FINAL REPORT

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In accordance with the provisions of SI 205 of 1997, the Chief Inspector of Air Accidents, on 18/8/05, appointed Mr John Hughes as the Investigator-in-Charge to carry out a Field Investigation into this Serious Incident and prepare a Synoptic Report.

Aircraft Type and Registration:	A330-301, EI-CRK
No. and Type of Engines:	2 x CF6-80E1A2
Aircraft Serial Number:	070
Year of Manufacture:	1994
Date and Time (UTC):	18 August 2005 @ 15.15 hrs
Location:	53N 15W (MALOT)
Type of Flight:	Scheduled Public Transport
Persons on Board:	Crew 2 + 10 Passengers - 225
Injuries:	Crew - Nil Passengers - Nil
Nature of Damage:	Nil
Commander's Licence:	ATPL(A)
Commander's Details:	Male, aged 49 years
Commander's Flying Experience:	17,500 hours
Information Source:	The Operator, AAIU Investigation.

SYNOPSIS

The Captain of EI-CRK was making an approach for Runway (RWY) 24 at Shannon when he reported a pressurisation problem and was unable to control cabin altitude. The aircraft broke off the approach and was vectored for a second approach. The aircraft landed safely at 13.17 hrs.

The aircraft later took off for JFK Airport (New York, USA) but at 53N 15W the Captain declared a PAN due to pressurisation problems. The aircraft made an emergency descent from FL350 and the Captain requested a diversion to Shannon. A normal approach was executed and the aircraft, although overweight, landed safely at 16.23 hrs. There were no injuries.

FINAL REPORT

1. FACTUAL INFORMATION

1.1 History of the Flight

1.1.1 Previous Flight to Shannon

The aircraft was airborne from Dublin at 12.41 hrs. Shortly after take off an Electronic Centralised Aircraft Monitoring (ECAM) warning "ENG. 1 BLEED LOW TEMP" was indicated. The ECAM actions were carried out but the indication remained. As the aircraft reached 10,000 ft the crew noted that the Cabin Pressure Altitude was indicating 4,900 ft. The Captain decided to continue the flight at 10,000 ft rather than climbing to the Flight Plan altitude of 16,000 ft. During the descent the Captain contacted ATC and requested permission to carry out an orbit in order to allow a gradual reduction in the Cabin Pressure Altitude for passenger comfort.

ATC reported that "*the pilot of EIN107, on approach for RWY 24 at Shannon, reports pressurisation problem and unable to lose altitude on this approach. Aircraft broken off approach and vectored for a second approach. A normal approach is executed and aircraft lands safely at 13.17 hrs UTC"*

1.1.2 Troubleshooting at Shannon

The Post Flight Report (PFR), reported automatically by the aircraft maintenance computer, referred to two problems, an Engine 1 bleed problem and also a cross bleed problem. There was no reference on the PFR to a pressurisation problem. The Bleed Management Computer (BMC 1) test revealed a Class 3 (amber) fault. Even though the fault was indicated as having been cleared, the BMC 1 was replaced. In order to verify the serviceability of Engine 1 bleed and the cross bleed an engine run was carried out. The bleed system was found to function normally. Although the PFR did not mention a pressurisation problem, the engineers decided to carry out a check of the pressurisation system. Tests were carried out on Cabin Pressure Controllers (CPC) 1 and 2. No faults were indicated for either CPC and the outflow valve was observed to function correctly. The aircraft was released for service.

1.1.3 Flight from Shannon

The engine bleed and pressurisation systems were again checked by the Flight Crew, and all indications were normal with the aircraft pressurising normally.

As the Cabin Pressure Altitude passed through 7,500 ft the crew monitored the situation carefully as they felt that this was a higher Cabin Pressure Altitude than they had expected. The aircraft climb mode was changed to vertical speed (V/S) and the rate of climb was reduced.

The Cabin Pressure Altitude continued to climb until it exceeded 8,500 ft and cabin differential (delta) pressure exceeded 7.0 psi. The pressurisation mode was switched from automatic to manual. All efforts to control the Cabin Pressure Altitude were unsuccessful and the aircraft at this time was levelling off at the cleared level of FL350 at position 53N 15W (MALOT). As the crew had confirmed that they could not control cabin pressure loss, the Captain decided to return to Shannon. An immediate turn and descent were requested from ATC.

