEL) did give guidance on how to measure the fuel tank contents in the event of u/s or unreliable fuel gauges. However neither the MEL nor the Operators Manual gave any guidance as to the precaution to be taken in the event of fuel gauge failure, i.e. drip-stick measurement of tanks after each refuelling, or before each flight etc.

## 3. CONCLUSIONS

### (a) Findings

1. The shut down of the RH engine was caused by the absence of fuel in the tank feeding this engine.

2. The absence of fuel in the RH tank was the result of the Captain inadvertently diverting all the uplifted fuel into the LH tank during the refuelling at Luton.

3. The inoperative LH tank fuel gauge resulted in the Captain not detecting diversion of fuel to the incorrect tank.

4. Due to the persistent problem with the LH fuel gauge, the Captain assumed that the low fuel reading on the RH gauge was the result of a gauging error, rather than the fact that the fuel had been inadvertently loaded into the other tank and that the low contents indications from the RH gauge were actually accurate. His assumption was reinforced because the faulty LH gauge failed to reveal the excess fuel loaded into the LH tank.

5. The practice, by several of the operator's flight crews, of carrying a faulty fuel gauge for an extended time always had the potential to cause a serious problem. Thus it was probable that sooner or later this problem, compounded by other problems and errors, would lead to the type of situation that finally did result in this serious incident.

6. The Operator's system of dealing with deferrable defects resulted in delays, particularly at outstations. Flight crews sometimes perceived such delays as irksome and un-necessary. This gave rise to the practice of not recording such defects in the aircraft's technical log. This ultimately led to the non-rectification of such defects, such as the LH fuel gauge defect in this case.

7. The crew was faced with considerable operational pressures and a lack of resources, including the simple non-availability of a set of steps to check the drip-stick indicators. These circumstances contributed to inadequate fuel management.

8. The fact that the inclinometer graduations were not maintained in good condition added to the difficulties faced by the crew.

9. The fact that the low fuel contents warning lights were not independent of the gauging problem negated the usefulness of this warning system in this incident.

10. The Operations Manual did not lay down procedures for the operation of the aircraft in the event of fuel gauge failure nor did it lay down any extra precautions to be taken, such as dipping the tanks prior to each flight.

**(b) Causes**

1. The direct cause of this serious incident was the absence of fuel in the RH fuel tank.

2. The crew did not ensure that fuel management was correctly maintained throughout the day's operation. This should have been a high priority because of the known gauging problems.

3. The Operator's procedures did not include instructions or precautions relating to fuel management in the event of fuel tank gauge failure.

4. Operational pressures, and lack of support infrastructure were significant factors in the crew's failure to ensure adequate fuel management.

5. A practice of not recording deferrable defects, which developed at outstations, had evolved among the Operator's flight crews. This practice was a by-product of the system for dealing with such defects.

## 4. SAFETY RECOMMENDATIONS

In addition to the three interim safety recommends made previously (ref section 1.18.5 above), the Investigation also makes the following safety recommendations:

**4.1** The Aircraft Manufacturer should consider fitting markings on the valve operating toggles on the manual refuelling valves in the wing of the ATR 42 that would clearly identify the relevant LH and RH valves. This is considered important, as it is rarely necessary to use these valves due to the reliability of the main Electrical Refuelling Control Panel. The consequent lack of familiarity with the manual valves can therefore result in mis-selection. **(SR 8 of 2005)**

**4.2** The Operator should amend their procedures to include a section covering the operation of their aircraft in the event of unserviceable or suspected unreliability of the fuel gauges, particularly with regarding to dip-stick measurement of the tank contents before each flight. **(SR 9 of 2005)**

*In response to the draft report of this Investigation, the Operator stated that they implemented an FCI, dated 16 August 2004, to cover the use of Drip Sticks (MMI's) in the event of unserviceable fuel gauges.*

**4.3** The European Air Safety Agency (EASA) should review the certification criteria for public transport aircraft low fuel contents warning systems, with a view to requiring such systems to be independent of the main contents gauging systems. **(SR 10 of 2005)**

**Annex A**

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**ATR-42-300**

**MINIMUM EQUIPMENT LIST**

| Revision No: 0 | Issue: 2 | Date: 16/07/01 | Section : Fuel<br>Page : 2-28-4 |
|---|---|---|---|

