# Depressurizaton En Route, Airbus A320 (EI-CPD), en route near Cardiff, UK, January 26, 2004.

**Micro-summary:** **This Airbus A320 experienced a depressurization incident.**

**Event Date:** **2004-01-26 at 1052 UTC**

**Investigative Body:** **Air Accident Investigation Unit (AAIU), Ireland**

**Investigative Body's Web Site:** **http://www.aaiu.ie/**

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1. Accident reports can be and sometimes are revised. Be sure to consult the investigative agency for the latest version before basing anything significant on content (e.g., thesis, research, etc).

2. Readers are advised that each report is a glimpse of events at specific points in time. While broad themes permeate the causal events leading up to crashes, and we can learn from those, the specific regulatory and technological environments can and do change. ***Your company's flight operations manual is the final authority as to the safe operation of your aircraft!***

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# FINAL REPORT

**AAIU Synoptic Report No:2005-020**
**AAIU File No: 2004/0006**
**Published: 7/10/05**

**In accordance with the provisions of SI 205 of 1997, the Chief Inspector of Accidents, on 26 January 2004 appointed John Hughes as the Investigator-in-Charge to carry out a Field Investigation into this occurrence and prepare a Synoptic Report.**

| | |
|---|---|
| **Aircraft Type and Registration:** | Airbus 321-200, EI-CPD |
| **No. and Type of Engines:** | 2 x CFM 56-5B/3P |
| **Aircraft Serial Number:** | 0841 |
| **Year of Manufacture:** | 1998 |
| **Date and Time (UTC):** | 26/01/04 @ 10.52 hours |
| **Location:** | En-route London to Dublin |
| **Type of Flight:** | Scheduled Transport |
| **Persons on Board:** | Crew - 8 Passengers -155 |
| **Injuries:** | Crew - Nil Passengers - Nil |
| **Nature of Damage:** | LH air conditioning bellows ruptured<br>No aircraft exterior damage |
| **Commander's Licence:** | ATPL |
| **Commander's Age:** | 42 years |
| **Commander's Flying Experience:** | 12,521 hours of which 1,540 were on type |
| **Information Source:** | Operators Air Safety Office |

## SYNOPSIS

On landing at London Heathrow earlier in the morning, a noise from the forward hold area was reported by the flight crew. An inspection by ground crew found a blow out panel open. Finding nothing amiss, the panel was reset and the aircraft released for the return flight to Dublin. Whilst the aircraft was climbing through FL266, the flight crew received an ECAM (Electronic Centralised Aircraft Monitoring) warning that the cabin altitude was excessive and a subsequent warning of low cabin differential pressure. An emergency descent was initiated and executed without further incident at Cardiff Airport.

# FINAL REPORT

## 1. FACTUAL INFORMATION

### 1.1 History of the Flight

The aircraft took off from London Heathrow airport at 10.36 hrs. Twelve minutes later, whilst passing Flight Level 266 (FL 266), the Captain noticed the Cabin Altitude reading pulsing bright green indicating “9,500 ft”. He contacted ATC and made a request to level off. However, the Cabin Altitude continued to climb indicating “10,000 ft.” in red. The Captain donned his oxygen mask and requested a descent to FL 200. The ECAM system then warned of “Cabin Pressure Excess Altitude”. Rapid depressurisation continued and the crew carried out the relevant recall/memory actions in accordance with the Quick Reference Handbook (QRH) and the Flight Crew Operations Manual (FCOM).

The First Officer (FO) donned his oxygen mask as the Captain requested a descent to FL100. There were further actions taken in response to ECAM warnings and the FO put out an emergency PAN call and received descent clearance.

The aircraft descended at 320-330 kt at engine idle thrust. Once the Captain satisfied himself that there was no structural damage to the aircraft he applied the speed brakes. This produced a rate of descent of about 5000 ft/min.

The Captain reported that the incident occurred North of Cardiff and the weather there was good. Vectors to Cardiff were offered by London ATC, which the Captain accepted. Subsequently the Captain changed to Cardiff Radar and levelled the aircraft at FL100. Oxygen masks were removed, the ECAM cleared, an assessment of the situation was made and the Captain continued with the diversion. The Captain then briefed the Cabin Crew Members (CCMs) and passengers. The passenger masks had not deployed, as cabin altitude had not reached a level where passenger oxygen masks would automatically deploy (14,000 ft approximately). The FO set up the Multipurpose Control and Display Unit (MCDU) for the landing phase. All checks were completed and the remainder of the flight was uneventful. The Captain said that he was familiar with Cardiff Airport.