As the turn was being initiated the master warning and ECAM warning activated and, with the Cabin Pressure Altitude approaching 10,000 ft, the Flight Crew donned their oxygen masks. A PAN was declared, the ECAM actions were completed and an emergency descent to 10,000 ft ASL was carried out. The maximum Cabin Pressure Altitude was 10,100 ft. On levelling off, the Emergency Descent procedures were completed, backed up by the Quick Reference Handbook. On completion of the checklists the Flight Crew conducted a full CRM review of the situation and, having considered all options, including burning off fuel etc., it was decided to prepare for an overweight landing at Shannon and to land as soon as possible.

The Cabin Manager briefed the Cabin Crew and also made a P.A. to the passengers explaining that a technical problem had arisen. The Captain also made a P.A to the passengers to reassure them that everything was under control. The overweight landing checklist was completed before reaching Ennis. ATC were advised that one circuit of the Hold would be required. ATC were asked for vectors for a long final for RWY 24 and were advised that the full length of the runway and a back track would be required.

The overweight landing was completed normally and within limits and, having rolled to the end of the runway, a 180-degree turn was completed with the brake temperatures within limits. The aircraft landed at Shannon at 16.23 hrs and arrived on Stand at 16.30 hrs. Neither the passengers nor the crew reported any ill effects.

1.1.4 Further Troubleshooting

The Maintenance Crew at Shannon obtained a detailed report from the Flight Crew. The outflow valve was visually inspected and no abnormalities noticed. The engineers inspected the seal on the rear cargo door as they were aware of its recent replacement in Dublin. Following consultation with the Airbus representative in Dublin and a comparison with the forward cargo door it was noted that the inflation holes of the door seal, which should be facing inwards towards the centre of the door, were facing outwards and that the seal was also upside down. It was found that the aft cargo door seal had been incorrectly installed.

1.1.5 Aircraft Information

In order to form a seal and prevent leakage of pressure the door seal itself is pressurised. Pressurised air from the Cargo Hold enters the seal through small inflation holes and the seal expands to fill the gap between the door and the surrounding aircraft structure.

An ECAM warning "CAB PR EXCESS CAB ALT" appears only if the cabin altitude exceeds 9,550 ft. The Maintenance Computer, fed by the ECAM system, produces the PFR automatically once the engines are shut down. The manufacturers Maintenance Task following excessive cabin altitude states that if the PFR gives a maintenance message related to the ECAM warning or gives another fault in the air conditioning system reference should be made to the applicable trouble shooting procedure.

1.2 Recent Maintenance History

The aircraft had undergone an "A" check at the operator's maintenance base at Shannon on 16 August 2005. During the check, it was noticed that the Aft Cargo Hold door seal was damaged. The damage was outside repair limits and, since a replacement seal was not available at Shannon, it was decided to position the aircraft, unpressurised, to Dublin where the seal would be replaced. The Operator's contracted maintenance company was requested to carry out the seal replacement.

A replacement seal was not available and had to be ordered from the manufacturer. It was due in at 16.30 hrs but did not arrive. The contracted maintenance company assigned a Crew Leader and four mechanics to the task. This was the first occasion on which the Crew Leader had carried out a cargo door seal replacement on an A330 aircraft. Further, neither he nor any of the four mechanics had ever replaced a door seal previously. The Crew Leader read the Aircraft Maintenance Manual (AAM) extract applicable to the seal replacement task. The damaged seal was removed from the Aft Cargo Hold door while the aircraft was on Stand 34 at Dublin. At 18.00 hrs the Crew Leader was requested to move the aircraft to Stand 69R. This required that a significant amount of work undertaken to prepare for the seal replacement had to be undone. The aircraft was moved to Stand 69R at 20.00 hrs.

The seal did not arrive until 22.00 hrs. The Crew Leader obtained the seal from the stores, checked that the part number and aircraft affectivity were correct and that the seal was in good condition, and brought the seal to the aircraft. At this time, in accordance with procedures, the door was supported and the hydraulic system had been isolated.

The Crew Leader removed the bolt from the cargo door actuator and fitted the seal in its retainer around the actuator. He then refitted the bolt. The Crew Leader drew the attention of the mechanics to the need to install the seal with the corner colour reference markings positioned as depicted in the schematic **(APPENDIX A**). The Crew Leader and his crew commenced the installation of the seal. He then left the aircraft to order a bonding strip to replace one which was broken in the vicinity of the actuator. When he returned the mechanics had almost completed the seal installation and he helped them to complete the job.

