NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

November 21, 2001

Systems Group Chairman's Factual Report

MIA-01-FA-029

A. ACCIDENT

Operator:	American Airlines
Location:	Miami, Florida
Date:	November 20, 2000
Time:	Approximately 12:00 PM EST
Airplane:	Airbus A300-600, N14056

B. SYSTEMS GROUP

Chairman:

Scott Warren, NTSB
Aerospace Engineer
Washington, D.C.

Members – Miami, Florida Activities:

Randy Harris
American Airlines
Tulsa, Oklahoma

Charles Meyer
American Airlines
Tulsa, Oklahoma

George Rojas
American Airlines
Miami, Florida

Ursuss Alvarez
Transport Workers Union
Miami, Florida

James Knapp
Transport Workers Union
Miami, Florida

Charles Rinchko
Federal Aviation Administration
Miami, Florida

Suzanne Mejia
Federal Aviation Administration
Miami, Florida

Ken Clark
American Airlines, Allied Pilots Association
Miami, Florida

Gilles Juan
Airbus Industrie
Toulouse, France

Members – Tulsa, Oklahoma Activities:

Randy Harris
American Airlines
Tulsa, Oklahoma

Charles Meyer
American Airlines
Tulsa, Oklahoma

Michael Cafasso
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Dave Jewitt
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Steve Morton
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Federal Aviation Administration
Miami, Florida

Larry Birdwell
Allied Pilots Association
Tulsa, Oklahoma

C. SUMMARY

On November 20, 2000, about 1222 eastern standard time, an Airbus Industrie A300B4-605R, N14056, registered to Wilmington Trust Company, and operated by American Airlines, Inc., as flight 1291, a Title 14 CFR Part 121 scheduled international passenger flight, from Miami, Florida, to Port Au Prince, Haiti, had a flight attendant receive fatal injuries during an emergency evacuation after the flight returned to Miami. Visual meteorological conditions prevailed at the time and an instrument flight rules flight plan was filed. The aircraft received substantial damage and the airline transport-rated pilot, first officer, 6 flight attendants, and 100 passengers were not injured. One flight attendant received fatal injuries, 3 passengers received serious injuries, and 18 passengers received minor injuries. The flight originated from Miami, Florida, the same day, about 1149 EST.

The captain stated that both automatic cabin pressurization controllers would not control cabin pressure while climbing through 16,000 feet, about 8 minutes after departure, and that the forward outflow valve went to the full open position. About 11 minutes after departure, he stated to air traffic controllers that he was unable to control the pressurization and that he would need to return to Miami. About 3 minutes before landing and after reports of lavatory smoke alarms sounding in the cabin, the captain declared an emergency with air traffic controllers and requested that fire trucks be standing by for the landing. He stated that after landing, the ram air switch did not depressurize the aircraft on the ground and that 45 seconds after landing, the aircraft did not depressurize. About 2 minutes after landing, the fire commander reported no signs of fire and stated they would follow the aircraft to the gate. About 1 minute later, the crew noted a cargo smoke detector loop fault light and the captain reported he had a fire and that they would evacuate the aircraft. Fire department personnel stated that shortly after the captain reported they had a fire and would evacuate the aircraft, the left front door of the aircraft "exploded open" and a flight attendant was ejected out of the aircraft and landed on the tarmac. The other doors opened and the evacuation slides deployed. They assisted the flight attendant on the tarmac and also assisted the passengers as they evacuated the aircraft.

The Systems Group met in Miami, Florida during the period of November 21-23, 2000, and in Tulsa, Oklahoma during the period of November 28 – December 2, 2000, and again during the period of February 20-22, 2001.

D. DETAILS OF THE INVESTIGATION

1.0 VISUAL INSPECTION OF LAVATORIES, GALLEYS, AND CARGO AREAS

All 7 of the aircraft's lavatories were inspected to look for any signs of smoke or fire. The lavatories' waste bins, water heaters, and overhead spaces were all checked and no signs of soot or fire were found. A cigarette was found at the bottom of the waste bin for lavatory Y (see figure 1).

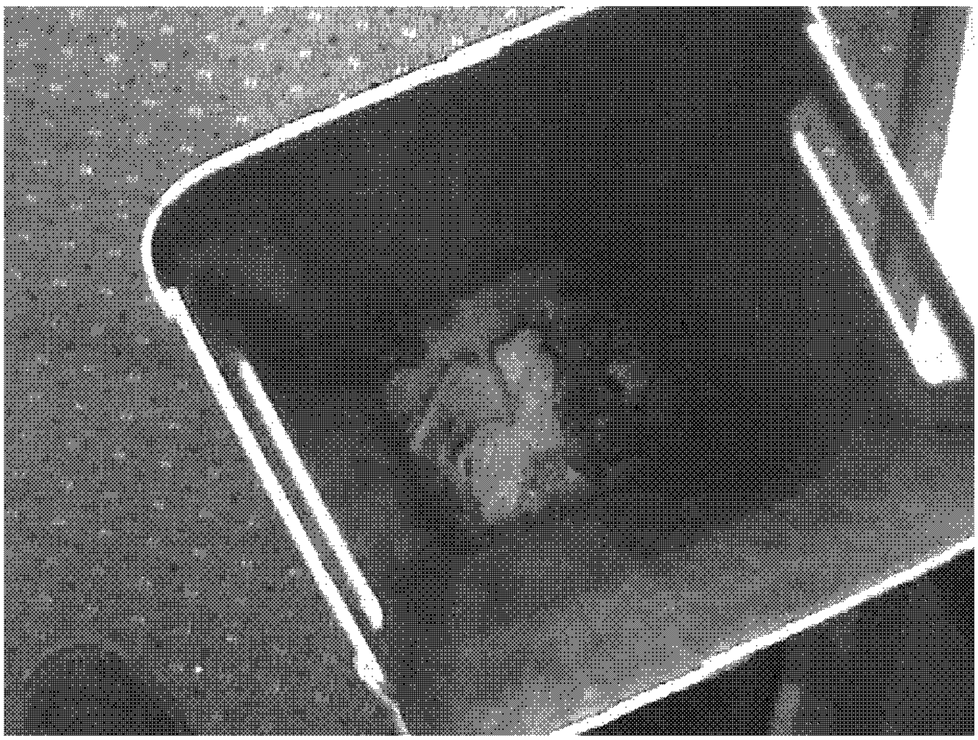


Figure 1 – Cigarette Found at the Bottom of the Waste Bin for Lavatory Y

All of the galleys on the aircraft were inspected to look for any signs of smoke or fire. All of the ovens, waste containers, and food storage areas were inspected, and no signs of soot or fire were found.

All of the cargo compartments on the aircraft were inspected to look for any signs of smoke or fire. All of the areas around the smoke detectors as well as other areas inside the cargo compartments and behind the cargo compartment walls were inspected, and no signs of soot or fire were found.

2.0 PRESSURIZATION SYSTEM

2.1 SYSTEM DESCRIPTION

The pressurization control system is a fully automatic, electrically operated system. It consists of two identical independent automatic systems operating two outflow valves, one situated forward of the air conditioning bay and the other aft of the bulk cargo compartment. Each valve is operated by one of three electric motors, two of these motors are controlled independently by the two automatic systems, and the third motor (for the manual system) is controlled by a toggle switch located on the overhead panel in the flight compartment. In each valve, the drive mechanism and butterfly valve are common to either system, and the two automatic systems will alternately operate both valves. Each system is used alternately for each flight, the changeover being affected automatically between flights. In the event of a system failure, control is automatically transferred to the other system. The system function is dependent on pre-programmed cabin pressure altitude, aircraft altitude, and pre-selected landing altitude information. This information is relayed to the pressurization controller of either of the two systems selected. These units also automatically control pre-pressurization and depressurization procedures.

Two safety valves are installed in the pressurized area. They operate independently and perform the following safety functions:

a. overpressure safety (relief of positive differential pressure between the cabin and the atmosphere);
b. negative pressure safety (relief of negative differential pressure between the cabin and the atmosphere).

Apart from these two essential safety functions, each of the valves contains an electrical device to transmit valve position indication signals to the Electronic Centralized Aircraft Monitoring (ECAM) system display and to the maintenance panel located on the aft wall of the flight compartment.

The cabin pressure controllers, mounted in the avionics compartment, are electronic devices intended to optimize the pressure build-up in the cabin while minimizing pressure fluctuations. In automatic mode, the controllers monitor and control cabin pressure automatically during all phases of flight. After landing (main landing gear compressed), the automatic mode commands the outflow valves to a fully open position 45 seconds after touchdown. When the cabin pressure is being controlled in manual mode, the outflow valves do not open automatically after touchdown.

When manual pressurization control mode is selected, the ECAM pressurization system indications for cabin differential pressure, cabin altitude rate of change, and cabin altitude no longer function. Pressurization system status monitoring is performed by referencing the cabin differential pressure indicator, the cabin altitude rate of change indicator, and the cabin altimeter. These indicators are located in the overhead panel of the flight compartment (see figure 2).