### 1.2. Aircraft Inspection for Damage

On inspection of the aircraft at Cardiff the following was reported:

The metal clamp holding the forward bellows to the LH air conditioning condenser unit was found broken. The bellows had detached from the condenser and was found ruptured. The Pack Outlet Check Valve (POCV) flap downstream from the condenser was also found broken. This would have allowed the cabin air to exhaust to atmosphere through the ruptured bellows unit. In addition, a small 1.5 cm piece had broken away from the centre of the flap and was not found. The blow-out panel had opened.

The clamp, check valve and bellows were replaced and the LH duct and condenser were checked for debris with nil findings. The LH air conditioning pack was operated as per the aircraft maintenance manual (AMM) and found satisfactory. The aircraft was flown back to Dublin with that pack inoperative. The damaged parts were returned to the aircraft manufacturer for inspection.

## 1.3 Aircraft Information

### 1.3.1 Pressurisation System

Pressurization is performed by controlling the amount of air discharged overboard through one outflow valve. The system has two identical and independent automatic controllers. Only one controller operates at a time, the other is in active stand-by.

In normal operation, the system is fully automatic. The automatic cabin pressure control operation is dependent on a control programme and on information fed from the Flight Management and Guidance Computers (FMGCs) and Air Data/Inertial Reference Units (ADIRUs).

The cabin altitude is displayed with indicated values in green when in normal range and pulses advisory when cabin altitude is greater than 8,800 ft. It changes to red when cabin altitude reaches 9,550 ft.

The cabin differential pressure is displayed with indicated values in green when in normal range. It changes to amber when less than 0.4 PSI or greater than 8.5 PSI

The aircraft had been on a "C" Check which was completed on 19 January 2004. The clamp, which was found to be broken on the condenser end of the bellows, had been removed and reinstalled during that inspection. The aircraft had carried out 36 flights since that inspection.

### 1.3.2 Description of Check Valve

The check valve is a light alloy, single-flap non-return-valve **(See Appendix A).** It has a flanged valve seat with two lugs between which a circular valve flap returns about a pivot pin. A spring installed on the pivot pin closes the valve flap when the air pressure at the inlet falls. The valve seat is attached with bolts to the flange of the housing. A mechanical stop is secured to the inside of the valve housing.

### 1.3.3 Operation of Check Valve

The check valve permits air-flow in only one direction, inlet to outlet. The valve opens when the air pressure at the valve inlet is more than the preset load of the spring. In normal conditions, the inlet pressure is more than the air pressure at the outlet side of the valve. When the valve is open the mechanical stop prevents more movement of the flap. The valve closes when the air pressure at the valve inlet decreases to a value less than the preset load of the spring. This prevents leakage from the pressurized zone when a failure of the air conditioning system occurs.

### 1.3.4 Operation of the Blow-Out Panel

The blow-out panel is included in the air conditioning bay quick-release access panel 192KB, fitted to the wing/ fuselage under belly fairing **(see Appendix A).** If during flight, an overpressure condition occurs in the air conditioning bay, the blow-out panel will open. This occurs when the differential between the bay pressure and the outside ambient pressure exceeds 112 mBar. The panel is pushed open against spring tension and remains open until it can be closed by hand during ground maintenance.

## 1.4 Technical Analysis

### 1.4.1 Aircraft Manufacturer Observations

A comprehensive report was sent to the aircraft manufacturer by the Operator's Maintenance Contractor. The manufacturer stated that in the past 10 years they had received about 15 reports from operators who had experienced damaged Pack Outlet Check Valve (POCV) flaps. Six of them actually happened in conjunction with or after a damaged bellows or a failed bellows clamp and led to depressurization.

In the opinion of the aircraft manufacturer, following receipt of photographs of the damaged parts, the clamp had originally been installed incorrectly. It appeared that one end of the aluband (clamp) became stuck between the other end of the aluband and the riveted steel lock **(see Appendix C).** This seemed to have bent the free end of the aluband slightly downwards which then had caused a deformation at the location of the second row of rivets. If the clamp is installed in this way, it would need more torque value to get a tight seat of the clamp on the bellows, which as a consequence would imply more stress on the aluband which might not lead to an immediate rupture but, in conjunction with time and vibration could lead to a rupture at a later stage.