1.3 Crew Leader Comments

The Crew Leader involved stated that he was working a 10.00 hrs to 18.00 hrs (Local Time) shift on the day in question. In the afternoon he was working on EI-EWR which was positioned on Stand 36 and was operating the EI-125 flight to Chicago. This flight was scheduled to depart at 16.25 hrs. He was aware that he was required to change a cargo door seal on EI-CRK later on when the aircraft arrived from Shannon. He was also aware that EI-CRK was positioning from Shannon un-pressurised. He had expected the aircraft to arrive after 17.00 hrs but it arrived on Stand 34 at 15.30 hrs. He requested one of his mechanics to "see in" EI-CRK but the mechanic involved had no experience marshalling A330 aircraft so he performed the task himself. When the aircraft was chocked and secured he explained to the four mechanics involved that the cargo door seal had to be replaced. The four mechanics then organised equipment to access the cargo door area. However, when he was satisfied that the mechanics understood what was required he returned to Flight EI-125 and it departed at approximately 17.00 hrs.

Following the departure of Flight EI-125 he went to the Line Maintenance office to look for the replacement door seal as it was expected from Germany at approximately 17.00 hrs. It had not arrived so he read the AMM extract and went to the cargo door where he pulled the circuit breakers to isolate the Yellow System hydraulics which operate the cargo door actuator. At this stage the door was supported on a platform using suitable protective supports to prevent damage to the door. The actuator was also connected.

At approximately 18.00 hrs, he was told that the seal was not on the flight on which it was expected and that it was now expected at 22.00 hrs and that his aircraft's intended flight was now cancelled.

Nevertheless, he decided to stay on to complete the task with the four mechanics. At this stage he was requested to move the aircraft to Stand 69R. This meant that he had to undo all the work which had been performed and move the Aircraft. This was approximately 20.00 hrs and darkness was descending.

At 22.00 hrs he received a call to say that the seal was now available. He went to stores where he compared the Part Number of the seal with the Part Number in the IPC and found it to be correct. He then returned to the aircraft where he and the mechanics again supported the door and isolated and secured the hydraulic system. He removed the bolt from the door actuator and fitted the seal around it; following this he refitted the bolt.

He stated that he had not viewed the colour markings on the seal himself but had noted the reference to them in the AMM. The Crew Leader made no reference to the mechanics in relation to the "Upper" and "Lower" markings. He had not seen these particular markings which were also highlighted in the AAM.

The Crew Leader and his crew started to fit the seal to the door. Later, while the mechanics were still fitting the seal to the door the Crew Leader said that he left the aircraft to order a bonding strip to replace one which was broken in the vicinity of the actuator. When he returned to the aircraft he assisted the mechanics in completing the seal installation and then carried out an inspection of the seal to ensure that it was correctly located in the seal retainer. Following this inspection he was satisfied that the seal was correctly installed.

1.4 Maintenance Crew Experience

The person occupying the position of Crew Leader was a Deputising Crew Leader and had been in the position for only two days. He has been with the company since 1990 and holds full company approvals on this aircraft type. Two of the mechanics had 15 years experience with their company, whilst the two junior mechanics had 5 and 7 years experience respectively. The majority of crew experience was in Base Maintenance with the remainder Line Maintenance.

1.5 Organisational and Management

In accordance with the IAA Aeronautical Notice A67 issued in February 2002, the Contractor instigated a Maintenance Safety Management System (MSMS). The purpose of the MSMS is to focus directly on safety related issues and trends and is independent of the normal JAR 145 quality system. Its manager is responsible for internal safety event investigations, reporting to executive management and implementing remedial action. In that regard, the CAA Civil Aircraft Airworthiness Information & Procedures (CAP 562, Leaflet 11-21) covers the conducting of Safety Critical Maintenance Tasks and offers the following advice:

"Procedures should be established to provide maintenance and planning personnel with guidance on the identification and accomplishment of safety critical tasks conducted during scheduled and non-scheduled maintenance activities. Routine tasks documentation should identify those tasks which may have a critical effect on safety and should clearly identify the individual stages of such tasks. Maintenance Programme or Maintenance Schedule basic rules should provide the necessary standards to ensure the identification of critical scheduled maintenance tasks."