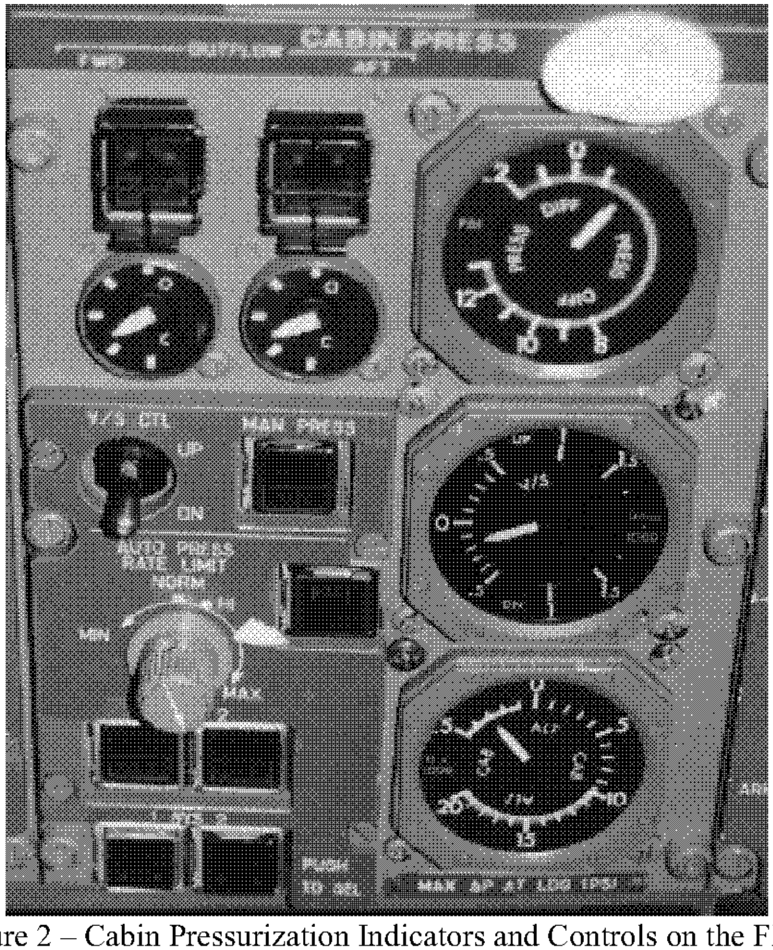


Figure 2 – Cabin Pressurization Indicators and Controls on the Flight Compartment Overhead Panel

2.2 FUNCTIONAL TEST ON THE ACCIDENT AIRCRAFT

The cabin pressurization system was tested in accordance with maintenance manual procedure 21-31-00, “Cabin Pressure Control and Monitoring – Adjustment/Test”. The test procedure consisted of the following parts:

1.C.2.a – Test of automatic controls;
1.C.2.b – Test of ditching configuration;
1.C.2.c – Test of outflow valves manual control;
1.C.2.e – Test of cabin pressure outflow valves opening (controlled by emergency ram air inlet);
1.C.2.f – Test of cabin pressure controller;
2.C.2.a – Perform Test OK on both systems;
2.C.2.b – Check for correct operation of pressurization in MAN mode;
2.C.2.c – Check for correct operation of pressurization in automatic mode;

All of the tests performed did not show any discrepancies in the system. The test procedures were modified slightly to accommodate the fact that repairs to the forward passenger door on the left side of the aircraft were not complete and the pressurization levels were reduced to approximately 2 psi differential. The system was pressurized using the aircraft’s auxiliary power unit.

In addition to the maintenance manual procedure, tests were performed with one or both outflow valves blocked. The purpose of the tests was to document the response of the cabin pressure controllers to the various failure conditions. In all of the tests, the system performed in accordance with its designed operation. The tests performed are given below:

Test Point	Mode (Note 1)	Forward Outflow Valve Blockage (Note 2)	Aft Outflow Valve Blockage	Cabin Rate of Climb/Descent (ft/min) (Note 3)
1	Auto	No blockage	No blockage	500 1,000 1,500
2	Auto	No blockage	Blocked	500 1,000 1,500
3	Auto	Partially blocked (Note 4)	Blocked	500 1,000 1,500
4	Manual	Partially blocked	Blocked	500 1,000 1,500

Notes: (1) Test points were repeated in the auto mode to use both cabin pressure controllers.

(2) The outflow valves were blocked using insulation blankets in a manner similar to that found in the accident aircraft.

(3) Cabin rate of climb was varied by using the autopressurization rate limit selector. For test points of 500 ft/min, the normal position was used with actual rates of climb ranging from +350 to –450 ft/min. For test points of 1,000 ft/min, the point midway between norm and max was selected with actual rates of climb ranging from +850 to –750 ft/min. For test points of 1,500 ft/min, the max position was used with actual rates of climb ranging from +1600 to –1250 ft/min.

(4) During portions of this test point, the blanket blocking the forward outflow valve moved from the partially blocking position to a position where 90% of the valve was blocked. The automatic mode could not maintain the desired rate of climb, and the outflow valves were commanded to the full open

position. This resulted in an ECAM presentation where the cabin altitude was very low (and descending slightly) and the outflow valves were at the full open position (see figure 3). When the blanket was reset to the partially blocking position, the outflow valve moved towards the closed position, and contacted some of the wires on the outflow valve intake screen.

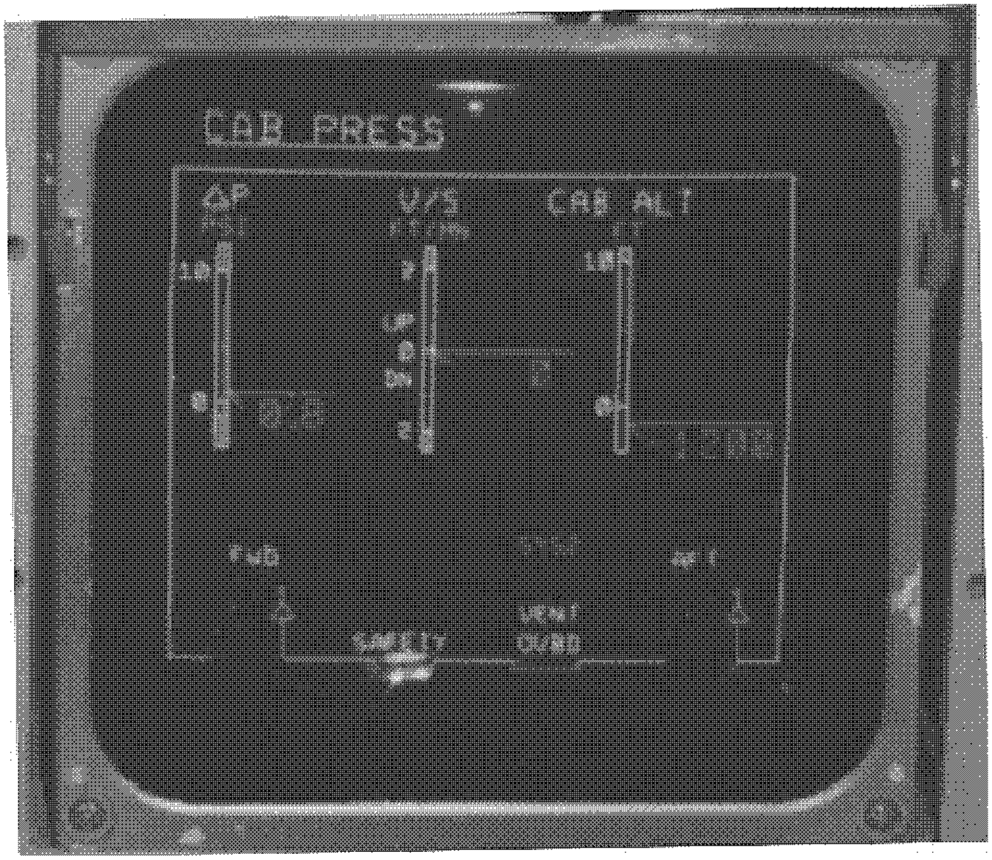


Figure 3 – ECAM Display of Cabin Pressurization Indicators and Controls with Both Outflow Valves Blocked by Insulation Blankets

2.3 COCKPIT CONTROLS AND GAUGES

The flight deck switch positions were documented in two phases. The first phase was conducted immediately after the accident and documented the positions of the pressurization system related switches and the ECAM displays. This phase was conducted immediately after the accident and prior to towing the aircraft to the hanger. The second phase documented all of the switch positions in the flight deck, and was conducted after the aircraft was towed to the hanger. There were no disagreements between the switch positions noted during the two examinations.

Significant items noted during the first phase examination included:

Pack 1 "fault" light illuminated;
Pack 2 "fault" light illuminated;
Ram Air Switch "open" "on" lights illuminated;
Air Bleed x-feed valve "closed";
L and R Engine bleed valves "fault" lights illuminated;
L and R HP valves "closed"; ECAM shows R valve "open" and L valve "closed";
APU Bleed "off";
Fwd Outflow valve position indication - "3/8 open";
Aft Outflow valve position indication – closed;
Manual Pressure control switch "on" with "arrow" light illuminated;
Auto Pressure rate limit – 1/3 of the way from high towards max;
Number 1 and 2 regulator "fault" lights illuminated;

Right Hand ECAM Display:
Eng 1 – "Eng 1 Shut Down" (yellow)
Eng 2 – "Eng 2 Shut Down" (yellow)
Air:
    Bleed valve 1 fault – "off" (blue)
    Bleed valve 2 fault – "off" (blue)
Cabin Pressure:
    Cab press reg 1 fault – "off" (blue)
    Cab press reg 2 fault – "off" (blue)
        Proc: "Cab Press Man Ctl" (blue)
Loop:
    "Aft Compt Loop B Off" (white)
    "C/B monitor open" (white)

Landing elevation selected as "50 feet"

During the second phase examination of the cockpit, the following additional items were noted:

The Captain's oxygen mask was deployed;
The First Officer's and both observers' oxygen masks were stowed;

The fire handles for engine 1, engine 2, and the APU were pulled.