In the past, the failure of the POCV appeared as a subsequent result of the bellows, or clamp failure. There are two failure scenarios.

- If the bellows ruptures explosively, the air immediately escapes into the pack bay area and no further air would be supplied to the POCV. The cabin pressure downstream of the POCV will then immediately close the POCV and prevent depressurization.
- On some rare occasions, the airflow is not stopped abruptly but the bellows slowly disintegrates or comes loose at the condenser side with the result that the air is partly supplied to the POCV and partly streams into the pack bay. This then will lead to an inconstant airflow in which, at one point, the cabin pressure and the dynamic pressure caused by the remaining pack outlet airflow will have nearly the same value. At this point the flap of the POCV has been seen to heavily oscillate between the two end stops. In this, admittedly very rare scenario, only a couple of heavy bangs against the stopper, which can even be heard in the cabin/cockpit, are sufficient to destroy the metal casted POCV flap, thus leading to depressurization.

Each scenario, which includes a big air leakage in the pack bay, would open the belly fairing blow-out panel.

The manufacturer was of the opinion that the damage to the bellows, which is only present at the side where the bellows was attached by the clamp, was as a result of the loose bellows rubbing against the clamp at the condenser outlet.

The manufacturer also indicated that if the aircraft had been inspected on arrival at London Heathrow in accordance with the Trouble Shooting Manual (TSM) for a blow-out panel in the open position, then the damage to the bellows would have been observed.

The manufacturer indicated that the Mean Time Between Unit Removal ( MTBUR) of the POCV was about 0.5 million flight hours and was considered as a sufficiently reliable component in itself. Six cases of failure on 880 aircraft over 15 years were well within the limits of Certification Authority failure probabilities. The aircraft manufacturer is not contemplating a retrospective modification or service instruction of the POCV.

The inspection of all aircraft of the Operator's fleet was recommended by the aircraft manufacturer. This inspection covered the left and right hand pack condensers, pack outlet valves and attaching ducts.

### 1.4.2 Manufacturers Modifications

#### 1.4.2.1 New Clamp

After a similar event of clamp rupture in May 2002 the aircraft manufacturer developed a new style of clamp which is made from a different type of material and which is spot welded rather than riveted **(see Appendix B).** However, this new "Style 2" clamp, although promulgated in the Standards Manual in November 2002, has not yet been illustrated in the IPC (parts catalogue).

The new clamp, P/N NSA5532C612, will be introduced by modification No. 35038. The modification is still in the certification process. The embodiment rank has been fixed to MSN 2509 to be delivered in Aug-05. For in-service aircraft, SB No. A320-21-1155, (rated *"Desirable"*), will allow operators to replace old clamps by a new clamp. The target date for SB dispatch to airlines is currently Sep-05.

As part of the above process, the Ilustrated Parts Catalogue (IPC) will be updated to reflect this change when it becomes available.

#### 1.4.2.2 Pack Outlet Check Valve (POCV)

The POCV installed on this aircraft was of the older type (Part No. 769A0000-02, Serial No. 01887). In June1998, the subcontractor had introduced a newer type of POCV (Part No. 769B0000-01) but after this introduction two further batches of the older design were delivered to the aircraft manufacturer. However, the broken flap, serial number 01887, did not belong to either of these batches. The sole available spare is now of the modified type. No reported cases of failure of this newer standard had been received.

### 1.4.3 Aircraft Manufacturer's Subcontractor Examination

The fractured POCV was sent to the subcontractor for examination and report. On one side of the flap they discovered scratches caused by roughing/cleaning carried out by the casting manufacturer. These scratches should not be evident. Metallographic inspection of the fracture also revealed some abnormal inclusions in the material in the cracked area. They concluded that these inclusions and possibly abnormal severe conditions caused the flap to fracture.

### 1.4.4 Aircraft Manufacturer Recommendations

- The manufacturer stated the need to highlight that an open Blow Out panel is to be treated as any other kind of aircraft failure and is under NO circumstances to be closed without an inspection.
- Considering that this was the third event of this kind reported by contractors, the manufacturer recommended the out phasing of the riveted clamps and to replace them with the new standard welded clamps.
- The simultaneous use of the Air Conditioning Pack and Low Pressure Ground Connector could also lead to an oscillation of the POCV flap. For this reason, the aircraft manufacturer does not recommend the simultaneous use of Air Conditioning Packs and Low Pressure Ground Connector.