"Maintenance personnel's initial and continuation training should highlight the critical nature of conducting maintenance tasks on essential or primary systems. The instruction given should provide personnel with the necessary information to identify and satisfactorily accomplish such tasks. Training programmes should focus on safety critical tasks and the possible consequences of failure to follow the associated maintenance procedures. The development of these training programmes should use feedback from maintenance experience, to enhance the programme and maintenance procedures."

1.6 Additional Information

Instructions for the installation of the door seal is covered in the Aircraft Maintenance Manual Ch. 52-32-18-400-801. There is a note on page 2 indicating that the installer should make sure that the areas on the seal marked UP and DOWN are put in the correct position **(APPENDIX A)**. There is no reference to the correct positioning of the 2 mm inflation holes situated on the top and sides of the seal. In practice, neither the indications of UP and DOWN or the colour markings on the corners of the seal were clearly visible **(APPENDIX B)**.

As a result of a similar incident on an A320 aircraft with another operator some years ago, the relevant AMM chapter was reissued and included the following caution:

"*...Make sure that the inflation holes of the door seal (1) are in their correct position on the inner side of the cargo door. If the door seal is not installed in the correct position, it cannot inflate correctly during the flight. This causes the cabin pressure to decrease and can result in a disruption of the flight...*"

The ambiguity in the case of the A320 was thus removed, but no cross reference to the A330 was made at the time. In addition, the Manufacturer supplied training material for the A330 does not make any reference to the location of the inflation holes.

2. ANALYSIS

2.1 ECAM Warnings

Unfortunately, the trouble-shooting on arrival at Shannon from Dublin was compounded by the fact that there had been a Class 3 fault recorded in BMC 1 which was then cleared. The CPCs were checked and the outflow valve was seen to function correctly. The flight from Dublin to Shannon took place at FL100 with the cabin pressure altitude at 4,900 ft. Thus the cabin never reached the altitude of 9,550 ft to trigger the cabin altitude ECAM warning. The Flight Crew were satisfied with the pressurisation control prior to departure to New York. A leak in the cabin causing failure to maintain a proper differential pressure in flight was not therefore suspected.

2.2 Seal Installation

This was the first occasion on which the Crew Leader had carried out a cargo door seal replacement on an A330 aircraft. The installation of the door seal could be considered a safety critical maintenance task and required the manager to be present with his crew particularly as he had no previous experience in its fitting. The manager left the aircraft in order to acquire a bonding tag just at a time when he might have questioned the mode of seal installation.

However, there were mitigating circumstances. His attentions had been divided between two aircraft. There was also the length of time taken to acquire a seal, the time spent on the job as a consequence, the movement of the aircraft to another Stand and the encroaching darkness. Had the new seal been fitted at the time of the damaged seal removal, its correct orientation in the door might, as a consequence, have been obvious to the crew. The crew might also have noted that the inflation holes were on the incorrect side and facing out from the door centre. As it was, the crew could have fitted the seal in a number of different ways, as follows:

- Correctly
- Correct way up but inside out
- Upside down
- Inside out and upside down

This seal was fitted inside out and upside down. This would indicate that neither the Crew Leader or crewmembers understood how the seal functioned in flight. Taken collectively, they all had adequate experience but obviously none were aware of the significance of the inflation holes. This serious incident should signal the need for a review of the Contractor's initial and ongoing training system.

2.3 Cabin Pressurisation

The AAIU has, over the years, investigated a number of incidents relating to pressurisation and air conditioning events on commercial aircraft. This incident should be considered very serious because of the possible onset of hypoxia* on the flight crew. When an un-pressurized aircraft climbs to altitude, the effects of low barometric pressure can be quite subtle and insidious, as the body will attempt to acclimatise to the altitude change. It is therefore possible that judgement may be impaired to such an extent that corrective actions associated with dealing with an emergency situation may lead to an inappropriate response which could endanger the aircraft.

However, in this incident the flight crew took all the appropriate ECAM actions. The Operator's Operations Manual stipulates that in the event of pressurisation failure, the flight crew must use oxygen when the cabin altitude exceeds 10,000 ft. Both pilots donned their oxygen masks, and an emergency descent was completed. The Captain requested a diversion to Shannon. The Captain later expressed his gratitude to ATC personnel for their attention and assistance during the descent and return to Shannon. A normal approach was executed and the aircraft landed safely at 16.23 hrs. There were no reported ill effects on the passengers.