The "Loop B" button was out with the "off" light illuminated on the Cargo Compt Smoke Det, Aft panel;

The Compt Temp selectors for the "Bulk Cargo", "Aft Cabin", "Mid Cabin", and "Cockpit" were all selected to the max cold position. The selector for the "Fwd Cabin" was selected to a point between the max cold and the marking just prior to max cold. The selector for the "Fwd Cargo" was selected to auto.

The cabin altimeter (pressure gauge) was bench tested in the American Airlines test laboratory on 11/30/00. The gauge was placed inside a pressure chamber, and the pressure was varied through a range of +20,000 ft to –11,000 ft. The cabin altimeter part number was 37000-3, the serial number was 246, and the control date was 12/88. The ambient pressure in the laboratory was 29.556 in Hg or 338 ft MSL. During the tests, the cabin altimeter indicated +20,000 ft when the actual pressure was approximately –9,000 ft (see figure 4).

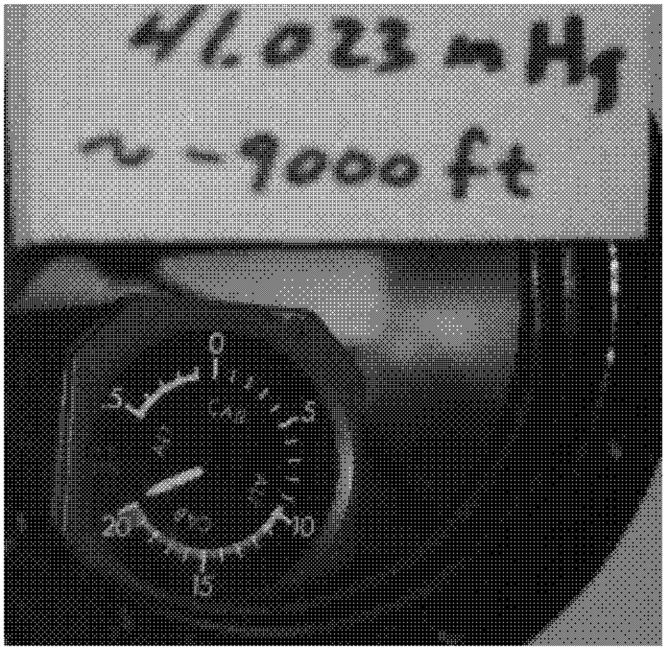


Figure 4 – Cabin Altitude Indicator During Pressure Testing at 41.023 in. Hg (approximately –9,000 ft)

The full set of test points conducted and their results are given below:

Test Point Number	Cabin Altimeter Reading (ft)	Test Equipment Altitude Setting (ft)	Test Equipment Altitude Setting (in Hg) (See Note 1)	Vertical Speed (ft/sec) or (in Hg/sec)
1	4200	5000		1000
2	6500	7500		1000
3	9100	10000		1000
4	14100	15000		1000
5	19100	20000		1000
6	14100	15000		-3000
7	9100	10000		-3000
8	4100	5000		-3000
9	-800	0		-3000
10	-2700	-2000		-1000
11	-2700	(-2000) (See Note 2)	32.145	-0.5
12	-4800	(-4000)	34.507	-0.134
13	Beyond indicated range	(-5000)	35.738	-0.1
14	Beyond indicated range	(-7000)	38.307	-0.1
15	Approx. +20000	(-9000)	41.023	-0.1
16	Approx. +19000	(-11000)	43.893	-0.1
17	-800	0		4000
18	4100	5000		4000
19	9100	10000		4000
20	14100	15000		4000
21	19100	20000		4000
22	-700	0		-4000

Note 1: This value was only recorded for those test points where the test equipment altitude setting in feet was out of range.

Note 2: The altitude number enclosed by a set of parenthesis indicates that the altitude reading is an estimate based on the in. Hg reading.

Detailed examination and teardown of the cabin altimeter, cabin vertical speed indicator and the cabin differential pressure indicator was conducted at Barfield Inc. in Miami, Florida.

Testing of the cabin altimeter indicated that the cabin altimeter consistently read between 1000 and 1350 ft lower than the calibrated test equipment. These values were outside of the allowed tolerance bands for the component. The cabin altimeter was exposed to increased pressure to determine at what value of increased pressure the indicator would read 20,000 ft. This value was found to be 1351.9 mb (40.03 in. Hg or 19.61 psia). Disassembly of the unit did not reveal any evidence of mechanical stops that would stop the pointer at the ends of the marked ranges on the dial.

Testing of the cabin differential pressure indicator (part number 33135-3, serial number 241) determined that the indicator was reading consistently 0.5 psi higher than the calibrated test equipment. These values were outside of the allowed tolerance bands for the component.

Testing of the cabin vertical speed indicator (part number 33140-3, serial number 1066) determined that the indicator was operating within the required tolerance bands.

2.4 OVERPRESSURE SAFETY VALVES

The magnetically latched overpressure safety valve actuation indicators on the maintenance panel in the cockpit did not indicate that the overpressure safety valves were cracked (opened by high pressure) during the accident flight.

Bench testing of the overpressure safety valves was conducted at the American Airlines facility in Tulsa, Oklahoma. The testing was conducted in accordance with their standard shop procedures. The test recorded the pressure differential required to first crack open the valves. The results of the checks are listed below:

Part Number	Serial Number	Cracking Pressure (psid)
81050B020100	688	8.77
81050B020100	680	8.73

2.5 CABIN PRESSURE CONTROLLERS

Both cabin pressure controllers were bench tested using American Airlines' automated test bench in Tulsa, Oklahoma. The controllers tested were:

System 1: P/N: 82010C051100, S/N: 748, Inspected 2/87
System 2: P/N: 82010C051100, S/N: 1308, Inspected AIT 92

Controller S/N 748 registered two failures during the tests. Test TSN 310000, part 6 had a measured value of –0.07235 volts with the acceptable range being +/- 0.05 volts. Test TSN 314000, part 1 had a measured value of 0.14000 volts with the acceptable range being 0.150 to 0.250 volts.

Controller S/N 1308 did not register any failures during the tests.

3.0 OUTFLOW VALVES

3.1 SYSTEM DESCRIPTION

Each valve is of the butterfly type and consists of a light alloy case with convergent intake. The operating principle of the valve is based upon the application of a triple actuator system comprising:

a. a planetary type reduction gearbox with two irreversible drives;
b. a double-rotor, brushless DC motor powers one drive for the automatic control mode systems 1 and 2;
c. a standard DC motor powers the other drive for the manual emergency control mode.

The valve also features an electronic controller mounted on the valve body. It is an autonomous unit capable of following position instructions given by a signal from the system controller. When operating in the normal automatic mode (system 1 or system 2), the appropriate motor on the double motor drive is activated driving the irreversible worm gear. This results in movement of the output gear that is connected to the butterfly by a linkage coupling. If both automatic systems fail, the single motor drive is activated by operating the manual toggle switch located on the cockpit overhead panel. This motor drives a second irreversible worm gear that, through other gears, drives the butterfly.

3.2 VISUAL INSPECTION (INCLUDING THE COMPARTMENTS IN WHICH THE OUTFLOW VALVES ARE LOCATED)

The outflow valves and the compartments in which the outflow valves are located were inspected shortly after the accident to look for any signs of discrepancies which might have caused the pressurization problems reported by the flight crew. The aft outflow valve was noted to be in the fully closed position, and the forward outflow valve was in the ¼ to 3/8 open position (see figures 5 and 6). Closer inspection of the aft outflow valve found that an insulation blanket was obstructing the intake side of the valve, and the blanket was drawn through the intake screen in some areas (see figures 7, 8, and 9). In addition, many of the insulation blankets in the compartment containing the aft outflow valve were displaced from their proper positions and were not secured in place (see figures 10, 11, 12, and 13). Closer inspection of the forward outflow valve found that an insulation blanket was partially obstructing the intake side of that valve (see figure 14). This insulation blanket had impressions on it that were of the same size and shape as the complete intake grill (see figure 15). Inspection of the compartment containing the forward outflow valve and the forward cargo compartment found that many of the insulation blankets in these compartments were displaced from their proper positions and were not secured in place (see figures 16, 17, and 18).