### 1.4.5 Operator's Contractor Recommendations

The contractor recommended the out phasing of the older riveted clamps and their replacement by the new standard welded clamp. In the meantime, a review of the installation procedure took place in-house. As recommended by the manufacturer an Engineering Order Inspection (EOI) was issued in April 2004 to cover the fleet inspection of the left and right hand pack condensers, pack outlet valves and attaching ducts. It requested the inspection of the inlet flap valve for signs of damage and/or cracking and the installation of Style 2 clamps. One year after this incident seven out of a fleet of ten A320/321 aircraft had been inspected. Slight deterioration of the bellows was found on only two aircraft with no other damage apparent. In May 2004, a Quality Advisory Notice was issued warning maintenance personnel that it is possible to incorrectly install the older clamp. However, at that time there were none of the older clamps in their stock.

## 1.5 Flight Data Recorder

The FDR readout for altitude and cabin pressure warning discrete are shown at **Appendix C.** The aircraft took off at 10.36 hrs with an initial climb rate of 2066 ft/min up to FL150. The climb rate then reduced to 1858 ft/min until the aircraft reached a maximum height of 27,324 ft.

The aircraft then started to descend and 17 seconds later at 27,136 ft the Cabin Pressure Warning activated. The aircraft continued to descend at a rate of 4310 ft/min until FL100 was reached. The warning deactivated at 15,176 ft having remained activated for a little over 3 minutes. From FL100 the aircraft continued its descent to Cardiff at a reduced rate of 1293 ft/min.

## 2. ANALYSIS

The flight crew reported a noise from the forward hold area on the inbound flight to London. A more exhaustive search on the ground could have revealed the loose bellows and broken clamp. The manufacturers Trouble Shooting Manual directs personnel, on finding a blow-out panel in the open position, to examine the pack outlet bellows for correct condition.

The Style 2 clamp seems superior in design and this incident would be less likely to occur with such a clamp installed. It was issued in the Standards Manual in November 2002. It is unfortunate that it has taken so long to appear in the IPC catalogue.

The POCV has also been updated with only the new design flap available as a spare part. It is not known how many aircraft are in service with the older flap valve that might contain inclusions in the casting.

The manufacturer's customer services publish a periodic technical magazine and a newsletter as sources of information for customers, operators and suppliers. In an "A320 Special" magazine edition, published in May 2005, attention by the manufacturer has been drawn to the failure of the bellows and the modification of the bellows clip planned for September 2005. At the same time, the Investigation had concerns that there might be other aircraft in service having sub-standard flap castings. Due to the low failure rate in service, the manufacturer does not see a need to track and to replace the flaps from the same batches, which may have inclusions in the casting. A flap failure alone would only lead to an overheat of the associated pack which would be monitored by the crew.

However, the Trouble Shooting Manual (TSM) was amended in May 2004 and the AMM in May 2005 and now includes a direction and method for a detailed inspection of the POCV flappers as part of a general inspection of the bellows when a blow-out panel is found open.

This recent amendment to the TSM and AMM alleviates the concerns, which the Investigation had regarding the quality of the casting in some of the older flappers. In view of this action, the Investigation feels that further safety actions/recommendations by the manufacturer are not required.

## 3. CONCLUSIONS

### (a) Findings

1. Following a normal landing at Heathrow a blow out panel was found open. As an inspection revealed nothing abnormal, the panel was closed.
2. Twelve minutes after take off from Heathrow, on a return flight to Dublin, the aircraft experienced a rapid depressurisation, which necessitated the immediate descent of the aircraft to 10,000 ft, followed by a diversion to Cardiff Airport.