2.4 Manufacturer Action

From the manufacturers viewpoint, the markings and colours on the seal needed to be improved and the instructions in Ch. 52-32-18-400-801 made less ambiguous and to correspond exactly to the markings on the seal. The chapter should have referred to the purpose of the inflation holes as in the case of the AMM for the A320 aircraft.

* Hypoxic hypoxia is a condition caused by reduced barometric pressure, affecting the body's ability to transfer oxygen from the lungs to the bloodstream

3. CONCLUSIONS

(a) Findings

The absence of adequate pressurisation at 53 N 15 W was due to a faulty installation of the aft cargo door seal.

(b) Cause

The door seal had not been correctly installed as the aircraft manufacturer intended.

4. SAFETY RECOMMENDATIONS

The following Safety Recommendations were included in those made to the aircraft Manufacturer by the Operator and Contractor and are endorsed by the Investigation:

1. The aircraft manufacturer should review the instructions given in the AAM in order to make them less ambiguous. **(SR 10 of 2007)**

   Manufacturers Response

   In January 2006, the Manufacturer re-issued Chapter 52-32-18 as follows:

   "The instructions for FWD and AFT cargo door seal installation were improved by highlighting the presence of inflation holes and the illustrations were revised by showing inflation holes facing inside the cargo door. An additional step and note were also added." **(APPENDIX C)**

2. The aircraft manufacturer should improve the markings on the seal in order to identify its orientation in the door retainer during installation. **(SR 11 of 2007)**

   Manufacturers Response

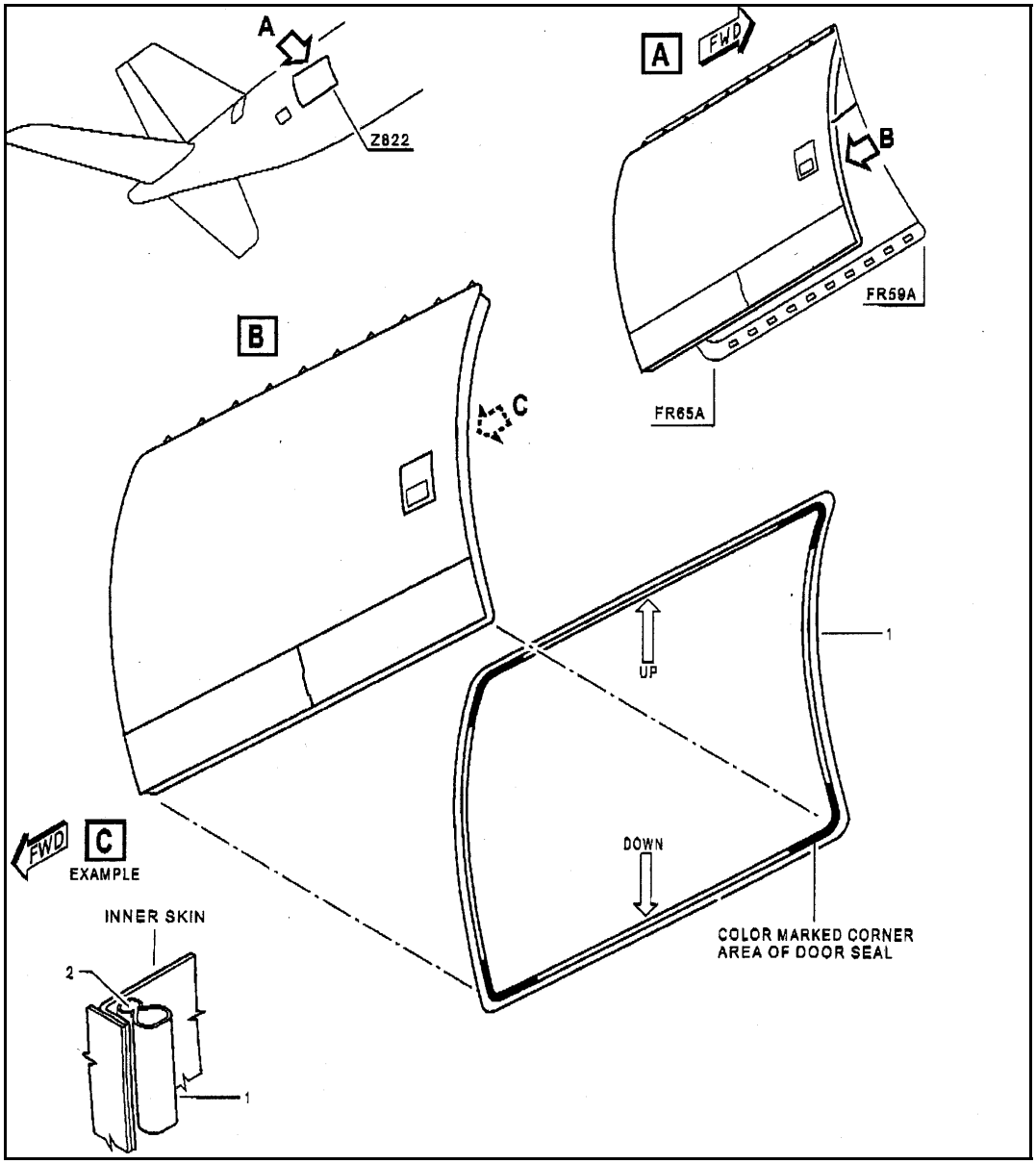
   "Drawing F523 71011 of the subject seal was modified with domestic Mod 54211 to define the seal marking UP/DOWN and the corner areas in white colour in order to improve its visibility".