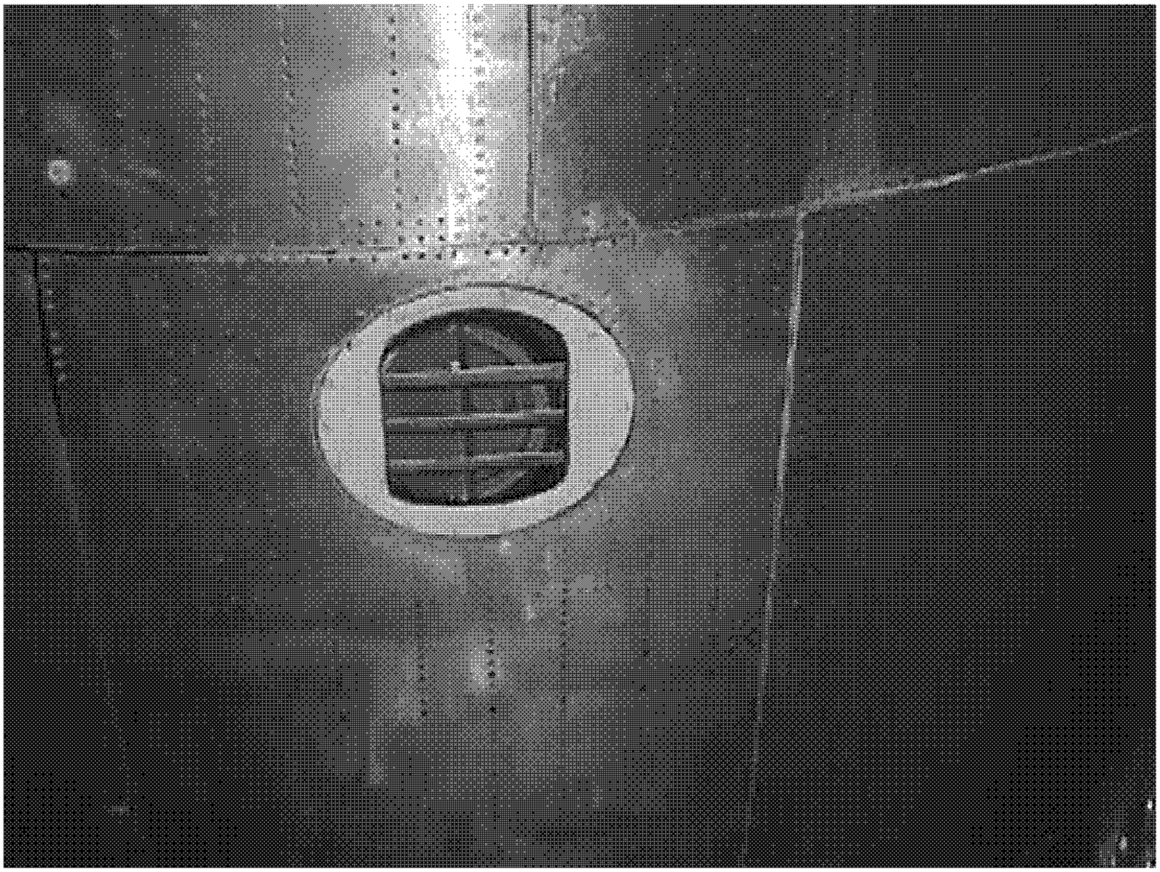


Figure 5 – Aft Outflow Valve as Found in Closed Position

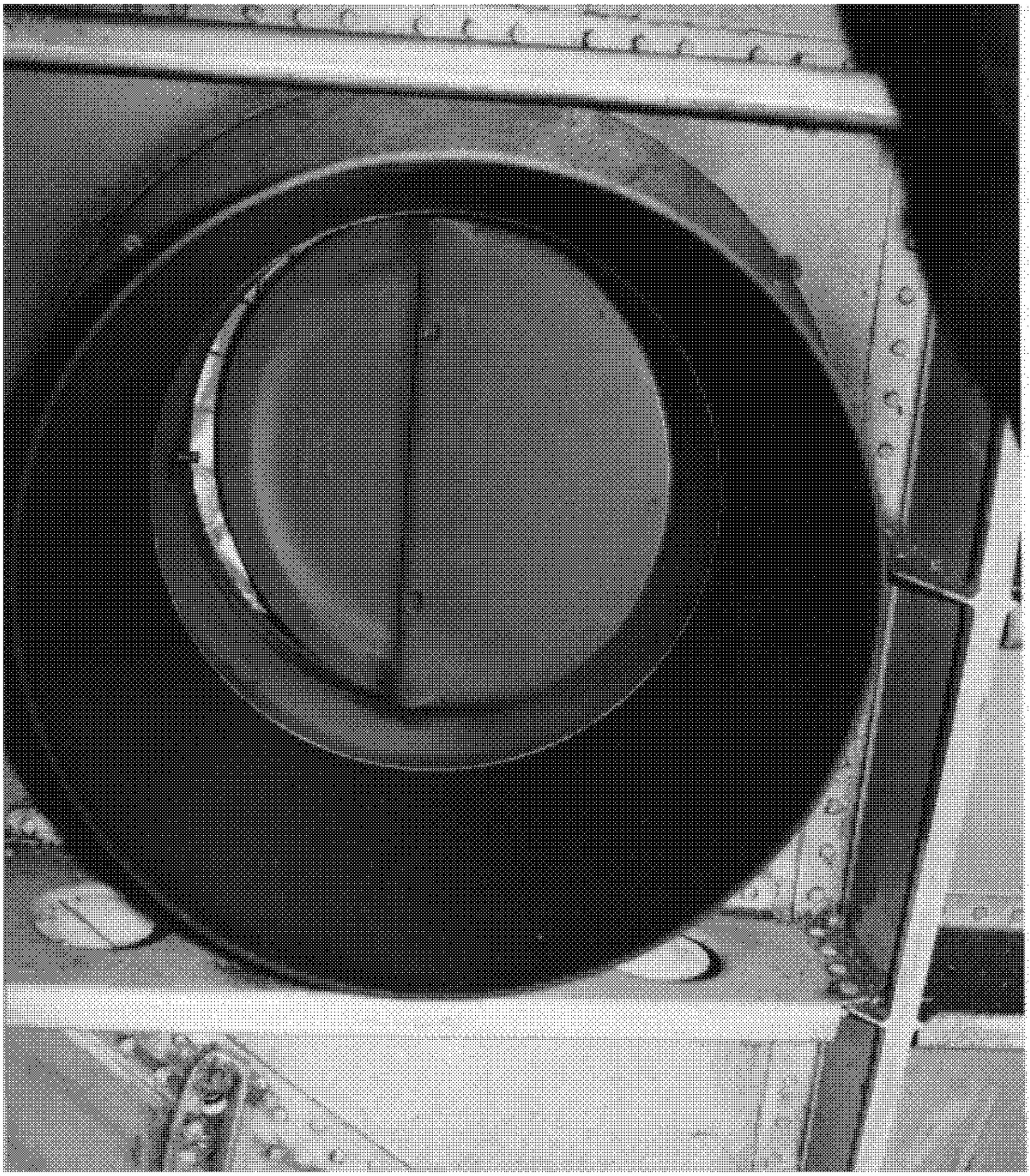


Figure 6 – Forward Outflow Valve as Found in ¼ to 3/8 Open Position

Figure 7 – Aft Outflow Valve With Insulation Blanket Obstructing Intake

Figure 8 – Aft Outflow Valve With Insulation Blanket Obstructing Intake

Figure 9 – Intake Screen From Aft Outflow Valve With Insulation Blanket Protruding Through The Intake Screen

Figure 10 – Left Side Of Compartment Containing Aft Outflow Valve Showing Displaced Insulation Blankets

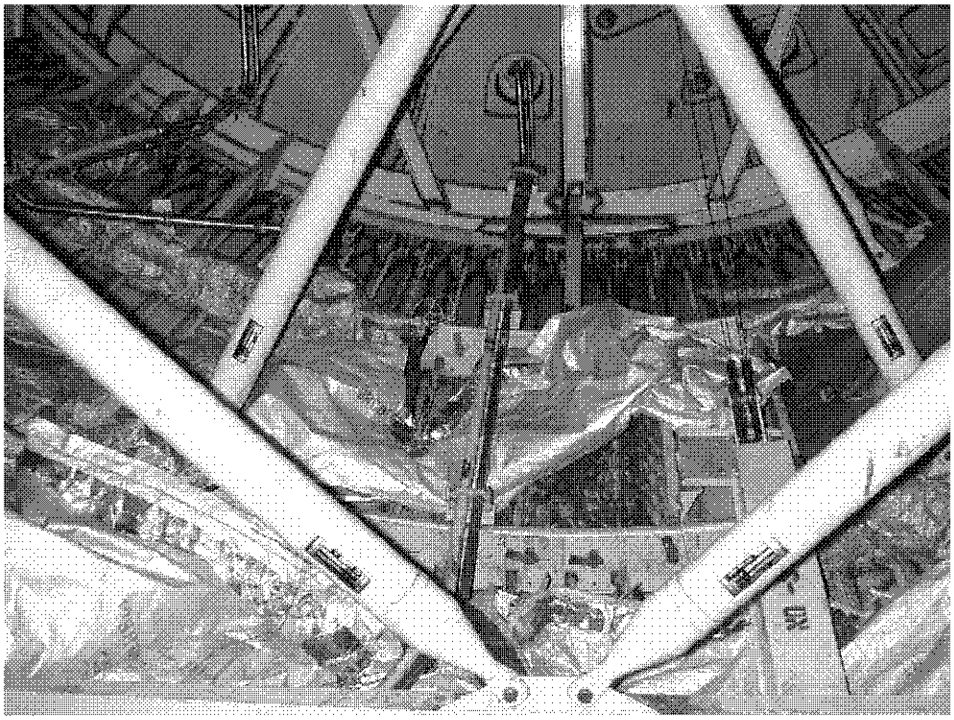


Figure 11 – Center Section Of Compartment Containing Aft Outflow Valve Showing Displaced Insulation Blankets