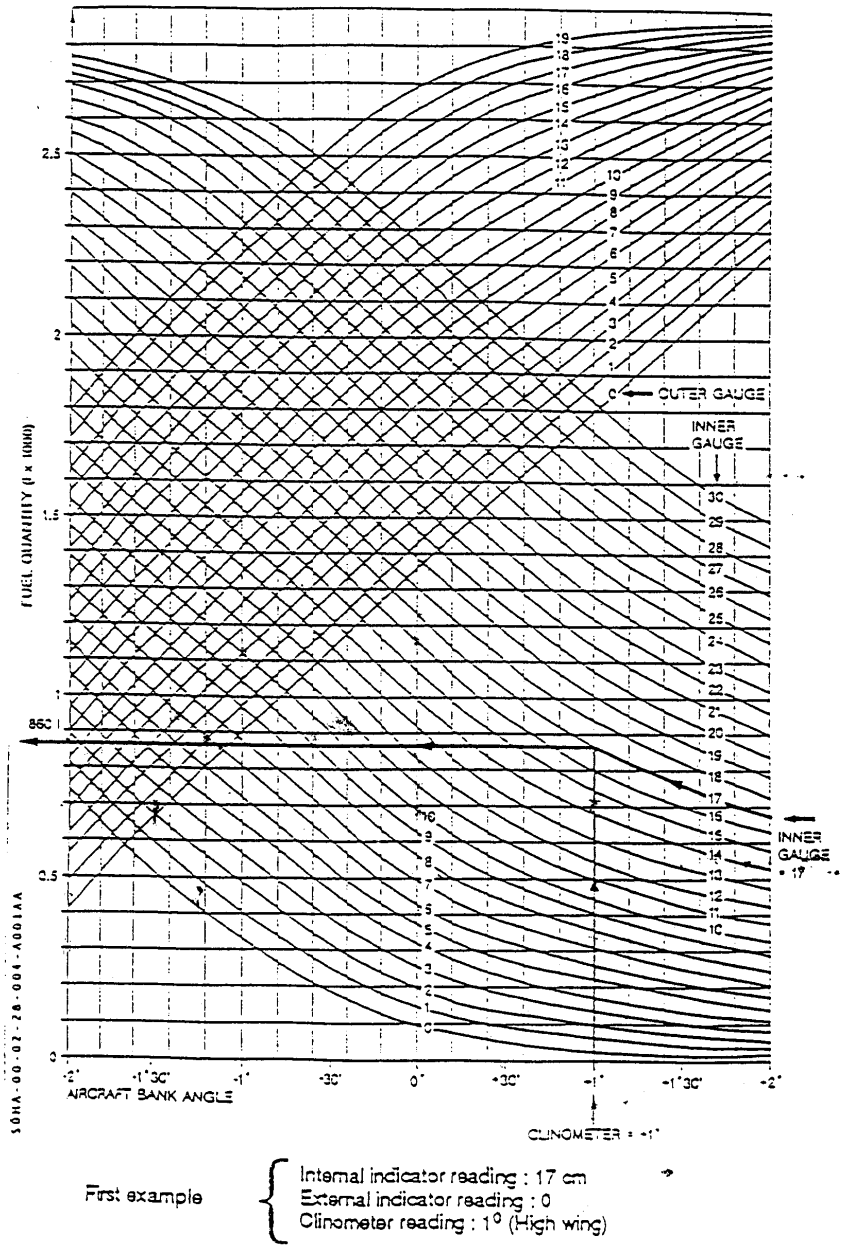



**Chart used for converting drip-stick readings into fuel tank contents (in litres)**

8.1.11.2 Entering of Defects

The Commander must ensure that all defects are properly entered in the Log after flight, giving as far as possible a full report of all abnormal indications. If there are no new defects, a "NIL" entry should be made.

Where a defect is identified prior to flight, the commander should enter the defect in the Tech Log at that time, whether rectification takes place before departure or the defect is deferred in accordance with the Minimum Equipment List (MEL).

8.1.11.3 Deferring of Defects

Prior to flight, commanders should ensure that defects have either been certified as cleared or are entered as carried forward in the Technical Log.

The Minimum Equipment List provides the Commander with authority to operate a flight where rectification of a defect has been deferred. Such authority does not extend beyond the items listed in the MEL and the MEL states the conditions associated with the deferral of a defect.