3. The Investigation recommends that the Maintenance Contractor's initial and continuation training should include aspects of Leaflet 11-21, Safety Critical Maintenance Tasks as in CAA CAP 562. **(SR 12 of 2007)**

   Contractors Response:

   The Contractor said that they were complying with this Safety Recommendation.

APPENDIX A



Page 6 of Task 52-32-18-400-801 issue Jul 01/05

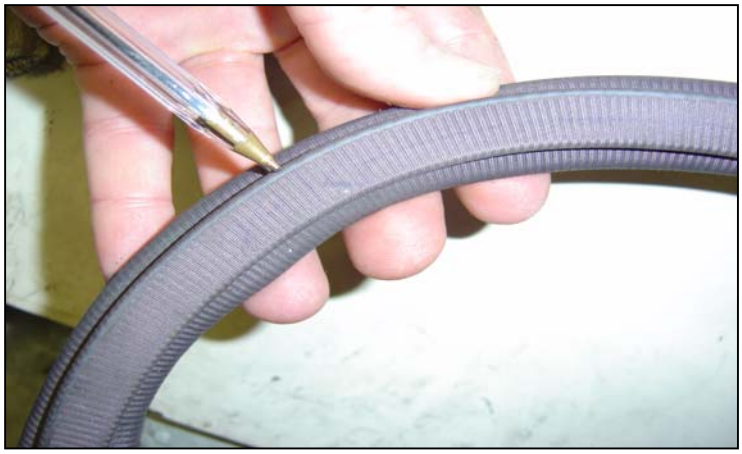
Page 2 of the above Task issue Jul 01/05 includes the following:

"Put the colour marked corner areas of the replacement door seal (1) in the upper and lower corners of the retainers (2).

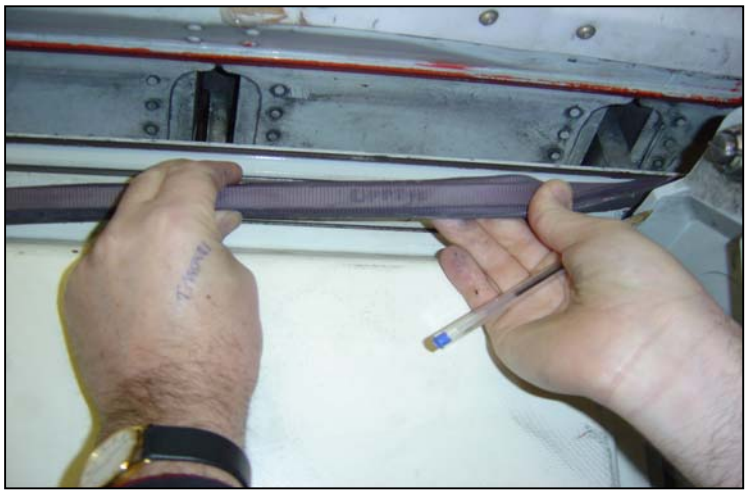
***Note:** Make sure that the areas marked with UP and DOWN are in the correct position.*

Install the flat part of the door seal (1) into the retainer (2) with a suitable tool."