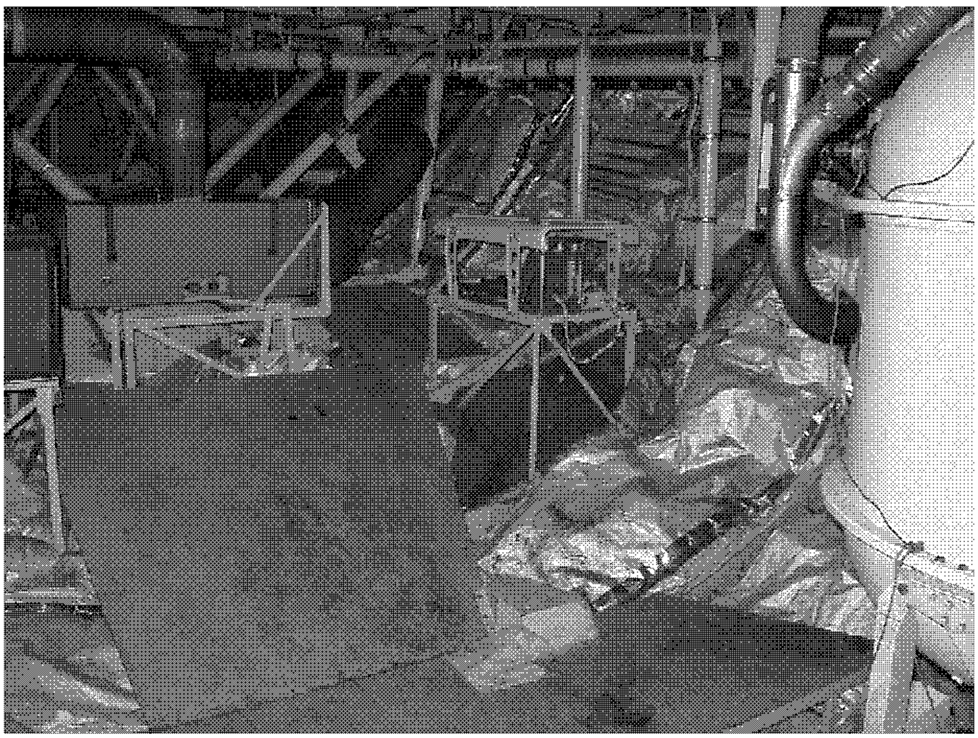


Figure 12 – Right Side Of Compartment Containing Aft Outflow Valve Showing Displaced Insulation Blankets

Figure 13 – Close Up View Of Right Side Of Compartment Containing Aft Outflow Valve Showing Displaced Insulation Blankets

Figure 14 – Forward Outflow Valve With Insulation Valve Partially Obstructing the Intake

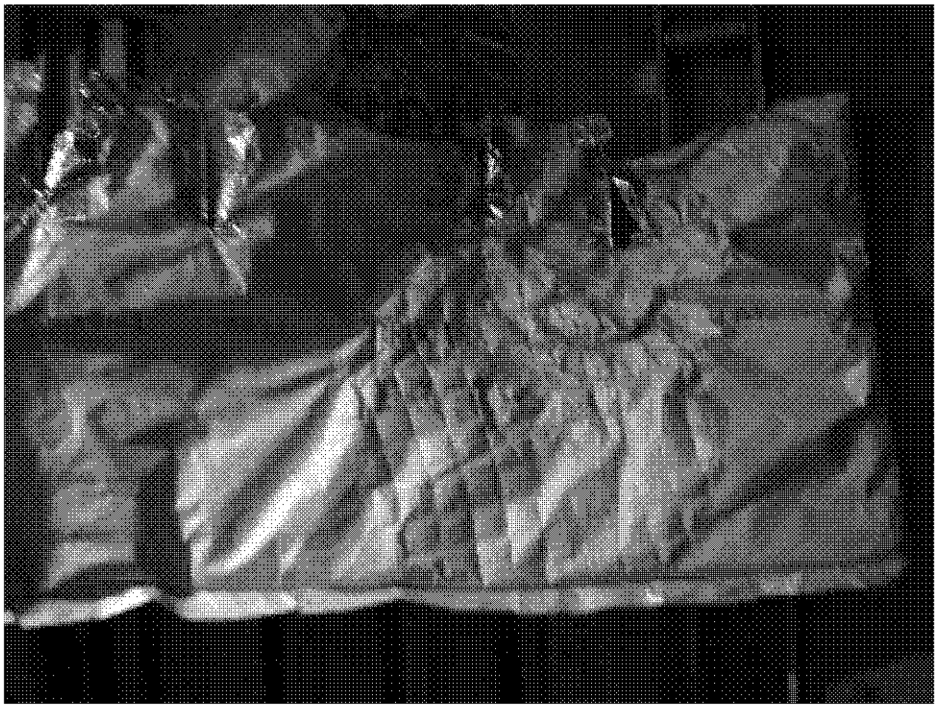


Figure 15 – Insulation Blanket That Was Obstructing The Forward Outflow Valve Showing The Impressions From The Intake Screen

Figure 16 – Right Side Of Compartment (Behind Cargo Compartment Removable Panels) Containing Forward Outflow Valve Showing Displaced Insulation Blankets

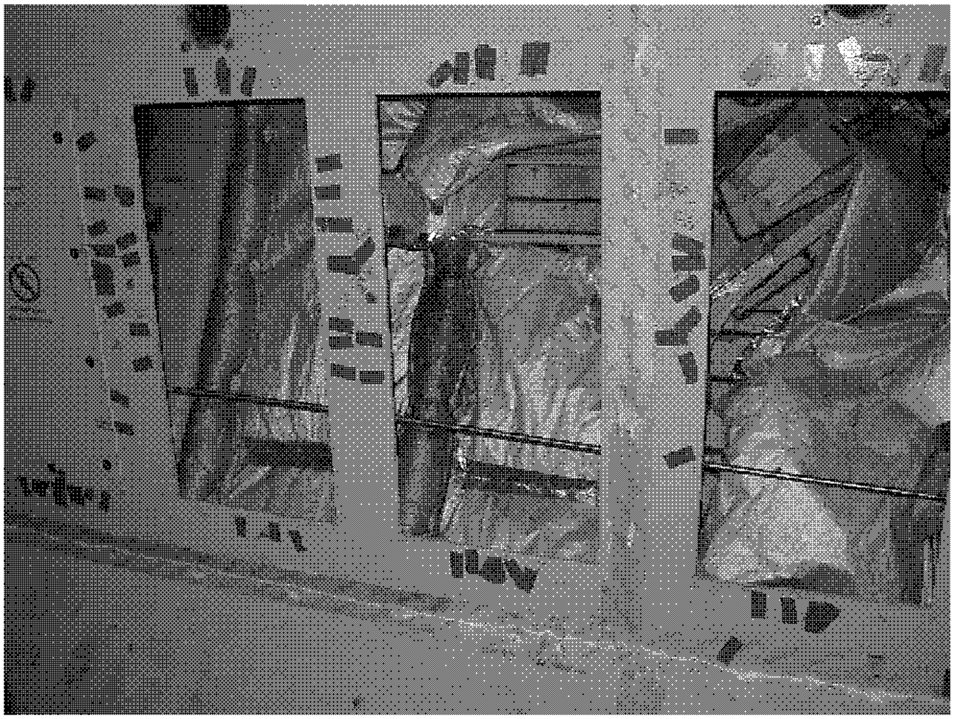


Figure 17 – Right Side Of Compartment (Behind Cargo Compartment Removable Panels) Containing Forward Outflow Valve Showing Displaced Insulation Blankets

Figure 18 – Right Side Of Compartment (Behind Cargo Compartment Removable Panels) Containing Forward Outflow Valve Showing Displaced Insulation Blankets

3.3 BENCH TESTS

The forward and aft outflow valves were bench tested in accordance with American Airlines specification ESO 30678, "ABG-SEMCA CMM-Cabin pressure outflow valve". The valves tested were:

Aft Outflow Valve:	P/N: 88005B0306, S/N: 573
Forward Outflow Valve:	P/N: 88005B0306, S/N: 160

Both valves passed the tests with no out of specification values.

3.4 DIFFERENTIAL PRESSURE TESTING AT THE OUTFLOW VALVE VENDOR

The outflow valve performance with elevated differential pressure was evaluated during tests conducted by the vendor, Liebherr-Aerospace in Toulouse, France. The systems group was not present for these tests, but the vendor provided a report of the activies. The complete test report is presented in appendix A.

The summary of the test report states that:

a. At 160 mbar of differential pressure, the grid started to deform;
b. At 200 mbar of differential pressure, the grid deformation induced a physical contact with the outflow valve butterfly section. The automatic mode was still fully operational;
c. At 240 mbar of differential pressure, the grid deformation induced a hard contact between the grid and the butterfly section of the outflow valve and the current consumption in the automatic mode significantly increased;
d. At 440 mbar of differential pressure, the time for the outflow valve to move from the open to closed position increased. When moving from the closed to open position, the valve was blocked by the grid, and did not move any further. Selection of the manual mode of operation allowed to valve to move to the fully open position;
e. At 520 mbar of differential pressure, the manual mode did not bypass the hard point between the grid and the butterfly section;
f. When the differential pressure was lowered to 360 mbar, the outflow valve operated normally;
g. After the tests, the grid was found to be deformed but no solder joints or grid wires were broken;

h. A functional test was performed on the outflow valve in accordance with the component maintenance manual (21-35-14), and the unit successfully passed the test.