Only the Commander is authorised to determine that a flight can be safely undertaken with inoperative equipment in accordance with the MEL under the anticipated flight conditions.

**Outstations.**

In the event of a defect arising at an outstation, where no maintenance support is available, the following procedure will be followed:

The extent of the defect must be identified by the normal onboard indication and warning system and or the normal pre-flight inspection. The aircraft commander will liase with the shift supervisor and consult the MEL. He will fax a copy of the technical log sector page to the shift supervisor. If satisfied that the defect can be deferred, the shift supervisor will enter the deferral in the technical log and fax this copy back to the aircraft commander. The faxed copy authorizing the deferral will be carried on board the aircraft. Operational restrictions, if any, will be complied with by the aircraft commander if any airworthiness requirements other than the pulling of circuit breakers, placarding etc, must be addressed as part of the deferral, the aircraft may not dispatch until an appropriately qualified certifying engineer has been dispatched to perform this task and make the necessary entry in the Technical Log.
On return to base, the shift supervisor will again review the defect and if satisfied, make an entry in the original of the technical log.

Note: Prior to flight care should be taken to ensure that the full nature and significance of a defect which is deferred, or about to be deferred, is understood. In particular, abnormal indications should be considered as prima facie evidence of systems or equipment malfunction until it has been positively confirmed that no fault exists within the operating system and that the fault exists only in the indicating part of the system.

8.1.11.4 Technical Log Procedures

8.1.11.4.1 Departure

Before accepting an aircraft, the Commander should check the following in the Tech Log:

a) all pre-flight and scheduled maintenance checks (valid Certificate of Release to Service) completed;

b) reported defects cleared or correctly deferred;

c) Certificate of Release to Service issued after any overhaul, repair, replacement, modification or mandatory inspection;

d) The fuel state of the aircraft on arrival and the fuel state of the aircraft on departure, signed by the person carrying out the refuelling. When fuel or oil is uplifted, the Commander should obtain a copy of the Supply Note from the supplier and this should be returned with the navigation log on completion of the flight.

8.1.11.4.2 Arrival

On completion of a flight, the Commander shall make the following entries in the Tech Log:

a) all defects or a “NIL” defect as appropriate;
b) flight details;

c) flight times;

d) fuel remaining;

e) commander’s signature.

*Aer Arann*

# FLIGHT CREW INSTRUCTION (FCI)

| | |
|---|---|
| **To:** | **All Flight Crew** |
| **From:** | **Flight Operations Manager.** |
| **Subject:** | **Tech Log Entries.** |
| **Date:** | **24th July 2003** |
| **FCI No:** | **ATR 08/03 TECHNICAL** |

**BACKGROUND:** Engineering has recently encountered a number of instances where Captains have accepted and flown aircraft with open entries in the defects column of the tech log.