### (b) Causes

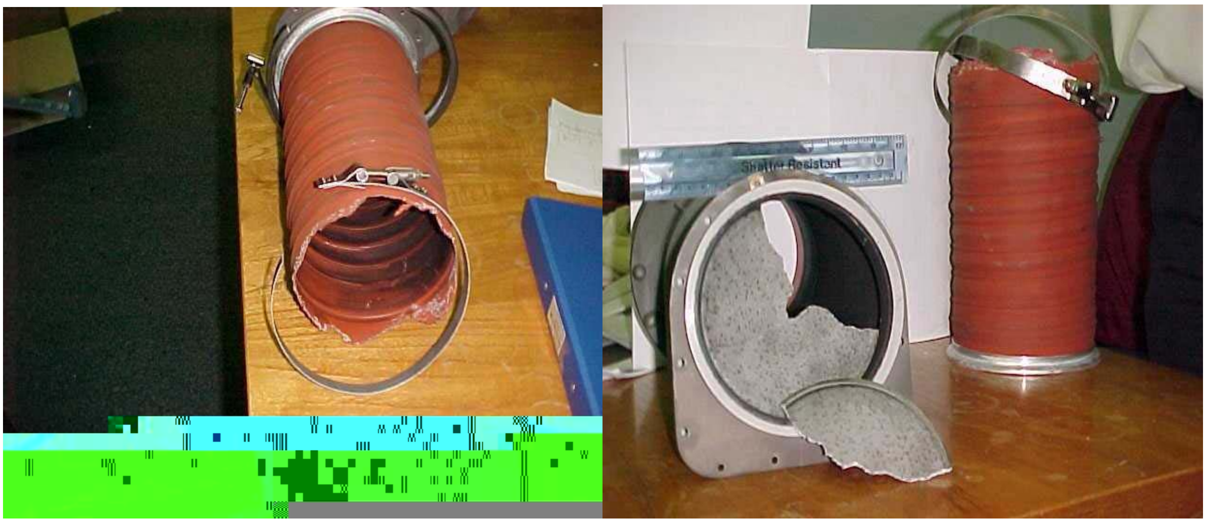
1. The clamp on the condenser in the left hand air conditioning bay fractured, causing the associated bellows unit to rupture
2. The rupture set up an oscillation in the airflow through the Pack Outlet Check Valve, which caused the valve flap to impinge on the valve stops. Foreign inclusions in the flap casting were a contributing factor in its subsequent fracture and failure.
3. The ground inspection failed to find the ruptured bellows during the initial trouble shooting at London LHR (in accordance with aircraft manufacturer's TSM Task 21-50-00-810-801)

## 4. SAFETY RECOMMENDATIONS

This Report does not sustain any Safety Recommendations

**FINAL REPORT**

## APPENDIX A




The photo on the left shows the broken clamp and the frayed end of the bellows unit. The photo on the right shows the broken check valve. The scratches on the flap casting and the missing centre portion can also be seen.