4.0 LAVATORY SMOKE DETECTORS

4.1 SYSTEM DESCRIPTION

The lavatory smoke detectors (manufactured by JAMCO, part numbers PU90-461R2 and PU90-461R3) are located in the ceiling of each lavatory on the aircraft. Each smoke detector assembly consists of a smoke detector, frame assembly, and sensor. The smoke detector is a dual chamber ionization type detector that generates an alarm signal by detecting the change of ion density due to smoke. The smoke detector is powered by 27.5 volt DC aircraft power.

According to the manufacturer's component maintenance manual, the smoke detector is designed for aircraft cabin applications based on RTCA requirements for aircraft equipment. These requirements include an operational altitude range of –1,000 to 15,000 ft.

4.2 TESTING CONDUCTED ON THE ACCIDENT AIRCRAFT

The lavatory smoke detectors were tested in accordance with maintenance manual procedure 26-17-00-5-02, "Lavatory Smoke Detector – Adjustment/Test". All of the items on the procedure were checked, and no discrepancies were noted.

It was noted that the green LED in the detector for lavatory "Y" was bent at a 90 deg angle, and could not been easily seen from outside the detector. As an additional functional test, the smoke detectors in lavatories "Y" and "V" were checked with a lit cigarette. The detector in lavatory "V" functioned properly, while the detector in lavatory "Y" did not sound its alarm. To further check this sensor, a smoke stick (which uses a chemical reaction to generate smoke) was used to test the sensor. When smoke from the smoke stick was blown across the sensor of the smoke detector, the detector sounded its alarm.

In the course of these tests, it was found that the following items were triggered when each lavatory smoke alarm was tested:

a. The red LED on the smoke detector was lit;
b. A repetitive tone was emitted from the smoke detector;
c. The corresponding red warning light on the lavatory wall blinked;
d. The red SMOKE LAV warning light on the Forward Attendant's Panel blinked;

e. The red SMOKE LAV warning light on the Aft Attendant's Panel blinked;
f. A repetitive HI/LO chime was broadcast in the cabin;
g. The white CAPT CALL lights at the Attendant telephone stations came on;
h. The green LED's on the keyboards of the Attendant telephone stations came on;
i. The area red call lights blinked;
j. The amber area call lights blinked indicating in which lavatory the alarm was located.

4.3 TESTING CONDUCTED AT AMBIENT PRESSURE

Bench testing of the lavatory smoke detectors at ambient pressure was conducted at the Unicorp facility in Tulsa, Oklahoma. The testing was conducted in accordance with the Jamco Component Maintenance manual procedure 26-10-02. The test procedure checked the sensitivity of the detector, the operation of the alarm in the presence of smoke, and the electrical wiring. All of the detectors passed all of the test items. The results of the sensitivity checks[1] are listed below:

Lavatory Designation	Part Number	Serial Number	Manufacturing Date	Sensitivity Check Results (Volts)
V	PU90-461R2	08290	1989	1.9
A	PU90-461R3	09782	1990 Dec	2.0
Y	PU90-461R2	08077	1989 Aug	2.2
L	PU90-461R3	11061	1991 Dec	1.8
M	PU90-461R3	08570	1989	1.8
U	PU90-461R3	07986	1989	2.6
Z	PU90-461R2	08289	1989	2.3

4.4 TESTING CONDUCTED AT ELEVATED PRESSURE

Additional testing of the lavatory smoke detectors at elevated pressures was conducted at the American Airlines facility in Tulsa, Oklahoma. The lavatory smoke detectors were placed inside a pressure vessel, and the sensitivity check was repeated at various elevated pressures. The test results are presented in appendix B.

[1] The sensitivity checks for both the lavatory and cargo compartment smoke detectors determine the additional voltage (due to smoke in the sensor) required to trip the sensor's alarm circuit. A lower voltage value indicates that the smoke detector will sound an alarm with less smoke present. If the value is zero, the smoke detector's alarm will sound with no smoke present.

5.0 CARGO COMPARTMENT SMOKE DETECTORS

5.1 SYSTEM DESCRIPTION

The cargo compartment smoke detection system for the A300 aft cargo compartment consists of four smoke detectors (manufactured by Cerberus Guinard, part number CG7PO) arranged in pairs with one pair located in the forward part of the compartment and one pair in the aft part of the compartment. In each cargo compartment, the association of one forward and one aft smoke detector composes a loop (A or B). On the flight compartment overhead panel, there are three red SMOKE warning lights, six LOOP/OFF pushbutton switches (one pushbutton switch for each of two loops in each of three cargo compartments), and a loop test pushbutton switch (see figure 19).

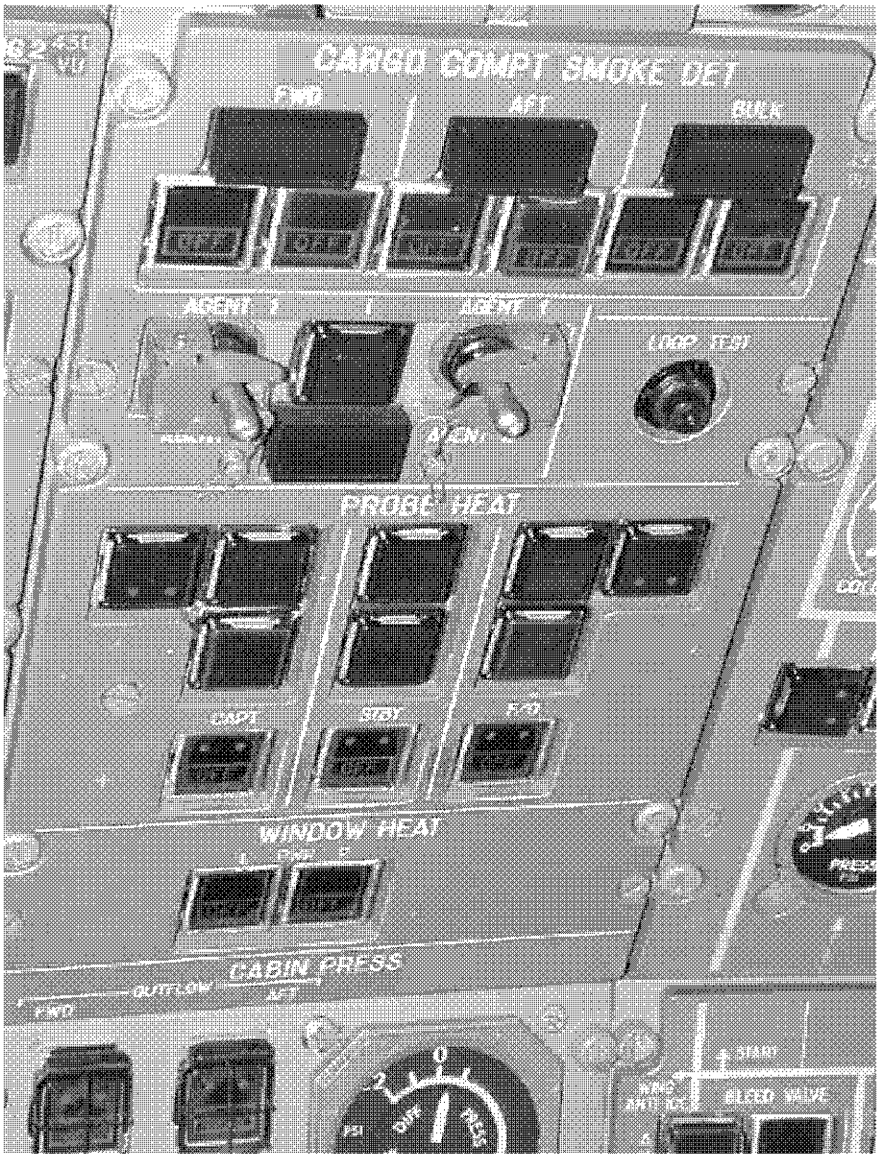


Figure 19 – Cargo Compartment Smoke Detection Control Layout (Note proximity to Cabin Pressure Indicators at bottom of figure)

In order to trigger a red SMOKE light, both smoke detectors in one loop must generate an alarm signal. If only one smoke detector in a loop generates an alarm signal, the LOOP light will illuminate. In the case of a LOOP light, the flight crew is directed to follow a troubleshooting procedure to determine if the smoke detector is faulty or if it is generating a valid alarm signal.

5.2 TESTING CONDUCTED ON THE ACCIDENT AIRCRAFT

The cargo compartment smoke detectors were tested in accordance with maintenance manual procedure 26-16-00-5, "Cargo Compartment Smoke Detection – Adjustment/Test". All of the items on the procedure were checked, and no discrepancies were noted.

5.3 TESTING CONDUCTED AT AMBIENT PRESSURE

Bench testing of the loop 'B' smoke detectors from the aft cargo bay was conducted at the Unicorp facility in Tulsa, Oklahoma. The testing was conducted at ambient pressure in accordance with the Cerberus Guinard Component Maintenance manual procedure 26-11-15. The test procedure checked the sensitivity of the detector and the operation of the alarm in the presence of smoke. With the exception of one test, all of the detectors passed all of the test items. The one item that did not meet the test requirements was a sensitivity test on detector S/N 3093. The test procedure called for a sensitivity voltage range of 6 +/- 1 volts. Detector S/N 3093 had a sensitivity voltage of 4.8 volts. This would tend to make the detector slightly more sensitive then a compliant unit. The results of the sensitivity checks are listed below:

Part Number	Serial Number	Position in the Aft Cargo Bay	Sensitivity Check Results (Volts)
CG7PO	4252	Forward	5.3
CG7PO	3093	Aft	4.8

5.4 TESTING CONDUCTED AT ELEVATED PRESSURE

Additional testing of the loop 'B' smoke detectors at elevated pressures was conducted at the American Airlines facility in Tulsa, Oklahoma. The loop 'B' smoke detectors were placed inside a pressure vessel, and the resting voltage[2] was measured at various elevated pressures. When the detector resting voltage became equal to the voltage required to trigger the alarm, the tests were terminated. The test results are presented in appendix C.