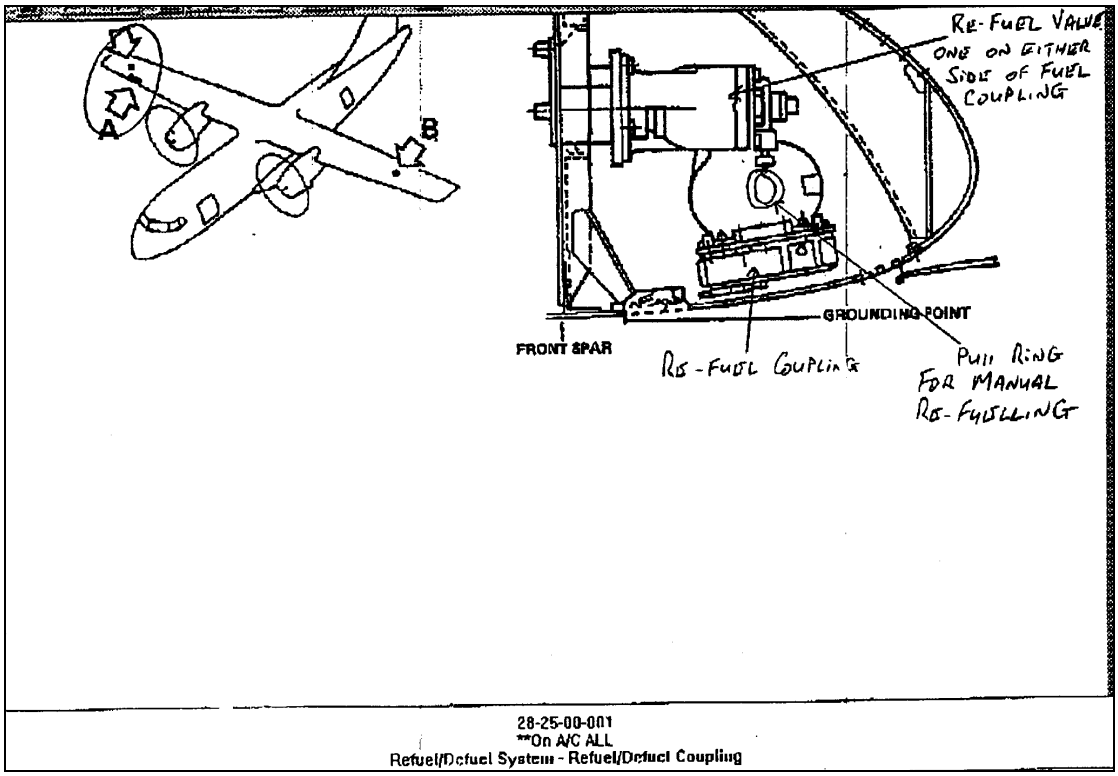
**INFORMATION:** Any open entry in the defect column of the aircraft tech log invalidates the aircrafts C of A which in turn invalidates the insurance on the aircraft. This applies to all entries made in the defect column of the tech log including those made "For information".

**ACTION**: All entries made in the defect column of the tech log must be cleared by a suitably qualified engineer before the aircraft is accepted for flight. Any entry made away from base may be closed by using the procedure laid out in section 8.1.11.3 of the Ops manual Part A.
**Under no circumstances should an aircraft be accepted for flight or flown with open entries in the tech log.**

**EFFECTIVE:** Further Notice

_____
Flight Operations Manager

## Annex D




**This is taken from Chapter 28 of the ATR 42 Maintenance Manual. Ref A on the left diagram shows the location of the pressure refuelling point which was used for refuelling of EI-CBK on the day of the incident. The gravity refuelling points (Ref B) were not used. The right diagram shows a section through the wing at the pressure refuelling point, and shows the triggers (pull ring) for opening the valve to the RH fuel tank.**

**Annex E**

# Fuel Usage Analysis

| Location/ Event | Duration (min) | Total Fuel Consumed (kg) | LH Tank Contents (kg) | LH Tank Fuel Consumed (kg) | RH Tank Contents (kg) | RH Tank Fuel Consumed (kg) | Comments |
|---|---|---|---|---|---|---|---|
| After refuelling @ Waterford | | | 618 | | 689 | | Dip readings prior to departure LH 600 RH 720 |
| Start & taxi at Waterford | | 14 | | 7 | | 7 | |
| Waterford – Luton @ 10 kg/min | 81 | 810 | | 405 | | 405 | |
| Arrive Luton | | | 206 | | 277 | | |
| Uplift @ Luton | | | | (960) | | 0 | Uplift shown as negative usage |
| Depart Luton for Galway | | | 1166 | | 227 | | Subsequently diverted to Shannon |
| Start & taxi @ Luton | | 14 | | 7 | | 7 | |
| Luton – Galway climb & cruise for 54 min at 10 kg/min | 54 | 540 | | 270 | | 270 | Normal tank-to-engine setting |
| Luton – Galway in cruise for 15 min at 9 kg/min | 15 | 135 | | 135 | | 0 | Cross-feeding, during which LH tank fed both LH and RH engines. Fuel consumption in crusing flight is 9 kg/min |
| At Engine stoppage | | | 754 | | 0 | | |
| Engine Stoppage to Shannon @ 7 kg/min | 30 | 210 | | 210 | | 0 | |
| Landing at Shannon | | | 544 | | 0 | | |
| Taxi At Shannon @ 5 kg/min | 5 | 25 | | 25 | | 0 | |
| 30 minutes running in hotel mode @ 1.3 kg/min | 30 | 39 | | 39 | 0 | 0 | |
| Contents on shutdown | | | 480 | | 0 | 0 | As confirmed by dip check |