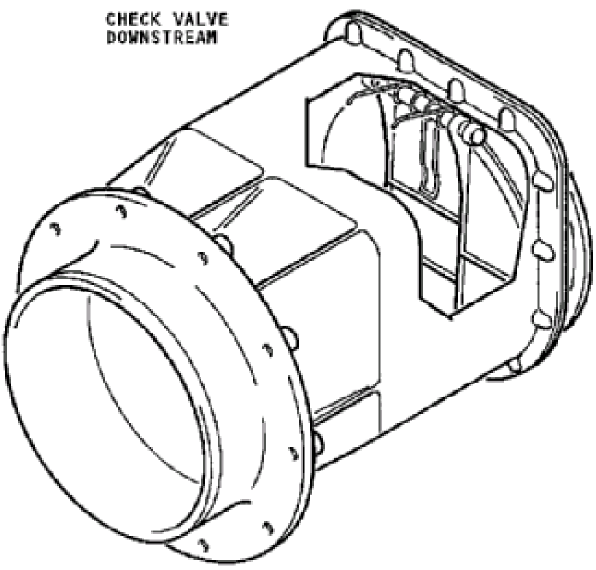
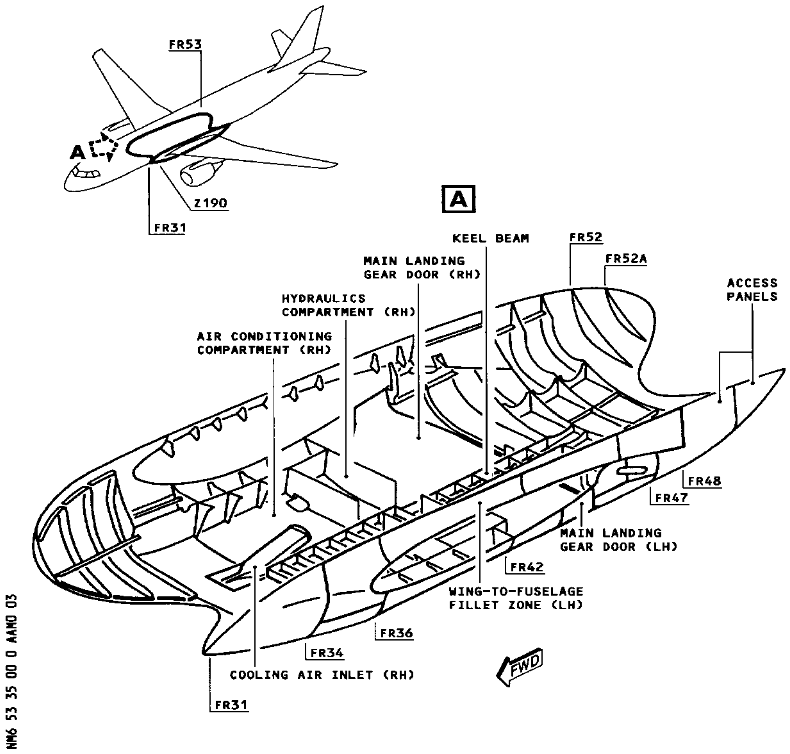
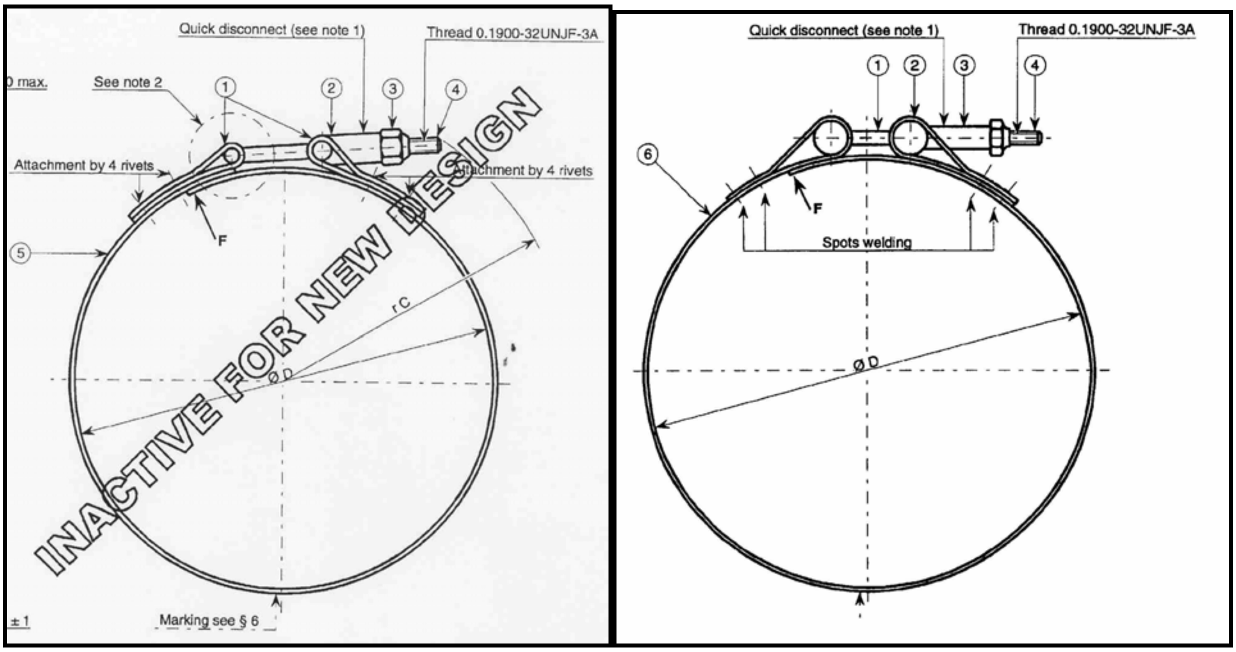



Diagram of the Pack Outlet Check Valve (POCV) downstream of the condenser unit. The valve is shown in the closed position under the action of the spring as the inlet pressure from the right reduces.