6.0 EVACUATION SIGNALING SYSTEM

6.1 SYSTEM DESCRIPTION

The controls and indicators for the evacuation signaling system are composed of pushbuttons in the flight compartment and at each flight attendant station that are used to initiate the evacuation signal and warning horns at each flight attendant station that sound the evacuation alarm. The evacuation system can be triggered from any pushbutton, and each warning horn is designed to emit an identical sound.

[2] The test method for the cargo compartment smoke detectors was slightly different from that of the lavatory smoke detector in that it measured both the resting voltage and the trigger voltage of the unit. The trigger voltage (the voltage at which the unit would trigger the alarm) minus the resting voltage (the voltage measured in the unit with no smoke present) yields the sensitivity voltage.

6.2 TESTING CONDUCTED ON THE ACCIDENT AIRCRAFT

The evacuation signaling equipment was tested in accordance with maintenance manual procedure 25-63-00-5, “Evacuation Signaling Equipment – Adjustment/Test”. The following discrepancies were noted:

a. The evacuation horn by the L4 door emitted a steady tone instead of the chirping tone;

b. Pushing the pushbutton “EVAC push for on” by the R2 door had no effect;

c. The evac pushbutton by the L4 door did not activate every time it was pushed;

d. The evac pushbutton by the R1 and R4 doors took several pushes for the system to activate.

7.0 INSULATION BLANKET INSPECTIONS

7.1 PRINCIPLE MAINTENANCE INSPECTOR INSPECTION OF A-300 AND A-310 INSULATION BLANKETS

According to an e-mail from the Seattle Aircraft Evaluation Group (AEG) Program Manager for the A300 aircraft (Airworthiness), the A-300 and A-310 principle maintenance inspectors (PMI) were informed of this accident and reported that of all U.S. operators, only American Airlines reported finding loose blankets in their aircraft. American reported that 4 of their 33 aircraft inspected had loose blankets. The e-mail also reported that American had installed additional fasteners to prevent future occurrences.

Scott Warren
Lead Aerospace Engineer

APPENDIX A

Liebherr-Aerospace Outflow Valve Differential Pressure Test Results Report SC/ST/01-224, dated February 27, 2001

LIEBHERR-AEROSPACE TOULOUSE S.A.

COMPTE-RENDU / MINUTES OF MEETING

REF. : SC/ST/01-4224 DATE : February 27th, 2001 PAGE : 1/5

NOM (Name) : Christophe DUPHIL DÉPT. : SC/ST	OBJET (Subject) : **Test on P/N 88005B0306**
PARTICIPANTS (Attendants) : AIRBUS : G. JUAN – A. LAN EADS : PH. AMIEL LTS : J. FRAISSE – D. CAUSSAT – P. LOPEZ – CH. DUPHIL	DIFFUSION (Distribution) : MEMBERS+ A. COURTEIX – P. PRADEAU – F. CARLA – M. EGLEM – U. VOLPE – C. ARAGNETTI – D. LORET

1. GOAL

The purpose of this test on OutFlow Valve (OFV) P/N 88005B0306 was to simulate the abnormal conditions of operation - valve grid fully plugged by a blanket - in order to picture the OFV behaviour under this stress. This phenomenum was experienced by AAL in November 2000 and does not correspond in any manner whatsoever to design operating conditions specified in the equipment technical specification.

2. INSTALLATION

OFV used:

Designation	P/N	Amdt	s/n
OFV	88005B0306	ACDEF	857
. Auto Motor	S4090	-	844D
. Manu Motor	S4019	-	206675
. ECU	2058A0601	AB	611
. Reducer	9220A02	ABC	855

The aircraft insulation blanket was simulated by a TRANSALL water extractor insulation blanket. It was placed on the OFV grid in order to cover 100% of the OFV diameter.

Test bench P/N 84-6 was used to control the OFV between opening and closing position in Automatic and Manual modes

Vaccum source was used in order simulate a differential pressure on A/C and to apply an effort on the grid previously plugged.

APPROBATION (Agreement) :

3. TEST PROCEDURE

3.1. OFV monitoring data generation used during the test :

3.1.1. OFV POSITION (CRT)

This value is function of the real position of the OFV butterfly.
Valve full open: CRT = 5 V
Valve full close: CRT = 0 V

3.1.2. OFV ERROR SIGNAL

This Error signal is a function of the difference between OFV butterfly position (CRT) and positioning target order (current) provided by the Cabin Pressure Controller on A/C or by the test bench.

When the valve butterfly positioning operates normally, this error remains within 1 % of the valve total travel range. Monitoring signal scale is as follows:

- 3,5 mA for an error of - 5%,
- 6 mA for zero error,
- 8,5 mA for an error of + 5%.

For higher servo positioning errors, scale is no longer linear. Value limits are as follows:

- 2,5 mA for an error > - 20%,
- 9,5 mA for an error > + 20%.

3.2. AUTOMATIC MODE CURRENT CONSUMPTION

The automatic mode current is the current consumption of the active automatic channel of the complete OFV (motor + electronic devices + sensors). This value is mainly linked to the motor consumption and then to the torque applied by the motor.

3.3. Procedure

Increase the differencial pressure in order to increase the effort on the grid. For each point of the ΔP selected throught the vaccum source :

Check the OFV operation by moving the OFV from a 20 mA positioning current target (full open) to a 12 mA positioning current target and then go back in 20mA

During this OFV operation, measure :

- Automatic mode current consumption.
- OFV butterfly position (CRT)
- Error signal

If the OFV is jammed, check that the manual mode is functional and measure the OFV butterfly position (CRT) and the manual mode consumption.

4. MEASUREMENT

ΔP (mbar)	CRT (V)	I manuel (mA)	Target Auto (mA)	I Auto (mA)	Error (mA)	Remarque
160	2.55		12	300	6.08	Deformation / grid
200	2.56		12	320	6.05	Contact point
220	2.547		12	402	6.07	
240	2.559		12	500	6.10	->
	5.154		20	760	6.07	<- hard point
270	2.55		12	482	6.04	->
	5.128		20	623	6.06	<- hard point
300	2.558		12	597	6.08	Hard point ->
	5.12		20	711	6.073	<-
320	2.571		12	595	6.09	
	5.129		20	764	6.07	
340	2.552		12	850	6.08	
	5.135		20	1020	6.05	
360	2.564		12	722	6.06	
	5.189		20	1.100	6.057	
380	2.564		12	650	6.077	
	5.145		20	1115	6.08	
400	2.566		12	681	6.06	
	5.155		20	1131	6.05	
420	2.552		12	997	6.045	
	5.1		20	1572	6.07	
440	2.54		12	1083	6.06	Increase time to reach position
	3.420		20	1572	2.366	Blocked closed -> open
		314				Man -> OK bypass
460	2.535		12			OK
	3.408		20		2.38	Blocked closed -> open
		350				Man -> OK bypass
480	3.85		12		9.495	Blocked open -> closed
		302	12			Man -> OK bypass

ΔP (mbar)	CRT (V)	I manuel (mA)	Target Auto (mA)	I Auto (mA)	Error (mA)	Remarque
500	3.92		12			Blocked open -> closed
		356				Man -> OK bypass
						OK AUTO closed-open
520		350			9.30	BLOCKED closed -> open
						NO MAN BY-PASS
357						No blockage any longer

5. TEST CAMPAIGN

At 160 mbar of differencial pressure, the grid starts getting deformed.

At 200 mbar of differencial pressure, the grid deformation induce a physical contact with the OFV butterfly. The automatic mode is still fully operational.

At 240 mbar of differencial pressure, the grid deformation induce hard point and a significant increase of the automatic mode current consumption.

At 440 mbar of differencial pressure, during operation from open to close, the time to reach the position increases. In addition, during operation from close to open position, the butterfly is blocked by the grid. Selection of the manual mode. The manual mode operation is able to bypass the hard point and to open the valve. Selection of the automatic mode.

At 480 mbar of differencial pressure, during operation from open to close position, the butterfly is blocked by the grid. Selection of the manual mode. The manual mode operation is able to bypass the hard point and to open the valve. The automatic mode operation is lost from this ΔP level.

At 520 mbar of differencial pressure, the manual mode did not bypass the hard point either which is perfectly understandable considering the abnormal conditions under which the tests where performed.

We decided not to increase further the ΔP. After having lowered the ΔP to around 360 mbar, the OFV was fully operational.

After the test, the grid was deformed but was found without any solder or grid wire brocken.

A complete CMM 21-35-14 test was performed on the OFV. The only finding was a little mark on the butterfly area in contact with the grid. The butterfly seal was not found damaged. The OFV passed successfully the CMM test.