APPENDIX B



Corner Marking



The Upper Marking

The Lower Marking

APPENDIX C

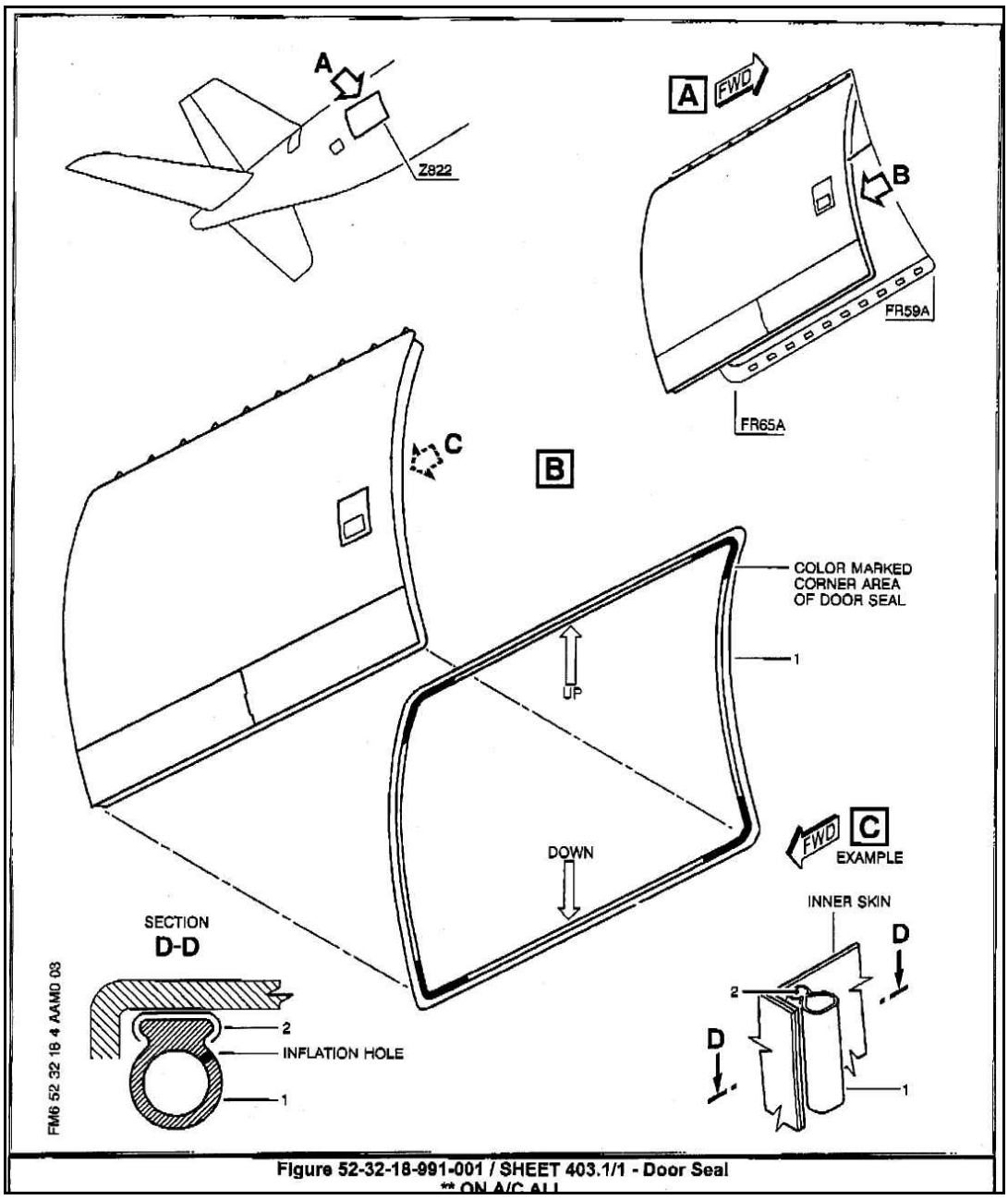


Figure 52-32-18-991-001 / SHEET 403.1/1 - Door Seal
** ON A/C ALL

New Page 6 of Task 52-32-18-400-801 (Issued Jan 01/07)

Page 2 of the above Task now includes the following caution:

"Make sure that the inflation holes of the door seal (1) are in their correct position on the inner side of the cargo door.

Note: *If the door seal is not installed in the correct position, it cannot inflate correctly during the flight. If this occurs, the cabin pressure can decrease and cause a disruption of the flight."*

- END -