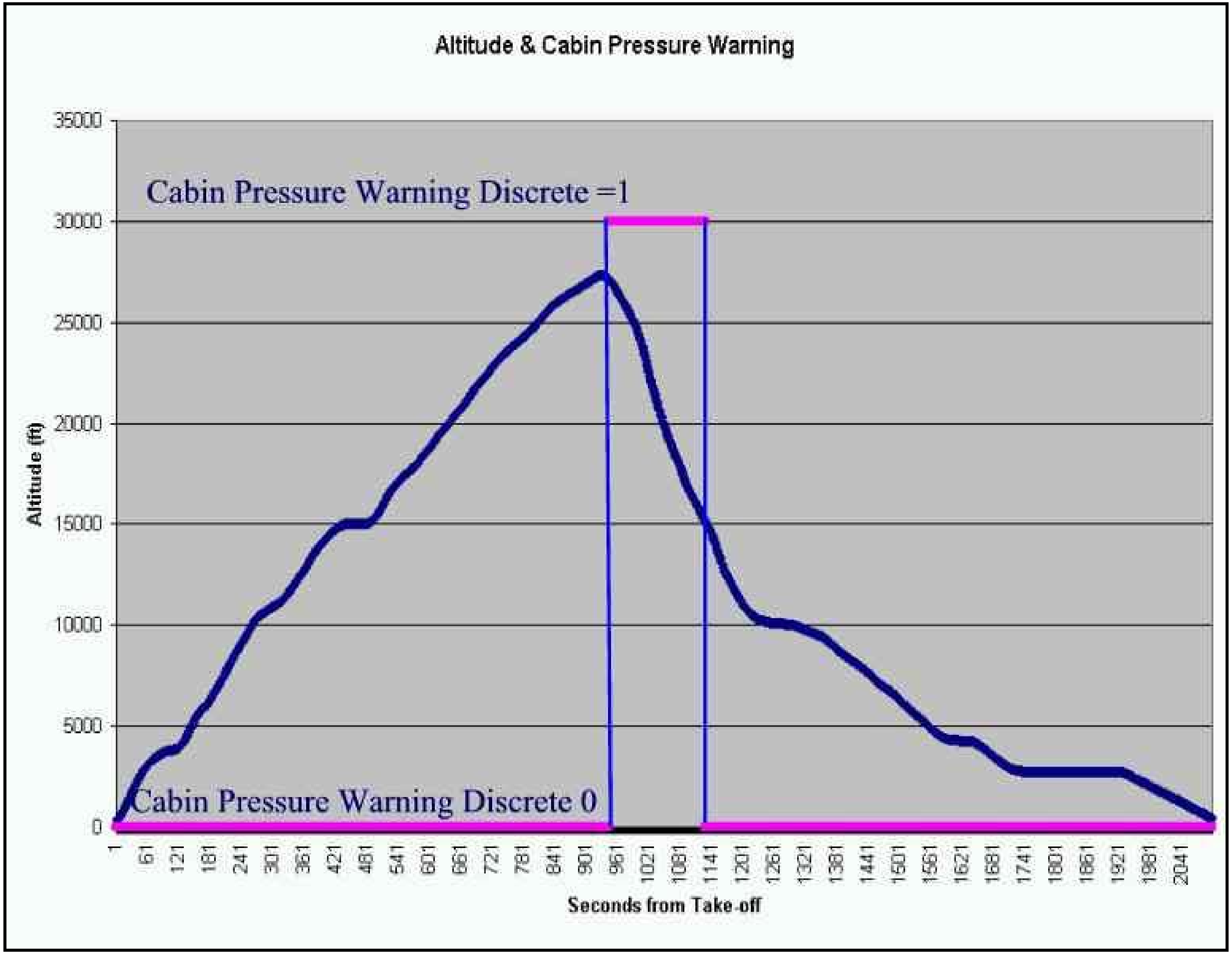

Drawing from the aircraft Maintenance Manual showing position of air conditioning units. (courtesy Airbus Industrie)

# APPENDIX B




Drawings from the Standards Manual. The drawing on the left shows the older band fabricated using rivets. It indicates where end "F" should be during the tightening process. That on the right is the newer "Style 2" design using spot-welded joints.


The clamp as found. End "F" was on the incorrect side of the opposite end of the band and became locked by the rivets.


Altitude & Cabin Pressure Warning
Cabin Pressure Warning Discrete =1
Cabin Pressure Warning Discrete 0
Altitude (ft)
35000
30000
25000
20000
15000
10000
5000
0
1
61
121
181
241
301
361
421
481
541
601
661
721
781
841
901
961
1021
1081
1141
1201
1261
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1441
1501
1561
1621
1681
1741
1801
1861
1921
1981
2041
Seconds from Take-off