6. CONCLUSION

The test performed may not be 100% representative of the conditions encountered on the AAL flight (different insulation blancket, different airflow), however, we are of the opinion that the OFV behaviour reflected herein can be considered as representative.

In case of OFV butterfly jammed in Automatic mode further to an abnormal grid deformation, the manual mode is able to bypass the hard point within an acceptable value of ΔP.

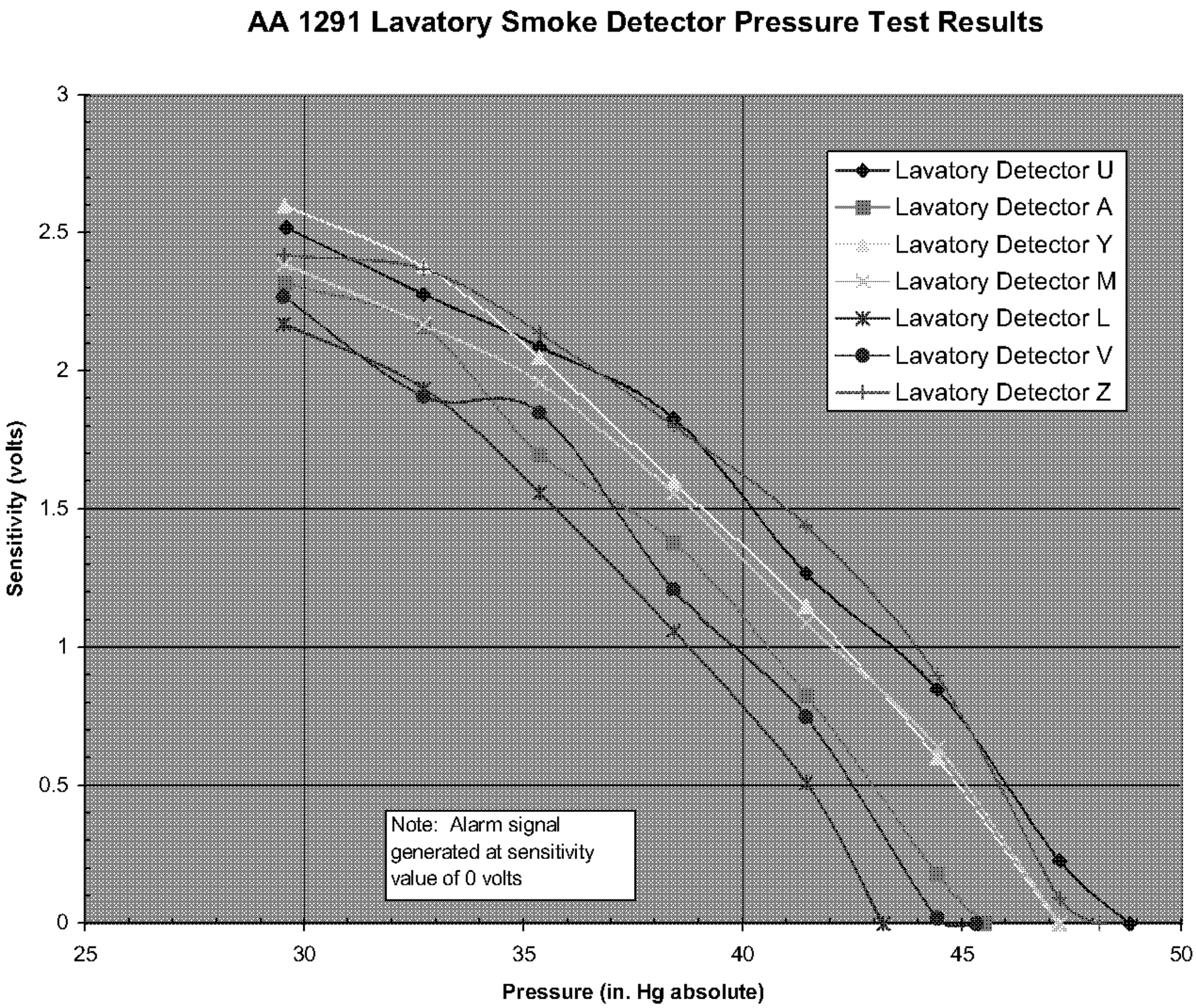
The OFV operation becomes normal as soon as the ΔP decreases to an acceptable value.

During all the tests performed, the electrical information provided by the OFV remained reliable and did not drift. The OFV position (CRT) provided the correct OFV position even when the butterfly was jammed. This information is provided to the pilot in order to have a feed back on the OFV position, especially during the manual mode operation.

The OFV operation, feed back and monitoring thus fully fulfilled the operational and safety requirements as per system initial specifications.

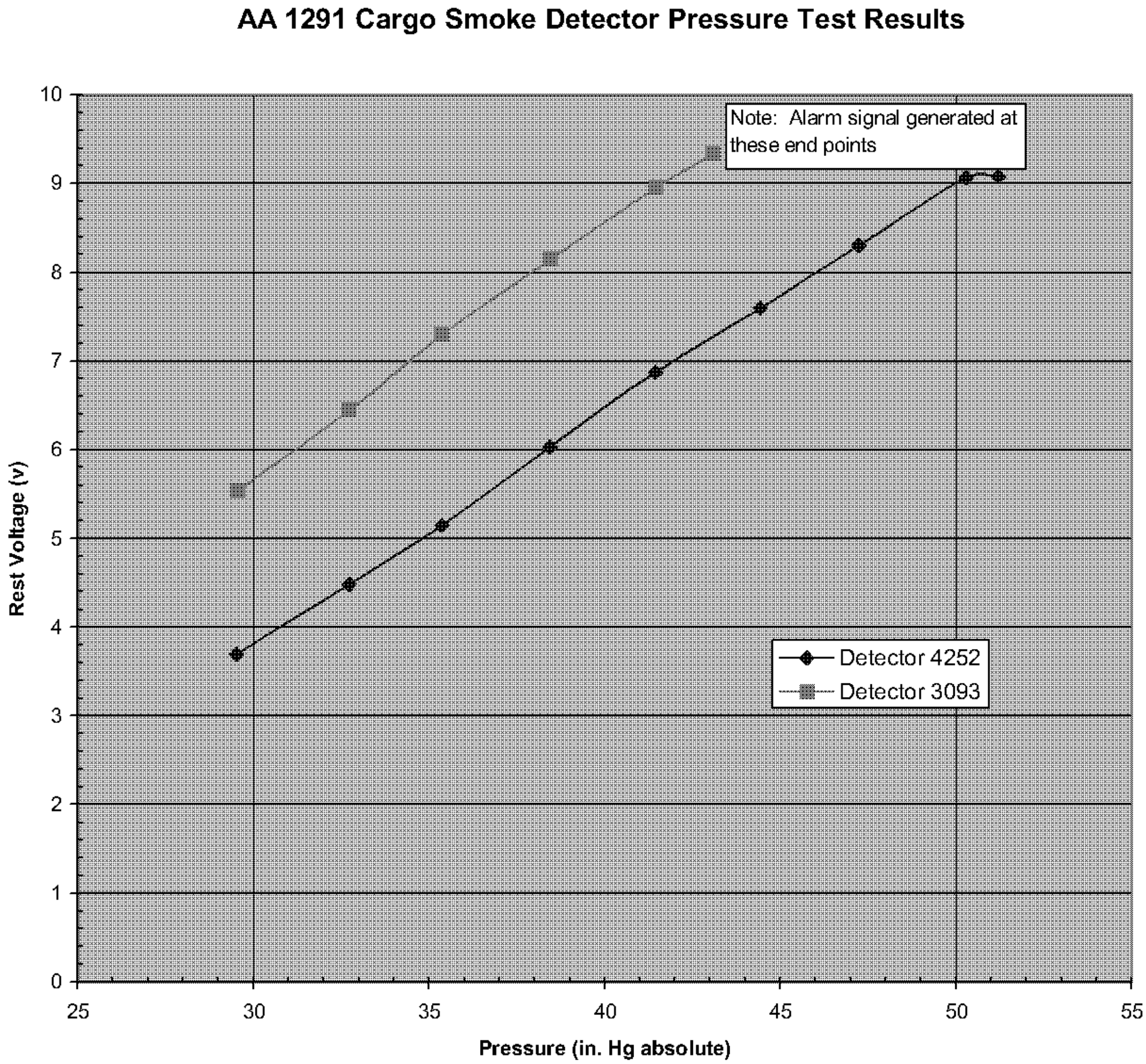
APPENDIX B

Lavatory Smoke Detector Sensitivity Test Results – Elevated Pressures


AA 1291 Lavatory Smoke Detector Pressure Test Results
Lavatory Detector U
Lavatory Detector A
Lavatory Detector Y
Lavatory Detector M
Lavatory Detector L
Lavatory Detector V
Lavatory Detector Z
Note: Alarm signal generated at sensitivity value of 0 volts
Sensitivity (volts)
Pressure (in. Hg absolute)
3
2.5
2
1.5
1
0.5
0
25
30
35
40
45
50

APPENDIX C

Aft Cargo Compartment Loop ‘B’ Smoke Detector Sensitivity Test Results – Elevated Pressures


AA 1291 Cargo Smoke Detector Pressure Test Results
Note: Alarm signal generated at these end points
Detector 4252
Detector 3093
Rest Voltage (v)
Pressure (in. Hg absolute)
0
1
2
3
4
5
6
7
8
9
10
25
30
35
40
45
50
55